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RESIDENTS' PERCEPTION OF THE HABITABLE BUILT ENVIRONMENT QUALITY IN INFORMAL RIVERBANK SETTLEMENTS, CASE STUDY: JODIPAN COLORFUL VILLAGE, INDONESIA

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Abstract

The transformation of Jodipan Colorful Village (Kampung Warna Warni Jodipan) from slums into tourist locations is leading to new activities in public spaces. However, these areas are not fully optimized as tourist locations due to the physical environment and residents' conditions factors. Evaluating the quality of the environment is crucial to creating comfort for residents and visitors while ensuring sustainability. The behaviour of these residents also plays a critical role in determining the quality of the environment. Therefore, this study aimed to explore the perception of residents in assessing and classifying the quality of livable built environments in the riverside settlements of Jodipan Colorful Village. The exploration was carried out in District 2 which was divided into sub-districts 6, 7, and 9. The data was collected through a questionnaire distributed to 169 respondents who reside in Jodipan Colorful Village and aged 17 years. Furthermore, data analysis adopted mean score analysis and instrument testing with validity and reliability tests. The results showed that all three sub-districts had medium quality levels where sub-district 6 achieved a mean score of 3.06 and sub-districts 7 as well as 9 both recorded 3.03. Residents positively evaluated physical aspects such as road conditions and roof quality while aspects including the location of settlements and street widths were viewed negatively. Despite these observed differences, the perceptions were useful for assessing environmental quality attributes. Consequently, physical aspects that moderately or adversely affected the quality of the village should be reviewed to maintain environmental quality and sustainability.

Keywords: Residents' Perceptions, Livable Built Environments, Quality Assessment, Riverbank Settlement, Tourist Locations.

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INTRODUCTION

The Ministry of Public Works and Public Housing oof Indonesia (PUPR) predicted that around 60% of Indonesian population will be living in the middle cities by 2025 (Ministry of PUPR, 2016). Due to the high demand for housing originating from urbanization, communities tend to create informal settlements which can impact the decrease of environmental quality. Other impacts of the urbanization phenomenon are slum settlements and poverty (Minnery et al., 2013) which will interfere with the sustainability of the city (Yuan et al., 1999). This urbanization impact prompts various mitigation actions focusing on sustainability, quality of life, and livability (Aliakbari et al., 2017; Pedro et al., 2021), specifically in developing countries (Yakob et al., 2012). Livability represents a critical component of Sustainable Development Goals (Kovacs-Györi et al., 2020) with indicators essential for assessing urban and housing quality (Ghasemi et al., 2018). Improving the quality of life in cities remains an important issue in urban planning (Mouratidis, 2021).

In this context, the "Kota Tanpa Kumuh" (KOTAKU/City without Slums) program has been found to reduce slum settlements in Malang City by 310.38 hectares since the inception in 2015. However, 72.37 hectares still require attention regarding the quality of the settlement. Uncontrolled urbanization has also caused unplanned growth and development in Jodipan Sub-district due to informal management (Wulandari et al., 2023). Residential areas without good management also have the potential to cause discomfort among residents (Yang et al., 2011). Furthermore, the position of the village which is lower than the surroundings possesses an impact on Malang City being perceived as a slum (Wulandari et al., 2023). This also impacts the quality of built environments in Jodipan Colorful Village which remains suboptimal.

The transformation of Jodipan Colorful Village *(Kampung Warna Warni Jodipan)* from slums to tourist locations has fostered new activities, particularly in public spaces such as road corridors frequented by tourists (Ratnawati et al., 2019). The transition of the Jodipan Colorful Village is shown in figure 1.

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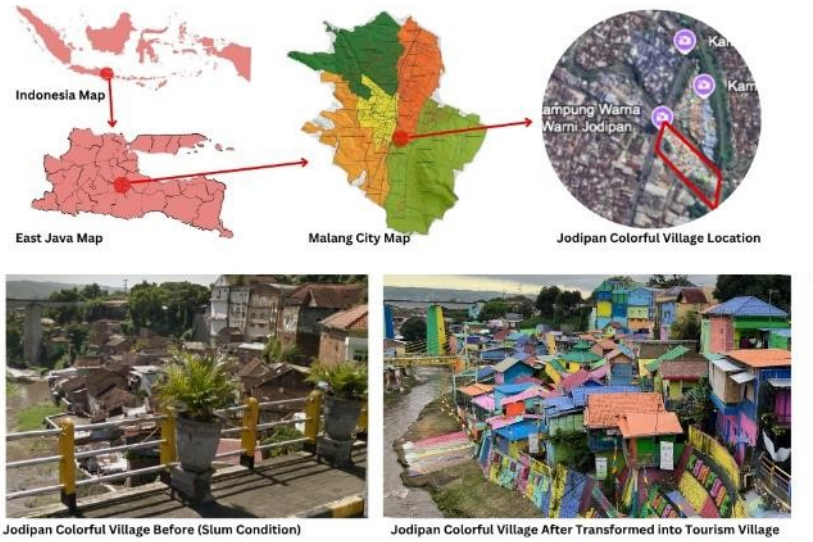


Figure 1: Location and Transformation of Jodipan Colorful Village

Due to forced conditions, Jodipan Colorful Village is not fully recognized as a tourist location, judging from the physical condition of the environment, infrastructure, and residents (Ningsih, T. R., 2017). Meanwhile, Tourist destinations must offer experiences aligned with market needs in order to maintain a competitive edge and thrive (Fan *et al*., 2024). This phenomenon of the village changes and development underscores the importance of assessing the quality of livable built environments from both residents' perceptions and field conditions. Furthermore, cities evolving into tourist destinations significantly experience a process of mutual influence between residents and communal spaces (Wulandari et al., 2023). This happened because the government made plans to improve residential conditions in inadequate settlements which is outlined in Law No. 4 of 1992 concerning housing and settlements. The Ministry of PURR initiated a program called KOTAKU to improve the quality of slum settlements, prevent the evolution of new slums, and support sustainable living (Ditjen PUPR, 2016). Therefore, continual evaluation of the initiatives is crucial to assess, uphold, and enhance residential environment quality in Jodipan Colorful Village, preserving the role as a tourist destination.

Unplanned growth of informal settlements fails to meet livable standards (Sabila et al, 2021; Atika, 2020). The term "livability" can be defined as peoples' satisfaction with human and physical surroundings (Mulligan et al., 2004), alongside the interactions with the environment (Campbell et al., 1976; Stimson et al, 2011). Physical (Ekartaji et al., 2016), social, and economic factors (Krisandriyana, 2017) are fundamental aspects that influence the quality of livable built environments for residents. Environmental planning and the

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provision of livable housing significantly impact residents living conditions (Kashef, 2016; Yakob et al., 2012).

The condition of residential environment in a location is greatly influenced by the interactions and relationships formed between residents. The habitable environment is very dependent on residents because every action taken by humans will affect the surroundings positively and negatively (Yuliastuti et al., 2011). Residents' perceptions can be used as a tool to assess the environmental quality attributes of settlements (Aslim et al., 2014). Environmental quality based on public perception can also be used as a method to persuasively explore the level of satisfaction and quality of environmental conditions. However, this will be with the limitation of results that are not isoform (equivalent) to all conditions in the world (Aslim et al., 2014). Based on this phenomenon, investigating residents' perceptions to assess and classify the quality of livable built environments based on physical aspects in the riverside settlement of Jodipan Colorful Village in Malang is essential.

LITERATURE REVIEW

Livability of Riverbank Settlement

The concept of adequate housing referred to the physical condition of the environment as assessed from the perspective of individuals in society, who evaluated housing quality (Heylen, 2006). According to Sari et al. (2014), informal settlements in riverside areas often evolved into uninhabitable slums. Decent housing also included the comfort level of the settlement as a suitable living environment for humans. Various factors could influence the settlements' comfort including building density, vegetation, air temperature, humidity, and building geometry (Maru et al, 2016). Furlan (2016) further explained that residential environment, specifically public open spaces, should be designed to promote social interaction between communities. Furthermore, Luhst (1997) emphasized that the quality of life including comfort and security in a home was greatly influenced by the location.

In this context, efforts to address uninhabitable or slum settlements were initiated by the Ministry of PUPR through KOTAKU which described livable settlements' indicators. The components of livable settlements consisted of physical environments that supported the social and economic activities in the community. This included not only livable housing but also well-designed environmental infrastructure, open spaces, and vegetation.

Physical Indicators that Formed the Quality of Livable Built Environments

Spatially, livable built environments included open and closed spaces comprising buildings and structures (built-up area/building coverage) (Pangarso, 2017). Informal settlements along riverbanks were included in the built environments category where urban villages often lacked adequate environmental quality conditions (Aslim et al., 2014).

Based on this context, the quality of a residential environment depended on environmental variables that influenced the overall quality including both location and physical variables (Rapoport, 1983). Physical aspects of buildings and the environment could be used as metrics for evaluating the quality of livable built environments (Cipta Karya PU, 2006). Assessing the quality of built environments included considering various physical indicators that contributed to the overall quality as presented in Table 1.

Table 1: Framework of Physical Indicators of Livable Built Environments' Quality

Physical Aspects	Indicators	References
Building Density	Open space and built-up/building coverage ratio	Soemarwoto, (1991); Cipta Karya PU, (2006)
	The distance between houses	Anugrah et al., (2021)
Settlement Location	Distance of settlements to activity centers, sources of pollution, and danger	Rapoport, (1983); Dursun et al, (2009); Cipta Karya PU, (2006)
Entry Road Width	Easy or not accessibility	Dursun et al, (2009); Atika, 2020; Fitri, (2021); Prabowo et al, (2021)
	Greater average road width led to better quality	Cipta Karya PU, (2006)
Road Surfaces Condition	Availability of adequate infrastructure	Anugrah et al, (2021).
	The condition of the road surface from the type of road paving material	Cipta Karya PU, (2006).
Vegetation	Vegetation as Environmental Comfort Management	Dursun et al, (2009).
	The existence of protective trees provides shade and absorbs pollutants	Cipta Karya PU, (2006).
Building Layouts	Spatial aspects: architectural characteristics, building dimensions, and building layout	Dursun et al, (2009)
	Building order, uniformity of facing direction, and building shape	Prasetyo et al,, (2013); Cipta Karya PU, (2006).
Building Roof Quality	The quality of the building roof, and the physical appearance includes the quality of the building roof elements	Ekartaji, 2016; & Cipta Karya PU, (2006)

Residents Perceptions of the Physical Quality of Livable Built Environments

In perception, individual differences in experiences and frames of reference could lead to varying results despite the stimulus remaining the same (Sarwono., 1994; Schiffman et al., 2004; Kotler et al, 2001; & Robbin., 1996). Residents also play an important role in determining environmental quality, influencing both attitudes and behaviours that impact the quality of residential environments (Bwarlele et al., 2023; Simbang et al., 2019). Aslim et al. (2014) stated that residents' perceptions served as a tool to assess the environmental quality attributes in

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settlements. Although public perception of environmental quality could effectively gauge satisfaction levels and environmental conditions, the results may not be universally applied (Aslim et al., 2014).

RESEARCH METHODOLOGY

This study used a quantitative method to explore residents' perceptions in assessing and classifying the quality of livable built environments in the riverside settlements of Jodipan Colorful Village focusing on the physical aspects. The selection of observation zones was segmented based on administrative sub-districts considering different locations and physical conditions.

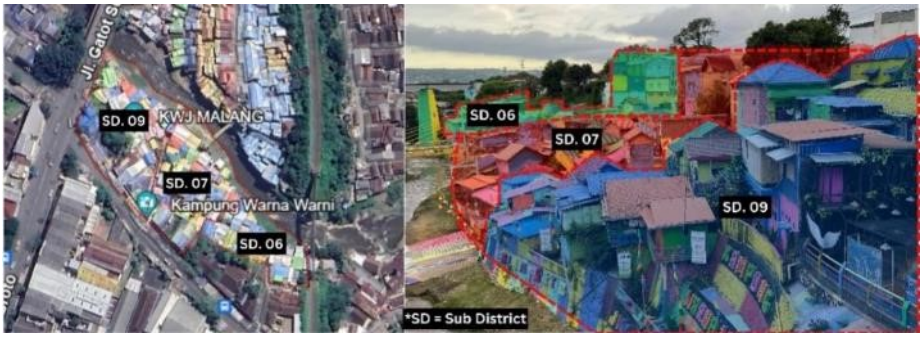


Figure 2: Location of Jodipan Colorful Village, Malang

The data collection included a questionnaire administered to 169 respondents aged a minimum of 17 years residing in Jodipan Colorful Village. The questionnaire comprised four parts including respondent characteristics (8), introductory questions (2), and quality assessment of livable built environments (10). The data analysis used mean score analysis and instrument testing including validity and reliability tests. This analysis aimed to show the quality of each sub-district and village based on residents' perceptions of physical aspects using a Likert scale depending on the mean score method. The Likert scale incorporated five levels of livable built environments quality satisfaction namely 1.00-1.79 (overly low quality), 1.80-2.59 (low quality), 2.60-3.39 (moderate), 3.40-4.19 (high quality), and 4.20-5.00 (very high quality). The analysis was expected to identify the most common and significant issues of physical aspects that possessed a moderate and bad influence on the quality of livable built environments in the village.

RESULTS AND DISCUSSION

Quality of Livable Built Environments in Jodipan Colorful Village Based on the Actual Physical Condition Assessments

Physical assessments were carried out using ArcGIS software to determine the scores for each physical parameter contributing to the quality of livable built environments. Weighting and calculation of values determined the classification of housing environment quality by adding up the value originating from the multiplication of the weights of each parameter which further influenced the value of the weight factor for each parameter.

Table 2: Analysis of Actual Conditions of Livable Built Environments' Quality

Variable	SD6		SD7		SD9		Summary
	Score	**Weight**	**Score**	**Weight**	**Score**	**Weight**	
Physical Aspects That Formed the Quality of Livable Built Environments							
Building Density	2.00	6.00	1.00	3.00	2.00	6.00	Moderate
Settlement Location	2.00	6.00	2.00	7.00	2.00	5.00	Moderate
Entry Road Width	1.00	2.00	1.00	2.00	1.00	2.00	Low
Road Surfaces Condition	3.00	6.00	3.00	6.00	3.00	6.00	Good
Vegetation	1.00	3.00	1.00	3.00	1.00	3.00	Low
Building Layout	1.00	1.00	1.00	1.00	1.00	1.00	Low
Building Roof Quality	3.00	3.00	3.00	3.00	3.00	3.00	Good
Livable Built-Environment Quality							
Sub-district Scale	27		25		26		Moderate
District Scale			26				Moderate

*Scoring test's interval value: (1.00) low; (2.00) moderate; (3.00) good
*Built-environment quality classification interval value: (15-25) low; (26-36) moderate; (37-45) good
SD6 (Sub-district 6), SD7 (Sub-district 7), SD9 (Sub-district 9)

Jodipan Colorful Village in general was classified as having moderate quality of livable built environments based on the physical condition assessments. Sub-district 7 had a lower score in the physical aspect assessment compared to other sub-districts, suggesting low quality of livable built environments in the area. Key aspects influencing built-environment quality included architectural conditions (Fitri, 2021; Atika, 2020; & Prabowo et al, 2021). Based on physical assessments using ArcGIS software, scoring, and weighting methods, positive influences were observed in road surface conditions and building roof quality (1.00), moderate influences in building density and residential location (2.00), and negative impacts in entry road width, shade trees, and building layout (3.00).

Residents' Perceptions of Livable Built Environments in Jodipan Colorful Village

Demographic profiling showed that 37.3% of respondents were aged 26-35 years with 30.2% aged 17-25 years. In terms of gender, female respondents accounted for 53.8% of the sample. In terms of domicile status and length of stay, 63.3% were native citizens, and 79.3% had resided in the village for over three years.

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Table 3: Respondents' Profiling

Variables	Variables	SD6	SD7	SD9	Total	%
Age	17-25	11	20	20	**51**	**30.2**
	26-35	9	26	28	**63**	**37.3**
	36-46	5	5	20	**31**	**18.3**
	46-55	4	6	10	**20**	**11.8**
	>55	2	2	0	**4**	**2.4**
Gender	Male	18	20	39	**78**	**46.2**
	Female	13	39	39	**91**	**53.8**
Domicile Status	Local Natives	25	37	44	**107**	**63.3**
	Comers	6	22	34	**62**	**36.7**
Length of Stay	<1 years	0	4	1	**5**	**3**
	1-3 years	5	15	10	**30**	**17.8**
	>3 years	26	40	67	**134**	**79.3**

SD6 (Sub-district 6), SD7 (Sub-district 7), SD9 (Sub-district 9)

Understanding the physical characteristics of built environments was critical for effective village development planning programs. Furthermore, Table 4 presented results based on seven physical aspects influencing the quality of livable built environments across sub-districts of Jodipan Colorful Village.

Table 4: Analysis of Livable Built Environments Quality Based on Residents' Perceptions

Variable	Mean Score			Validity Test	Reliability Test	Summary
	SD6	**SD7**	**SD9**			
Physical Aspects that Form the Quality of Livable Built Environments						
Building Density	2.9	2.69	2.9	0.615	0.765	Moderate
Settlement Location	2.96	2.23	2.37	0.563	0.765	Low quality
Entry Road Widht	2.48	2.18	1.91	0.581	0.765	Low quality
Road Surfaces Condition	4.22	3.86	3.7	0.380	0.765	Good quality
Vegetations	2.83	3.43	3.37	0.425	0.765	Moderate
Building Layout	2.45	2.6	2.75	0.666	0.765	Moderate
Building Roof Quality	4.00	3.95	3.96	0.345	0.765	Good quality
Livable Built-Environment Quality						
Sub-district Scale	3.06	3.03	3.03	0.859	0.765	Moderate
District Scale	3.19	3.19	3.19	0.687	0.765	Moderate

*Validity test's significant value at 0.05
*Reliability test's Alpha Cronbach Coefficient >0.6
SD6 (Sub-district 6), SD7 (Sub-district 7), SD9 (Sub-district 9)

In this context, respondents agreed that the overall quality of livable built environments was in the neutral/moderate category with an overall mean score of 3.19. Based on the results of the questionnaire analysis, the three sub-districts were classified as neutral environmental quality, suggesting neither good nor bad based on residents' assessments. Environmental quality based on public perception could be used as a method to persuasively explore the level of satisfaction and quality of environmental conditions. However, this would be with the limitation of results that were not isoform (equivalent) to all conditions in the world (Aslim et al., 2014). Seven indicators were further identified to contribute to significant differences in the quality of livable built environments

in sub-districts of Jodipan Colorful Village. The following key discoveries were based on physical aspects that formed the quality of livable built environments.

a) Residents' Perceptions of Building Density in Jodipan Colorful Village

Residents assessed the density of residential buildings in the three sub-districts as moderate. Sub-districts 6, 7, and 8 received a total mean score of 2.9, 2.69, and 2.9 respectively. These perceptions were formed due to adaptations formed while living in densely populated riverbank settlements. Internal factors such as experience and adaptation processes also shaped residents' perceptions in the interactions with the local environment (Simamora, 2008).

b) Residents' Perceptions of Settlement Location in Jodipan Colorful Village

Residential location in this village was rated as low quality across sub-districts. This assessment was influenced by indicators measuring how close residential blocks were to activity centers that could pose pollution or risk (Anugrah et al., 2021). Sub-districts 9 and 7 were areas directly affected by the flash flood disaster from Batu City and settlements along Brantas watershed including Jodipan Colorful Village which occurred on Thursday, November 4, 2021. Furthermore, sub-district 6 had the worst conditions because the location was at the very edge compared to 7 and 9 (Aru et al., 2018). Sub-district also bordered directly on sources of pollution and danger in the form of rivers and railroads.

c) Residents' Perceptions of Street Width in Jodipan Colorful Village

The width of the entrance to Jodipan Colorful Village was assessed as low quality with a score of 2.11. Specifically, sub-districts 6, 7, and 9 scored 2.48, 2.18, and 1.91 respectively. This assessment arose from the challenges in accessibility due to narrow roads ranging from 1 m to 3 m wide. Jodipan Colorful Village's contoured topography necessitated ramp-like circulation paths, accessible only to two-wheeled vehicles but not wheelchairs or four-wheeled vehicles (Bahar et al., 2019).

d) Residents' Perceptions of Road Surface Condition in Jodipan Colorful Village

The condition of the road surface was considered to be of good quality due to changes in the conditions when the village was still a slum and the current conditions after it became a tourist location. Before the village became a tourist location, the surface of the road was still dirt with some patches of cement leading to water pooling issues instead of proper drainage (Aru et al.,

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2018). Currently, 90% of road surfaces in sub-districts 6, 7, and 9 were paved or cemented. This improvement in road surface quality significantly influenced public perception of road attributes, shaped by internal factors such as experience, needs, and adaptation processes, as well as external elements including physical characteristics, color, or size (Simamora, 2008).

e) Residents' Perceptions of Vegetation in Jodipan Colorful Village

Residents possessed the perception that the shade trees in the village and sub-district were of moderate quality. Sub-district possessed a protective tree score of 3.43 which was in the good quality category. This was due to the availability of open spaces in the form of lush trees in sub-district 7. Furthermore, sub-districts 6 and 9 showed moderate quality assessments because the available vegetation was only filled with ornamental plants in the form of pots in each resident's house, which was considered sufficient.

f) Residents' Perceptions of Building Layout in Jodipan Colorful Village

Building layout showed a moderate quality rating in the village. Residents perceived the arrangement of houses as moderately orderly, influenced by the natural contours of riverside villages. Due to the absence of clear regulations governing settlement planning, residential areas along waterways often became congested and disorganized (Suprijanto, 2002). Residents' perceptions adapted to the arrangement of buildings which tended to be irregular, normalizing the local settlement patterns.

g) Residents' Perceptions of Building Roof Quality in Jodipan Colorful Village

The quality of building roofs was rated as a good quality category in all sub-districts. This was due to changes in the type of roof material before and after it became a tourist location. The quality of building roofs used permanent types of materials in the form of cast roofs or tile and galvalum roofs. The public feels safe regarding the change in the type of permanent roof covering, which influenced the perception in assessing the quality of the building roof. Self-defense was identified to be an internal factor shaping perceptions (Simamora, 2008).

Comparison of Livable Built Environments Quality Assessment Based on Actual Physical Condition and Residents' Perceptions

There were similarities and differences in quality assessments of physical aspects and overall settlement quality between actual conditions and residents' perceptions. This comparison was presented in Table 4 for proper understanding.

Table 5: Comparison of Livable Built Environments Quality

Variable	SD6		SD7		SD9		Summary
	PA	**RP**	**PA**	**RP**	**PA**	**RP**	
Physical Aspects that Form the Quality of Livable Built Environment							
Building Density	M	M	L	M	M	M	Gap
Settlement Location	M	M	M	L	M	L	Gap
Entry Road Width	L	L	L	L	L	L	Same
Road Surfaces Condition	G	VG	G	G	G	G	Same
Vegetations	L	M	L	G	L	M	Gap
Building Layout	L	L	L	M	L	M	Gap
Building Roof Quality	G	G	G	G	G	G	Same
Livable Built-Environment Quality							
Sub-district Scale	M	M	L	M	M	M	Gap
District Scale	M						Same

*PA (Physical Assessment), RP (Residents' Perception)
*M (Moderate Quality), L (Low Quality), G (Good Quality), VG (Very Good Quality)
*SD6 (Sub-district 6), SD7 (Sub-district 7), SD9 (Sub-district 9)

In this study, the aspects of building density, shade trees, and layout showed differences with residents rating these aspects as moderate to good. This was performed despite physical assessments classifying the aspects as moderate and poor. The aspect of residential location also showed different assessments where the people of sub-districts 7 and 9 rated the location as poor while physical assessments categorized the aspects as medium.

Many residents in sub-district 7 held a negative perception in assessing the quality. 90% classified the quality of residential environment as poor based on physical assessments while residents' perceptions rated it as medium quality. A discrepancy was evident in residential environment quality of sub-district 7 where residents assessed the quality as moderate. However, this was contrary to the results of the physical assessment where residents in sub-district 7 were classified as poor. The concept of adequate housing referred to the physical condition of the environment as evaluated by individuals, assessing housing conditions quality (Heylen, 2006).

Respondents' assessment of environmental quality based on physical aspects using the mean score method shows good quality in road surface condition and building roof quality (3.40-4.19). The physical aspects with a moderate rating are the variables building density, protective trees, and the layout ranging from 2.60 to 3.39. Furthermore, poor ratings are observed in the variables of residential location and entry road width with 1.80 to 2.59 scores. The quality of residential environment depends on environmental variables influencing the quality of the environment including physical and socio-cultural variables (Rapoport, 1983). These results implied that sub-districts with the highest level of quality comprised two essential physical aspects, namely road surface condition and building roof quality. However, the remaining sub-districts 7 and 9 both show relatively moderate performance levels of 3.03. The difference in assessment results in residents' perceptions and the quality of livable built

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environments actual condition in Jodipan Colorful Village is due to the subjectivity of perception and each individual has a different point of view. Individual historical experience factors, attitudes, values, social norms, societal environmental conditions, culture, needs, hopes, and personality will influence residents' perceptions of the aspects (Notoatmodjo, 2005). Hence, the community concluded that environmental responsibility should play a central role in responsible tourism and consulted experts in conservation and environmental management for advice (Rasdi *et al*., 2023)

CONCLUSION

In conclusion, livable built environments in Jodipan Colorful Village were classified as medium quality based on actual physical conditions assessed using ArcGIS software, scoring, and weighting methods. Sub-district 7 scored 25 showing low quality while sub-districts 6 and 9 were classified as moderate, scoring 27 and 26, respectively. Residents' perception assessments rated the quality of all three sub-districts as medium with sub-district 6 having the highest mean score of 3.06. Residents further evaluated road surface condition and building roof quality to be good while building density, protective trees, and building layout were observed to be moderate. Settlement location and driveway width also were perceived as poor. The perception influenced residents' perception in assessing each attribute of the physical aspects that formed the quality of livable built environments. Additionally, internal factors such as living experience and adaptation also influenced residents' perceptions in assessing the quality of the village. Changes in physical conditions from when it was a slum village to now being a tourist location also played a role in forming new perceptions to assess the quality of livable built environments in Jodipan Colorful Village.

The quality of livable built environments in this village showed different results between actual physical conditions and residents' perception assessments. Differences were noted in building density, residential location, protective trees, and building layout. This gap arose because perception was subjective, leading to different views despite seeing the same object. Differences in residential environment quality classifications based on actual physical conditions and residents' perceptions could serve as an evaluation to improve residential environment quality in Jodipan Colorful Village.

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DISCLOSURE STATEMENT

The author declares that there is no conflict of interest in this research.

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COMMERCIAL URBAN AGRICULTURE BUSINESS MODEL STRATEGIES: CITY PROXIMITY AND THE CHOICE OF VALUE PROPOSITIONS

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Abstract

Driven by urban residents, urban agriculture is advancing Commercial Urban Agriculture (CUA). As CUA evolves within unique geographic and urban settings, there is a necessity to explore sustainable business models. This research employs the Business Model Canvas (BMC) to analyse Malaysia's urban agriculture models, assisting practitioners and policymakers in understanding CUA sustainability. The study reveals that Malaysia's CUA mainly adopts low-cost specialisation, differentiation, and diversification strategies to remain competitive. Distinctive strategies, like organic branding and targeting upscale consumers, bolster farms' market positions. Beyond selling produce, these urban farms enhance their revenue by offering educational programs, food experiences, and leisure activities, thus broadening their economic base. Effective marketing and customer relations cultivate loyalty. Crucially, the findings establish a direct, empirically-driven link between the farm's geographic location (urban vs. peri-urban proximity) and its choice of value proposition strategy, underscoring the significance of spatial planning in CUA's success. This analysis highlights the varied strategies within CUA, emphasising its potential for innovation and long term sustainability.

Keywords: Commercial urban agriculture, urban agriculture, low-cost specialisation; differentiation, Business Model Canvas (BMC).

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INTRODUCTION

The rapid expansion of the global population puts a strain on the availability and quality of food, intensifying the worldwide food security crisis (Noraini Omar Chong et al., 2024). Given the United Nations' forecast of 840 million people experiencing food insecurity by 2030, this issue demands urgent international attention. Governments are turning to Urban Agriculture (UA) to modernise farming and build greener cities, encouraging young entrepreneurs to bring fresh energy and tech-savvy ideas to the field (Pölling et al., 2016; Talib, 2019). Malaysia joined this movement with the Green Earth Program and financial incentives to support urban farmers. Recent policies focus on using technology, attracting younger talent, and upgrading infrastructure, all aiming to grow high-value, sustainable commercial urban agriculture (CUA) businesses and create better jobs (Department of Agriculture, 2016; MAFI, 2021). Crucially, this pivot is essential, as rapid Malaysian urbanisation characterised by agricultural land loss and a diminishing rural workforce acutely threatens national food security (Marzuki and Jais, 2020)

However, the successful implementation of CUA policies requires filling strategic knowledge gaps, as business models are central to its success. Recognising that business models are central to CUA's success, researchers have explored which models thrive in different urban settings, since factors like population density and local business climates shape these choices (Liu, 2015; Pölling et al., 2016, 2017; Robinson et al., 2017; Van der Schans, 2010, 2015; Van der Schans et al., 2016; Zasada, 2011; Mougeot, 2000). It has overlooked the critical, granular relationship between a farm's specific geographic proximity (urban vs. peri-urban) and its choice of value propositions in the context of rapidly developing Southeast Asian cities. Therefore, this study examines how Malaysian urban farms adapt with competitive business models, aiming to answer who their customers are, what those customers value, and how farms can deliver value at the right cost (Casadesus-Masanell and Ricart, 2010). The goal is to suggest targeted interventions to strengthen CUA.

This study offers practical insights for policymakers, investors, and entrepreneurs on choosing effective urban agriculture (UA) business models suited to Malaysia's unique context. By examining how different strategies work within Asia's diverse ecosystem, it fills key research gaps and builds on global business model literature (Casadesus-Masanell and Ricart, 2010). The paper is structured as follows: Section 2 presents the theoretical framework, Section 3 covers research design, Section 4 discusses results, Section 5 explores implications, and Section 6 concludes.

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THEORETICAL FRAMEWORK: URBAN AGRICULTURE BUSINESS MODEL

More than just producing food, UA focuses on creative business strategies that enable farms to thrive in urban environments (Boons and Lüdeke-Freund, 2013). A business model explains how farms create, deliver, and capture value (Osterwalder and Pigneur, 2010), making it vital for success. As UA grows worldwide, researchers have identified several key business models (Van der Schans et al., 2016). Initially, three primary categories were established: low-cost specialization, differentiation, and diversification. Two supplementary categories, "the commons" (centered on shared ownership) and "experience" (focused on social or ecological benefits), were later incorporated to broaden the scope of the framework

Key Business Models

- Low-cost specialisation: Farms focus on a few high-value crops, like fresh fruits and vegetables, aiming for efficiency and lower costs (Gardner, 1994). This model works best on the urban edge where space allows for scale (Busck et al., 2006).
- Differentiation: Urban farms offer unique or niche crops and keep supply chains short, building direct relationships with customers and allowing premium pricing (Van der Schans, 2010). Vertical integration—from growing to processing and marketing is key.
- Diversification: Farms combine food production with services like education, leisure, or tourism, creating multiple income streams (Bryant et al., 2013). This model is popular as urban land gets scarcer and supports multifunctionality (Van der Schans, 2010).

Other models include shared ownership or “the commons,” and farms that prioritise social, ecological, or sensory experiences (Van der Schans, 2015). Researchers have also noted “innovative” and “experimental” models, characterised by advanced techniques and new marketing approaches (Pölling et al., 2015). However, these often blend with the main types above.

In summary, most urban farms rely on low-cost, differentiated, or diversified models to compete and adapt in a challenging city landscape, often mixing elements to suit their needs.

RESEARCH METHODOLOGY

Research Design

To investigate urban farm business models, this study used multiple qualitative case studies and semi-structured interviews (Yin, 2018). This method effectively

captures urban farmers' experiences and supports the exploration of new business model narratives (Merriam and Tisdell, 2015).

Framework and Interview Questions: The Business Model Canvas

This study used the Business Model Canvas (BMC) to analyse urban farm business strategies, following established frameworks (Zott et al., 2011; Lambert and Davidson, 2013; Osterwalder and Pigneur, 2010). The BMC's nine building blocks (customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, partnerships, and cost structure) guided the semi-structured interview questions. To ensure relevance and validity, questions were reviewed by subject experts, and ethical clearance was secured from the University Malaya, Malaysia Research Ethics Committee (UMREC). Informed consent was gained from all participating urban farmers prior to their inclusion in the study, and efforts were made to preserve their confidentiality.

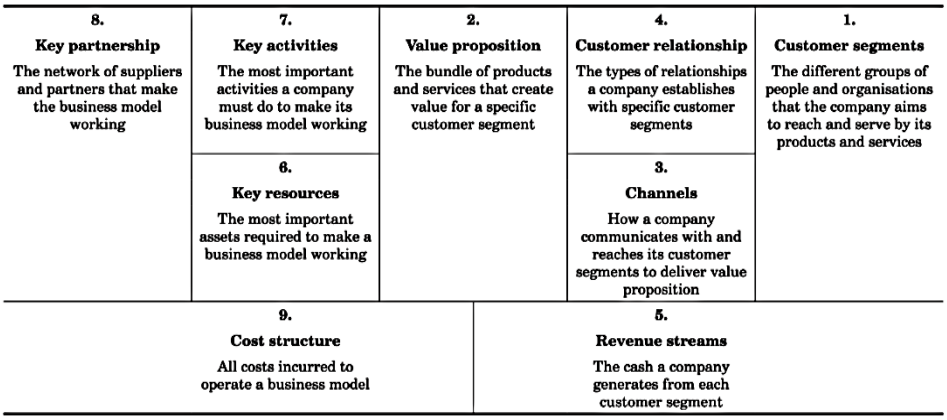


Figure 1: The Business Model Canvas (BMC) with its nine building blocks
Source: Osterwalder and Pigneur (2010)

Sampling

Commercial urban agriculture (CUA) involves farming in urban or peri-urban areas to generate income from agricultural products and services (Sroka et al., 2021). Also called "professional UA" (Pölling et al., 2016) or "metropolitan agriculture" (Heimlich, 1989), this model is relatively new in Malaysia, where there is no central record of farm locations. This study used purposive sampling to include farms from both urban and peri-urban areas, especially in the Klang Valley—the country's largest urban centre and a leader in UA policy (Mohamad Shukor, 2020; Shahbaz et al., 2016). Farms needed at least one year of experience. The sample was built using online searches, conventions,

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recommendations, and help from MARDI. Out of 21 contacted, 16 farm owners agreed to participate, with 14 based in urban and 2 in peri-urban locations.

Data Collection and Analysis

Data were collected through face-to-face and online interviews with farm owners, necessitated by pandemic restrictions (Patton, 2015). Rapport was established beforehand via WhatsApp and phone calls. Interviews were recorded and transcribed verbatim. Thematic analysis followed Braun and Clarke's (2006) six steps, with Nvivo software supporting coding and peer review ensuring rigour (Creswell and Poth, 2018).

ANALYSIS AND DISCUSSION

Results and Discussion

The analyses involved 16 commercial urban farms in Malaysia (see Table 2), with 14 farms emerging from the urban and 2 peri-urban areas, respectively. Of the 16 farms, 2 were low-cost farms, eight were differentiated farms and 6 were diversified farms. While the differentiated and diversified farms concentrated their activities on the nearby densely populated areas, the low-cost farms' locations have smaller population densities. The average farm sizes and jobs is greater in low-cost farms, followed by diversified and differentiated farms. For annual average sales, the earnings are almost comparable for both low-cost and diversified farms despite the smaller size of diversified farms. This is because diversified farms can charge higher prices on their tradable and non-tradable high-end products and services. The organic farming technique is apparent in most farms, with both the low-cost farms interviewed relying on soil-based organic farming. For the differentiated farms, an indoor vertical farming technique was popular, while the diversified farms exhibited a preference for indoor hydroponic and aquaponic farming techniques.

Table 2: Key Characteristics of the Interviewed Urban Farms

Key Characteristics	Low-cost specialised farms	Differentiated farms	Diversified farms
Number of farms	2	8	6
Average farm size [Sq. ft]	1,001,980.00	976.00	16,603.33
Average number of jobs [full-time equivalent]	30	3	6.17
% of average job intensity [(number of jobs/Sq. ft) x 100]	0.003	0.3	0.04

Key Characteristics	Low-cost specialised farms	Differentiated farms	Diversified farms
Average annual sales [RM]	1,900,000.00	503,000.50	1,800,261.33
Technique/System [number of farms]:			
Conventional	-	1	-
Indoor farming	-	7	3
Vertical farming	-	6	1
Hydroponic	-	4	3
Aquaponic	-	1	3
Organic	2	3	4
Biodynamic	1	-	-
Permaculture	-	-	1
Precision farming	-	1	1

Note: Total 16 farms: 14 urban farms and 2 peri-urban farms *Source: Authors' elaboration*

Table 3 classifies the urban farms into "low-cost specialisation," "differentiation," and "diversification" business model. Analysis of the nine segments of BMC clearly show that urban farms, while having their foci, are taking advantage of their resource endowments to capture features of different business models to diversify their revenue streams. The detail synthesis of low-cost specialised, differentiated and diversified farms is presented in the following sub-subsections.

Table 3: Synthesis of Low-Cost Specialised, Differentiated and Diversified Farms

	Low-cost specialised farms	Differentiated farms	Diversified farms
Customer segments	- Organic food/vegetable wholesalers - Families/Youth requesting leisure/recreational activities - Children willing to learn farming and explore vegetables	- Hotels - Fine-dining restaurants - Catering companies - Restaurants - Organic conscious households - Corporate & female clients requesting interior landscape - Organic shops/retailers	- Restaurants - Families seeking quality family time - Children seeking fun farm activities - Young couples - Wholesalers - Urban farmers (professional, community & hobby) - Organic shops - Export orientation - Farm equipment suppliers/vendors - Education institutions

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	Low-cost specialised farms	Differentiated farms	Diversified farms
Value proposition	- Organic vegetables - Fresh vegetables - Clean environmental practices (biodynamics) - Experience connection with nature - Accessibility to green landscape - Own organic branding	- Freshness - High-quality organic vegetables (organic branding) - Close customer relationship - Competitive price - Lower risk (lower product default and greater shelf life) - Convenient location - Product variety - Fast delivery - Customer experience (pick own vegetables) - On-demand vegetable cultivation service	- High-quality organic vegetables - Close customer relationship - Newness of concept - Competitive price - Environmentally friendly products & processes - Convenient location - Organic brand - Product variety - Customer experience (ambience, activities, self-service & service quality) - Community bonding - Education
Channels	- On-farm - Organic food/vegetable wholesalers - Supermarkets - Small sellers	Direct - On-farm - Web sales - Facebook shop - Famer's market - Sales during events Indirect - Supermarket - Distributors - Stockiest - Organic store - Online grocer	Direct - On-farm - Own store - Web sales - Facebook shop - Famer's market - Sales during events - Mobile application Indirect - Organic store - Online grocer
Customer relationship	- Personal to organic food/vegetable wholesalers - Personal assistance for recreational/leisure activities	- Personal assistance (individual basis) - Self-service - Co-creation - Offering club membership - Social media community (Facebook & Instagram)	- Personal assistance (individual basis) - Dedicated personal assistant - Self-service - Social media community (Facebook & Instagram)
Revenue streams	- Direct sale (wholesalers) - Fees for services (leisure & recreational)	- Direct sale - Short supply chain - Partial sales to other buyers of the value-added chain	- Product sales - Fees for services (leisure, recreational, education & training)

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	Low-cost specialised farms	Differentiated farms	Diversified farms
	- High turnover per farmland unit		
Key resources	- Land - Modified farming technique/method - Irrigation infrastructure	- Land - Farm infrastructure - Strong partnership (trust) - Networking - Knowledge - Business plan (competitive edge) - Modified farming technique/method - Workers - Financial - City proximity	- Land - Farm infrastructure - Strong partnership (trust) - Networking - Business plan (competitive advantage) - Modified farming technique/method - Workers - Financial - City proximity
Key activities	- Production of local organic vegetables - Composting - Educational tours - Camping activities - Direct sales - Vegetable product combo	- Agricultural activities (microgreens, edible flowers, local & special vegetables, seafood, livestock, edible plants and ornamental plants) - Product sale from own farm (including vegetable basket) - Product sales from other suppliers - Educational services (talks & book authorship) - Farm/herbs garden setting-up service - Sale of portable home farming system	- Agricultural activities (microgreens, local & special vegetables, seafood, edible plants, & heirloom plants) - Product processing (organic sauces & fruit jam, pickling, dried fruits, healthcare products & farm equipment and materials - Product sale from own farm - local craft & souvenir - Educational services (training, workshops, entrepreneurship programs & book authorship) - Setting up farms and therapy gardens - Rent a field - Farming system and supplies - Restaurant - Composting - Heritage projects
Key partnership	- Coopetition: Organic wholesalers - Buyer-supplier relationship: Seeds, input providers for organic fertilizer & farming equipment	- Strategic alliances: Hotels, retailers & vendors - Coopetition: Vendors - Buyer-supplier relationship: Seeds, fertilizers, organic	- Strategic alliances: local entrepreneurs & agencies. - Coopetition: competitor - Buyer-supplier relationship: Seeds, fertilizers, organic products, suppliers & farming equipment

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	Low-cost specialised farms	Differentiated farms	Diversified farms
		products, edible plants, ornamental plant suppliers, LED grow light & farming equipment	- Plastic industry - Professional urban farmers - Government - Associations
Cost structure	- Fertilizer - Irrigation system - Wages	- Seeds - Fertilizer - Utilities (water, electricity & rental) - Wages - Product packaging - Grow mat - Planting pot - LED grow light - Farming system & infrastructure	- Seeds - Fertilizer - Utilities (water, electricity & rental) - Fish feed - Wages - Product packaging - LED grow light - Farming equipment & materials - Farming system & infrastructure - Water filtration system

Source: Authors' elaboration

Low-Cost Specialised Farms

The location of low-cost specialised farms plays a pivotal role in their operational success, with many strategically situated at the urban periphery to optimise both spatial resources and proximity to consumers. These enterprises typically concentrate on the cultivation of high-value organic vegetables for a niche market, establishing robust relationships with wholesalers who contribute to efficient production planning and uphold stringent quality standards.

To stimulate future demand, select farms have diversified their activities by integrating agrotourism initiatives—such as offering camping facilities and culinary experiences utilising farm produce—while others deliver training programmes aimed at educating local stakeholders about organic agriculture and fostering investment partnerships. The ability of these farms to diversify is closely linked to the characteristics of their land; those endowed with scenic landscapes are more likely to engage in tourism-related ventures, whereas others emphasise training and collaborative models.

Despite the increased costs associated with organic farming methods—including investments in sustainable practices, infrastructure, and labour—these farms remain committed to ecological stewardship and the consistent delivery of high-quality produce. Central to their approach are strategies centred on community engagement, sustainability, and continuous innovation.

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Differentiated Farms

Figure 2 shows the key features of differentiated farms. Differentiated urban farms achieve success primarily through direct sales to consumers, hotels, and restaurants, utilising on-farm transactions and online platforms as principal distribution channels. By prioritising high-value crops such as microgreens and speciality vegetables, these operations cater to the distinct preferences of chefs and health-conscious clientele who are inclined to invest in superior freshness and quality.

The cultivation of close relationships is pivotal in this business model. Farms engage directly with chefs and households, tailoring produce offerings and providing distinctive experiences, including on-site farm visits. Their strategic placement within affluent neighbourhoods or urban centres enables these farms to attract customers who seek a diverse selection of organic products. Additionally, many farms expand their product range by retailing supplementary organic goods, thereby enhancing their market position.

The onset of the COVID-19 pandemic compelled many farms to accelerate their adoption of digital sales channels, and the resilience of their established customer relationships facilitated a swift post-pandemic recovery. Despite incurring elevated operational costs—particularly investments in specialised infrastructure and premium seeds—these farms distinguish themselves through continuous innovation, strategic collaboration, and the cultivation of loyal partnerships within niche markets.

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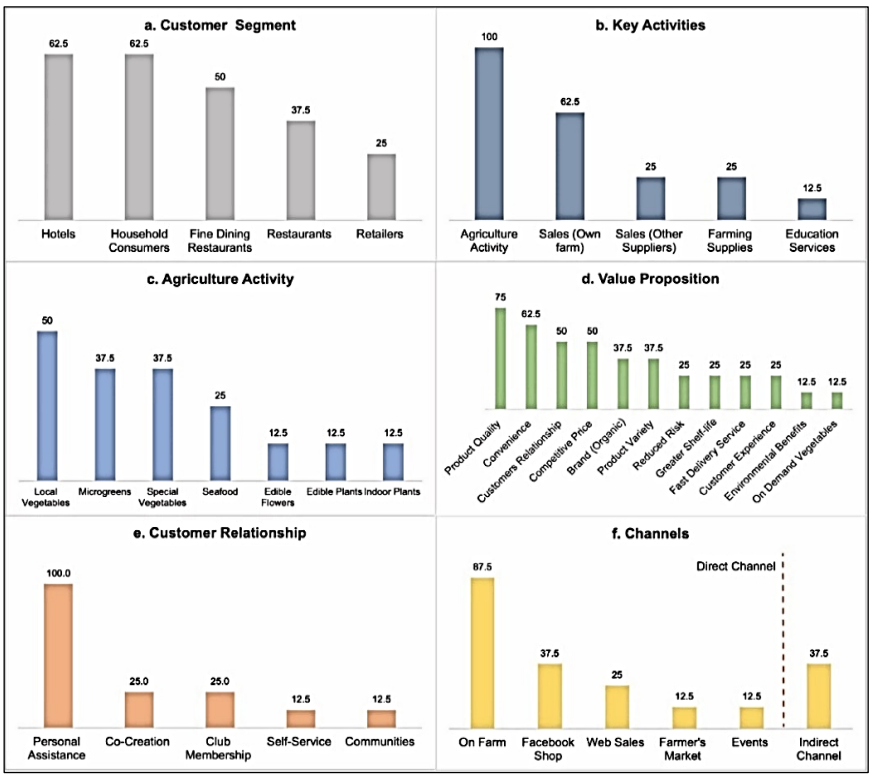


Figure 2: Key features of differentiated farms
Source: Interview and fieldwork

Diversified Farms

Diversified urban farms in Malaysia expand beyond crop production by offering business services—especially education, gastronomy, and leisure—which create economic and social value. Education is central: farms run training sessions and structured entrepreneurship programs, often collaborating with universities, hospitals, and NGOs to promote urban agriculture. These initiatives foster community engagement, equip aspiring growers, and encourage health-conscious habits. Gastronomical experiences, such as farm-to-table restaurants set in tranquil, out-of-city locations, allow families to enjoy organic food and participate in farm activities. These venues embrace sustainability through zero waste practices and recycled materials, while also providing unique experiences like petting zoos and hands-on workshops. By diversifying services, farms reach new markets and encourage innovation in equipment and processes, often partnering with suppliers to manage costs. This multi-faceted approach not only strengthens buyer-supplier relationships but ensures continued relevance in a niche market. Ultimately, diversified urban farms succeed by blending education,

culinary experience, and sustainable practice, positioning themselves as resilient, community-focused businesses despite high initial investments.

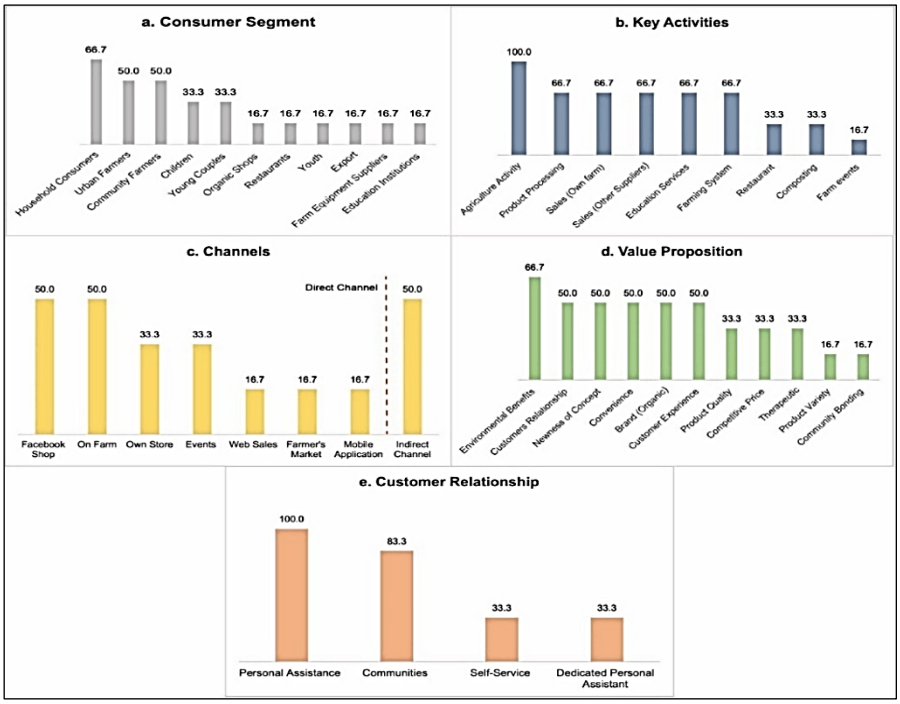


Figure 3: Key features of diversified farms
Source: Interview and Fieldwork

Managerial and Policy Implications

Drawing on these findings, we propose targeted policy and managerial strategies to unlock urban agriculture's potential. Policymakers are encouraged to pilot recommended measures and strengthen the sector's impact.

Low-Cost Specialised Farms

Low-cost specialised farms in Malaysia combine large-scale production with agritourism, leveraging peri-urban locations near tourist attractions to reach families and capitalise on local demand. These farms use soil-based organic methods, producing vegetables noted for their flavour and nutrition, and often offer educational experiences for visitors.

To address infrastructure and operational costs—such as irrigation on challenging terrain and manure management for animal farming—government support and public-private partnerships are essential. Expanding into local fruits, animal products, and on-site farmers' markets can further draw visitors and

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diversify income. Involving the Federal Agricultural Marketing Authority (FAMA) can help with marketing and distribution, while direct engagement in farmers' markets builds brand loyalty and strengthens connections with consumers.

Overall, these farms succeed by linking production scale with tourist experiences, fostering innovation, and collaborating across sectors to boost competitiveness and resilience in the urban agriculture sector.

Differentiated Farms

Differentiated farms are poised to feed growing urban populations and boost agribusiness exports. To shift from small-scale models to innovative plant factories—especially in urban centres—government support is essential, including grants, subsidies, and access to underutilised facilities. These farms thrive by focusing on high-value crops for premium markets, maintaining direct customer relationships, and embracing new technologies like AI to enhance the customer experience. Professional training and strategic partnerships are needed for export success, given that many farmers are self-taught. Notably, differentiated farms adapted well during the COVID-19 pandemic by offering contactless and cashless services. Their business models must deliver unique, hard-to-replicate value to remain competitive (Zott and Amit, 2008; Teece, 2010).

Diversified Farms

Diversified farms in Malaysia focus on transforming their agricultural produce into unique, high-value products, often pairing this with leisure and gastronomic experiences for urban residents. While funding for large-scale research and development is limited, government support—such as grants, partnerships with local enterprises and universities, and export promotion—can drive innovation and quality improvements. Strategic location planning within cities is key to accessibility and brand differentiation. These farms also provide training and serve as hubs for community-supported agriculture, linking local engagement with food security and profit potential. To sustain growth and avoid supply disruptions, collaboration between farms, policymakers, and training providers is essential. Although COVID-19 posed challenges for on-site research, adherence to strict methodology and data triangulation helped ensure reliable findings. Diversified farms thus play a vital role in urban agriculture's resilience and innovation (Zott and Amit, 2008; Teece, 2010).

CONCLUSION

This paper uses the BMC to analyse how CUA creates, delivers and captures value. Key findings of the study are as follows: First, organic branding and

targeting of high-end consumers are essential business strategies for differentiated and diversified farms. This strategy allows the farms to remain competitive while fetching higher profits and innovating to offer high-value products and services. Second, location is central for all business models to expand their revenue stream. While low-cost farms prefer peri-urban areas to experience scale economies, differentiated and diversified farms favour sites closer to cities and towns to expedite economies of scope through networking and unique business propositions. Third, farms from all three categories exhibit close customer relationships and use multi-channel marketing strategies to deliver quality and convenience value propositions. Lastly, a major farming diversification strategy is via educational services, recreation retreats and gastronomical experiences.

The study contributes to policy experimentation and provides useful managerial implications. The study creates an avenue for future research to develop a structured questionnaire covering a larger sample to comprehensively evaluate the commercial agriculture business models. This study provides an exploratory background, and it is limited to the selected case study.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal connections that might have influenced the research presented in this publication.

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DETERMINING FACTORS OF CORE VALUES (AKHLAK) IN INDONESIAN CONSTRUCTION

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Abstract

State-Owned Enterprises (BUMN) are companies owned by the government of the Republic of Indonesia to support economic growth which is a basic human need, and also support government programs in all sectors. In order to improve the Indonesian government's program, the BUMN Service encourages increased company performance along with all its supporting resources. One of the performance driving mottos is AKHLAK which is abbreviated as AKHLAK which each has 6 component factors. This study aims to see various problems in various aspects of the 6 main components of AKHLAK. This research method uses qualitative analysis to process data from various library sources. Differences and correlations that were analyzed in this study were processed using data that was produced by pad with 50 respondents using SPSS version 24.0. The results of the discussion above, if viewed as the 10 highest determining factors in sequence of Core Values, are X1.3 (morality), X1.9 (transparency), X2.4 (knowledge), X4.6 (manifesting), X4.5 (thinking), X4.3 (obedience), X4.2 (sacrifice), X1.1 (commitment), X1.2 (responsibility), and X6.5 (process).

Keywords: Core values, AKHLAK, Badan Usaha Milik Negara (BUMN), Indonesian Construction

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INTRODUCTION

According to Primanto and Undang (2022), the existence of good physical infrastructure such as roads, bridges, telecommunications, electricity, irrigation and transportation is also often linked as a trigger for development in various fields in a region. We can easily evaluate differences in welfare in a region by observing infrastructure gaps. The goal of development is basically to create progress in the economic sector and sustainable business capabilities, without ignoring equal rights and upholding the principles of justice. the Indonesian nation as a whole. Infrastructure development is included in physical development and is included in it. Perennial evidence which highlights that availability of good infrastructure, has significant contribution to intense development and meeting of fundamental community necessities such as food, cloth, shelter, education, and health.

Construction activities across Indonesia have supported infrastructure development that enables these other economic sectors including agriculture energy tourism manufacturing and more. The construction industry confronts various issues from internal and external sources that affect BUMN Contractor companies during their operations. Worsening problems exist because some stakeholders lack awareness of the understanding needed to tackle issues including Human Resources (HR) competency problems in projects leading to late implementation timeframes and growing budgets and declining quality metrics (Budiwibowo et.al. 2009; Mairizal. 2021; Hasim & Salleh, 2024; Fuzi et, al. 2024).

In this research, we try to find out the problems that occur and are related to the understanding of several parties about the strategies for the execution of Civil Engineering Infrastructures in Indonesia which is carried out directly by Construction Services Companies owned by the Government of the Republic of Indonesia in the form of State-Owned Enterprises (BUMN). In the process of fixing various problems in human resources, the Minister of BUMN, Mr. Erick Thohir, officially established morals as the core value of BUMN on Wednesday (1/7/2020). The establishment of AKHLAK as the core value of BUMN coincided with the event to change the logo and slogan of the Ministry of BUMN (Kompas, 2020).

LITERATURE REVIEW

Badan Usaha Milik Negara (BUMN)

State-owned enterprises (abbreviated as BUMN), formerly known as state companies (abbreviated as PN), are companies that are owned either wholly, mostly, or in small part by the government and the government gives control over them. What distinguishes BUMN from other government-owned agencies is the legal status, operational nature, activities, and objectives of its operations. Although BUMN plays a role in implementing public policy (for example, a

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state-owned railway company aims to facilitate public access and mobility), BUMN must be distinguished from ministries, non-ministerial government institutions, non-structural, and public service agencies because they have the status of a private corporate nature or those that stand independently to seek profit. (Wikipedia, 2024).

State-Owned Enterprises or Badan Usaha Milik Negara (BUMN) in the form of Limited Liability Companies (PERSERO) as referred to in Government Regulation Number 12 of 1998 and Public Companies (PERUM) as referred to in Government Regulation Number 13 of 1998. State-Owned Enterprises (BUMN) are one of the important economic actors in the national economy, which together with other economic actors, specifically, the private sectors (large-small and domestic-foreign) and cooperatives serve as epitome of the form of economic democracy that will be further evolved and enriched in gradual and steady manner.

BUMN is a business entity whose capital is at least fifty one percent owned by state capital through direct investment coming from separated state equity. Persero is a BUMN in the form of a limited liability company which its capital is in the form of shares of stock in which the Republic of Indonesia directly or indirectly holds all or at least fifty one per centum (51%) of the capital stock and has primaery aim of making profit. PERUM is a BUMN whose capital is wholly owned by the state but does not incorporate a capital of shares, and whose operations are for the public interest to offer goods/ services which are quality in the market while at the same time it gains profit by implementing the principle of management (President RI, 2003).

Core Values

Core values are principles that are held firmly by a person or organization. What is expected from these values will determine how a person behaves and interacts, both in everyday life and in the workplace. From another opinion, it is said that the main values or core values are principles that are held firmly by every individual and organization. Core values are important to identify considering that these values will determine how you interact and behave, both in everyday life and in the workplace.

For this reason, the Core Values for all BUMN Personnel through the Circular of the Minister of BUMN Number SE-7/MBU/07/2020 concerning the Core Values of Human Resources of State-Owned Enterprises. That is why the Core Values for all BUMN Personnel have been established in the Circular of the Minister of BUMN Number SE-7/MBU/07/2020 on Core Values of Human Resources of State-Owned Enterprises. AKHLAK is expected to be the identity and glue of work culture that supports sustainable performance improvement and supports the achievement of the objectives of the BUMN Human Capital

Transformation program, namely BUMN as a creator of talent and a company that is able to compete globally (BUMN & FHCI, 2022).

Pope and Wæraas (2023) stated that core values cannot deliver on their promise — defining company culture and guiding workers' decisions — if nobody remembers them. To fix the problem, companies are typically advised to double down on communication. The usual advice is to post the core values in even more places and mention them more often in reports and meetings. The hope is that, with enough repetition, the core values will eventually be drummed into everyone's skull. But for most companies, the battle was lost before it began. Workers simply cannot be expected to remember a laundry list of generic, taken-for-granted assumptions like honesty, integrity, accountability, and responsibility — the unmemorable words and phrases that make up most core values statements.

AKHLAK

BUMN AKHLAK is a behavioural guide for every human resource (HR) from companies under the Ministry of State-Owned Enterprises (SOE) or Badan Usaha Milik Negara (BUMN) to be implemented in daily behaviour and form a work culture within the BUMN environment. AKHLAK is an abbreviation of several factors, namely Trustworthy, Competent, Harmonious, Loyal, Adaptive and Collaborative. Core values are principles that are held firmly by a person or organization. Core values are important to identify considering that these values will determine how you interact and behave, both in everyday life and in the workplace (BUMN, 2022).

AKHLAK Culture Journey is an important indicator of the realization of BUMN with character and actualized in the behavior of its leaders and all employees where every action is based on AKHLAK values. The implementation of AKHLAK will not be successful without commitment and serious efforts from all BUMN Group Personnel. In addition, an evaluation is needed so that the implementation of AKHLAK can be planned and implemented properly. My hope is that this AKHLAK Culture Journey is like a roadmap for BUMN in transforming the company's culture so that it is in line with core values and supports sustainable performance improvement (BUMN & FHCI, 2022).

Below is an explanation of the six factors that form the basis of Core Values, abbreviated as AKHLAK.

Trustworthy

There are many definitions of trust. According to Munn (1995), is a decision to expose one to another and or rely on another with expectation of accruing a positive income in the process. However, Wood and McDermott (1999) defined trust as the extent to which one individual is prepared to depend on others, to take action based on the expectation that others will perform a particular way, thus

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making the individual vulnerable to the actions of the others being relied on. According to Shaw (1997), trust is not just confidence but not faith either. He then goes further to define trust as an assured confidence that those on whom reliance is placed will meet the expectation of the truster regarding the trusted (Andi et.al. 2008).

Trustworthy is an important component in human life, both personally and professionally. It can be observed that employees who trust can cut overhead costs, thereby increasing the experience that develops towards organizational citizenship behaviour (Srivastava and Mohaley, 2022; Fischer et al., 2020). Trust is also one of the factors that play a role and always offers the opportunity to look positive at work, for example, employee relations, negotiating, and communicating (Taylor et al., 2023).

Competent

Looking at several competency factors (Mairizal et.al. 2020), it would be evident that the last Project Manager competency factor helps in monitoring the progress of project performance from completion to performance. The stakeholders involved in the development of this EPC project must be in a position to challenge each other of the competency factors required in the industrial world of work including knowledge and technical and personal competency.

Many sources from various literature have discussed the definition of competence. Currently the term "competence" is commonly used according to two basic meanings. The first meaning of "competence", according to the Dictionary of Foreign Words, is strength, a field of action, and a range of power. The second meaning of "competence" linguistically is the ability to produce (Kalinova, 2008). But competence itself exists in three basic theories, this has been explained by Spencer & Spencer (1993), Rules of Competence Engagement (Roe, 2002), and Armstrong (2006).

Based on the basic theory, explained by experts such as Spencer & Spencer, Roe, and Armstrong, the competencies can be summarized as follows. Meanwhile, according to Spencer & Spencer (1993), there are twenty factors of competence, Spencer & Spencer define competency as a hidden character in an individual to perform efficiently in various situations (Adriadi et.al. 2024).

Harmonious

According to (Abdul Zahra, 2020); (Zwain & Noorulhudanabih, 2022), as the topic of research and theories that address harmony at work is relatively novel, this study merely examines it as a value, objective, or, more broadly, as a circumstance and context without considering its specific features and defining it as a high level of mutual exchange and mutual respect that results in long-term commitment can be referred to as harmony.

The results of Gao and Jiang (2019) indicated that the harmonious passion acts as a mediator in the empowering leadership and employee voice behaviours. Employees' job autonomy magnifies the link between their harmonious passion and voice thus increasing the indirect impact of empowering leadership on employee voice through harmonious passion.

It is revealed that harmonious passion has a positive and significant relationship with Innovative Working Behaviour (IWB) contingent on the level of service empowerment in hospitality firms. Also, it is established that the moderation effect of service empowerment on the indirect relationship between cooperative psychological climate and IWB via harmonious passion is significant. The implication is that practitioners who seek to increase harmonious passion and IWB in the workplace are able to foster a cooperative culture within their hospitality firms. This study is useful as there is limited literature on harmonious passion particularly in organizations and this study contributes to the literature on cooperative psychological climate in showing that this factor can lead to harmonious passion among employees thus making them exhibit IWB (Jan & Zainal. 2020).

Loyal

Hence a key issue that management practitioners are faced with is maintaining survivor employees' loyalty in a downsizing context. More so, theorists have found that organizational practices like; empowerment and job enrichment as means through which survivors can be able to deal with the consequences of downsizing. In this study, the authors have investigated how self reported managerial empowering behaviors, perceived job enrichment and employees' voluntary loyalty conduct with employees who have been maintained after downsizing in an organization. The study found out that there was no significant relationship between empowerment and loyalty but that it was mediated by job enrichment. The findings of the study are considered insofar as they concern theory and practice (Niehoff et.al. 2001).

According to Hasibuan (2017); (Susanti, et al. 2021); (Wardhani et.al. 2023) that employee loyalty is various forms of member participation in using energy, thoughts, and time in realizing organizational goals Gustara and Adiwati (2021) said that work loyalty is shown by the attitude of employees, namely being willing to provide all their abilities, thoughts, skills, and skills to achieve organizational goals, expertise to achieve company goals, carrying out tasks with full responsibility, discipline and honesty in working.

Meanwhile, In an open and integrated economy in particular. Business entities are experiencing perfect and most intense competitive environment. Numerous students have qualitatively confirmed that the quality of human resources performs an important and non-recoupable role and to capture the victory of many businesses in those competitions. What leaders should do for the

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company to grow is to be able to keep good and potential human capital. It will suffice to assert that the relationship with the superior, which means managers and employee or the leadership approach of the administrator, plays a vital role in the creativity, committed or the sense of identification and loyalty of the employees. Numerous publications have been released to illustrate this phenomenon (Ngo et.al. 2021).

Adaptive

Adaptive capacity has been described as the organisational efficiency to undertake activities and co ordinate the related procedures under normal as well as during unprecedented situations, which is possible only when one can respond to the situational calls. Recent studies in this area argue that only the ability of a team to promptly and effectively respond to environmental change affects performance, however, more research questions need to be formulated to enhance the constant development and effective management of adaptive teams (Bogdanovic et.al. 2015); (Anderson et.al. 2021).

Adaptive performance from various angles in light of its importance in recent years. It reveals several as-yet-unidentified job-related determinants of adaptive performance. The services sector must improve its adaptive performance to thrive in the modern workplace (Hurst et. al. 2018). Consequently, the adaptive performance of employees plays a crucial role in attaining desired organizational goals, including effectively managing change, fostering organizational learning, and successfully addressing evolving environmental demands (Hein et al., 2021); (Balay-Odao et al.,2022); Dinibutun (2024).

Change readiness is crucial for the professional persona to grow in complex dynamic organizational structure so that risk of change can be managed and realise the defined performance. There is a way that a person's adapt to work environment because a good adaptation enables him/her to learnt new values in environment effectively (Rachmawati et al. 2021); (Kurnianto & Ningsih, 2024).

Collaborative

In this symmetrical method of research, we use an exploratory lens to first focus in on cross-boundary collaboration as a competency, before employing a wide-angle lens to examine the composition of collaboration: the constituent elements. Altogether, these systems create a 'both/and' scenario – implying that both approaches are the right and the only way to go. While the collaboration literature broadly celebrates local, organic perspectives about cross-boundary interactivity (Edmondson, 2018; Mortensen & Haas, 2018); (Scott & Manning, 2024), the literature on extended and diverse collaborations prefers contentions of centralisation and process.

As pointed out by Scott & Manning (2024) that Collaborative Work – Work Tasks are Designed, Allocated and Managed to Foster Collaboration. The

first one – the design of collaborative work – drew attention to how leaders directed, allocated, and engaged with work.

In the research of Moradi & Kahkonen (2022) to review the literature, there is a new model that describes the core success factors to collaborative delivery models which is arranged in accordance with its conceptual affinity to five project delivery elements.

The findings of this study, which have been described earlier, therefore militate in arriving at the following conclusions on success factors of construction projects involving collaborative delivery models (especially in the area of alliances, integrated project delivery, and partnerships): (1) The types of success factors are defined by the characteristics and elements of the construction project delivery model. Among the approaches to dissecting the delivery of construction projects and their success, (2) project organisation, contractual relationships and operational system is arguably the most comprehensive because it forms the basis of understanding how construction projects are delivered. (3) Key constituents of the project include proper and relevant contracts, adhering to win-win concept, partnership and cooperation, parity, motivation structures, communication system, trust, and competent project members. (4) Out of all the factors overlaying success-crucial factors, equality and mutual trust are essential factors.

AKHLAK Summary

Below are several factors of core values abbreviated as AKHLAK from the following some literatures (Table.1).

Table 1: Several factors of Core values

	Trustworthy (X1)	**Competency (X2)**	**Harmonious (X3)**	**Loyalty (X4)**	**Adaptive (X5)**	**Collaborative (X6)**
BUMN (2022)	Commitment, responsibility, morality, ethic	Enhance, encourage, tasking quality	Appreciated, helpful, environment	Reputation, sacrifice, obedient	Accommodate, improvement, proactive	Opportunity, cooperative, Utilized
Srivastava & Mohaley, (2022)	Personally, professionally					
Fischer et al. (2020)	Personally, professionally					
Taylor et.al. (2023)	Collaboration, problem solving, and transparency					
Mairizal et.al. (2020)		Knowledge, Technical, Personal				
Edrizal et.al. (2020)		Knowledge, Technical, Personal				

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	Trustworthy (X1)	Competency (X2)	Harmonious (X3)	Loyalty (X4)	Adaptive (X5)	Collaborative (X6)
Mairizal et.al. (2023)		Knowledge, Technical, Personal				
Adriadi et.al. (2024)		Knowledge, Technical, Personal				
Abdul Zahra (2020)			Reciprocity and mutual respect			
Zwain & Noorul (2022)			Reciprocity and mutual respect			
Hasibuan (2017)				Participation, thoughts, realize		
Susanti, et al. (2021				Participation, thoughts, realize		
Wardhani et.al. (2023)				Participation, thoughts, realize		
Gustara & Adiwati (2021)				Abilities, thoughts, responsibility, discipline, honesty		
Bogdanovic et.al. (2015)					Coordination, Responsive	
Anderson et.al. (2021).					Coordination, Responsive	
Edmondson (2018)						Governance, process
Mortensen & Haas (2018)						Governance, process
Scott & Manning (2024)						Governance, process
Total frequency	**9**	**6**	**5**	**11**	**5**	**5**

Indonesian Construction

Construction industry is one of the influential segments of the Indonesia economy. Its role can be viewed from high domestic absorption which is a significant factor in the country's total gross domestic product. The following is the list of challenges experienced by this industry; Mainly because this industry operates in a volatile environment. In preparation for this, the construction industry has gained some notes and is participating in measures to transform the industry into a more significant one (Supriadi & Pheng, 2017).

Based on Law Number 18 of 1999 concerning Construction Services, the government is no longer the only institution that would control and coordinate the growth and development of construction industry. However, the construction community as it is known, decides its own fate, and the constructional actors among them are the ones responsible to the state. Based on the above analysis of

the process of implementing this law, one of the important implications is the new establishment of the National Construction Industry Services Development Agency, this indicates the participation of construction community in regulation of the industry. Twenty years later, in 2017, the DPR and the government made Law No. 2 on Construction Services that repealed Law No. 18. Hollis suggests that almost everything of importance on the regulation of the construction industry has for almost two decades been controlled by the construction community, and now has come full circle back to government as the key actor. There is a shift in a dramatic reduction on the part of development institutions that were once very influential (Soemardi & Pribadi, 2021).

RESEARCH METHODOLOGY

This research is descriptive research where this research method is intended to address existing of core values (AKHLAK) in Indonesian State-Owned Enterprises (BUMN) companies. The following explains the methodological steps used and the core values factors that cause excess performance as in Figure 1 below.

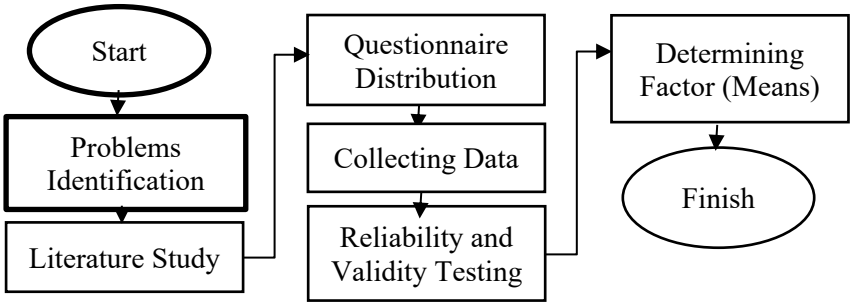


Figure 1. Research Methodology

This study produces determinants of core values and is tested on several respondents taken 5 peoples each from 10 BUMN companies in the Construction sector with a purposive sampling method. The study respondents consisted of five Senior Vice Presidents (SVPs) of each company who have accumulated over twenty years' experience working on construction project implementations. Based on the description of 6 factors that become 41 sub-factors in Table 2, then continued with data processing using SPSS to see the results of reliability and validity. From the results of the data processing, it is sorted based on the highest to lowest means value.

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Table 2: Several factors and sub-factors of Core values

Factors	Quantity	Sub-factors
Trustworthy (X1)	9	Commitment (X1.1), Responsibility (X1.2), Morality (X1.3), Ethic (X1.4), Personally (X1.5), Professionally (X1.6), Collaboration (X1.7), Problem solving (X1.8), Transparency (X1.9)
Competency (X2)	6	Enhance (X2.1), Encourage (X2.2), Tasking quality (X2.3), Knowledge (X2.4), Technical (X2.5), Personal (X2.6)
Harmonious (X3)	5	Appreciated (X3.1), Helpful (X3.2), Environment (X3.3), Reciprocity (X3.4), Mutual respect (X3.5)
Loyalty (X4)	11	Reputation (X4.1), Sacrifice (X4.2), Obedient (X4.3), Participation (X4.4), Thoughts (X4.5), Realize (X4.6), Abilities (X4,7), Thoughts (X4.8), Responsibility (X4.9), Discipline (X4.10), Honesty (X4.11)
Adaptive (X5)	8	Accommodate (X5.1), Improvement (X5.2), Proactive (X5.3), Coordination (X5.4), Responsive (X5.5)
Collaborative (X6)	8	Opportunity (X6.1), Cooperative (X6.2), Utilized (X6.3), Governance (X6.4), Process (X6.5)

ANALYSIS AND DISCUSSION

Data processing conducted in this study using SPSS version 24.0 with the results for the number of data (n) = 50 obtained r-table = 0.2353 (r-table for Pearson's Product Moment) with a significance level of 0.05. This paper presents the results of the analysis done using the SPSS data analysis software = 0.515 (X1.6 for transparency). Meanwhile, for the reliability test using the Cronbach Alpha value ranging from 0.967-0.968. In addition, the highest mean calculation result is 4.4200 (X1.3 or morality) and the lowest mean is 3.5500 (X5.5 or responsive).

Table 3: Item Statistics

Sub-factors	Mean	Std. Deviation	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	N
X1.1	4.1800	.69076	.699	.967	50
X1.2	4.1800	.66055	.691	.968	50
X1.3	4.4200	.60911	.608	.968	50
X1.4	4.1800	.56025	.792	.967	50
X1.5	4.0600	.68243	.695	.967	50
X1.6	3.7200	.72955	.515	.968	50
X1.7	4.0600	.54995	.727	.967	50
X1.8	4.3000	.64681	.701	.967	50
X1.9	4.3400	.62629	.713	.967	50
X2.1	4.1000	.81441	.682	.968	50
X2.2	4.2800	.75701	.772	.967	50
X2.3	4.0400	.63760	.634	.968	50
X2.4	4.2400	.55549	.558	.968	50
X2.5	4.1600	.58414	.615	.968	50
X2.6	3.9800	.71400	.548	.968	50
X3.1	4.0400	.63760	.691	.968	50

Sub-factors	Mean	Std. Deviation	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	N
X3.2	4.0800	.63374	.783	.967	50
X.3.3	4.0000	.67006	.673	.968	50
X3.4	4.0000	.67006	.621	.968	50
X3.5	4.0800	.60068	.753	.967	50
X4.1	4.1400	.57179	.731	.967	50
X4.2	4.2000	.69985	.583	.968	50
X4.3	4.3400	.59281	.667	.968	50
X4.4	4.1600	.79179	.674	.968	50
X4.5	4.2200	.76372	.688	.968	50
X4.6	4.2200	.61578	.630	.968	50
X4.7	4.1200	.77301	.573	.968	50
X4.8	3.9800	.71400	.615	.968	50
X4.9	3.8800	.71827	.617	.968	50
X4.10	3.9000	.73540	.720	.967	50
X4.11	3.7200	.75701	.692	.968	50
X5.1	4.0000	.72843	.597	.968	50
X5.2	3.7800	.84007	.561	.968	50
X5.3	3.9000	.64681	.627	.968	50
X5.4	4.0200	.71400	.590	.968	50
X5.5	3.5600	.73290	.459	.969	50
X6.1	3.8400	.58414	.544	.968	50
X6.2	3.9200	.63374	.659	.968	50
X6.3	3.8000	.80812	.646	.968	50
X6.4	3.6400	.77618	.613	.968	50
X6.5	4.1800	.71969	.701	.967	50

The analysis presented in Table 3 establishes the ordering of "Akhlak" factors that BUMN Construction firms together with BUMN-related organizations can use. The highest ranked factor in order comes from the 10 "Akhlak" elements is Morality (X1.3). People within organizations need to demonstrate behaviour that leads them to perform good deeds according to organizational standards. The second position belongs to Transparency factor (X1.9) which represents open communication as a truthful disclosure of complete information to organization members and the surrounding community. Human beings need to comprehend all information obtained from various human sources according to the ranking scheme of the factor set (X2.4). Humans can possess knowledge as facts in occurrences and concepts and theories and as a skill set. The Realize factor (X4.6) occupies the fourth rank as it represents the reality of human life that makes individuals aware of their displayed attitudes. The fifth rank comprises thought (X4.5) which provides meaning to mental ideas derived from perception together with emotions and action plans. The human mind functions to address problems in life through innovative solutions. The sixth rank and subsequent ranks will not be discussed because of restricted space limitations.

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CONCLUSION

The results of the discussion above, if viewed as the 10 highest determining factors in sequence from the Core Values, namely X1.3 (morality), X1.9 (transparency), X2.4 (knowledge), X4.6 (realize), X4.5 (thought), X4.3 (obedient), X4.2 (sacrifice), X1.1 (commitment), X1.2 (responsibility), and X6.5 (process). This study presents recommendations that can be used in BUMN Construction companies and other organizations affiliated with BUMN. "Morality" is the first rank that aims to improve the moral aspects of project HR and all employees in their devotion efforts. Good morality will reduce financial irregularities and prevent corruption. Likewise with other AKHLAK factors that need to be applied to BUMN Construction companies in particular and BUMN companies in general.

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OPTIMAL SITE ATTRIBUTES FOR SOLAR FARM DEVELOPMENT IN MALAYSIA: A CONCEPTUAL FRAMEWORK

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Abstract

Defining an optimal site for the development of solar farms is crucial for the long-term success of renewable energy projects. However, selecting suitable locations present challenges in Malaysia due to diverse environmental, geographical and socio-economic factors. Therefore, this paper aims to develop a conceptual framework focusing on important attributes that should be considered in defining an optimal site for solar farm development. This study embarks a systematic literature review (SLR) to identify key site selection attributes based on PRISMA guidelines and draws from databases including Emerald Insight, Scopus and ScienceDirect. The result illustrates a conceptual framework incorporating environmental (solar irradiance, soil quality, biodiversity conservation), geographical (land availability, topography, infrastructure access), and socio-economic (public acceptance, legal frameworks, long-term economic sustainability) attributes. This framework provides direction to decision makers, policymakers, and investors to promote an organized, well-informed site selection process, which ultimately lays the path for the long-term profitability of solar farm development.

Keywords: Solar Farm Development, Environmental Attributes, Geographical Attributes, Socio-economic Attributes, Conceptual Framework

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INTRODUCTION

With the growing demand for energy being increasingly more global, finding cleaner and more sustainable sources has been searched. It was spurred further by climate change concerns, the diminishing supplies of fossil fuels and commitments from nations around the world to reduce greenhouse gas emissions which have accelerated the transition to renewable energy. In particular, solar energy has become very powerful because it is abundant, has minimal environmental impact and the technological costs are in rapid decline. Solar energy, meanwhile, continues to be a cornerstone of global renewable energy policies, motivating photovoltaic technology innovation in PV technologies, grid integration and energy storage solutions in line with government and industry momentum toward carbon neutrality.

However, it has necessitated a shift toward alternative energy platforms that are sustainable, efficient, and environmentally friendly. Alternative energy encompasses a broad range of renewable sources, including solar, wind, hydropower, geothermal, and biomass, which offer viable solutions to reduce carbon emissions and mitigate climate change impacts (Sahid et al., 2021). Many countries have recognized the urgency of transitioning from conventional fossil-based energy to clean energy alternatives to meet their net-zero emissions targets and ensure long-term energy security.

Among various renewable energy sources, solar energy has emerged as a leading alternative due to its vast availability, declining costs, and technological advancements in photovoltaic (PV) systems. Countries with high solar irradiance, such as Malaysia, stand to benefit significantly from large-scale solar farm development. Apart from that, beyond solar energy, hybrid energy systems that combine multiple renewable sources, such as solar-wind or solar-hydro, are gaining traction as they enhance grid stability and provide continuous power supply. Additionally, emerging energy storage technologies, such as battery storage systems and hydrogen fuel cells, are revolutionizing the way renewable energy is managed, addressing issues related to intermittency and reliability (Adeyinka et al., 2024).

Therefore, Malaysia has aggressively promoted advancements in renewable energy through the use of National Renewable Energy Policy and Action Plan, the Feed into Tariff (FiT) and the Large Scale Solar LSS program. Nonetheless, solar farm placement sites face some challenges, which include site selection based on a weighed series of factors for energy production that creates environmental sustainability as well as socio-economic feasibility. In addition, the current approval process for large-scale solar developments in Malaysia particularly in Johor has identified that there is lacking comprehensive guidelines, leading land administrators to use telecommunication tower development as a benchmark for approving these projects (Sahid et al. (2021).

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Hence, balancing environmental, geographical and socio-economic considerations, the decision whether to treasure suitable locations for solar farms is a complex decision-making process. Additionally, land availability; solar radiation levels; topography and proximity to electrical grid are important for site viability (Kereush & Perovych, 2017). It is also important to realize that the establishment of large-scale solar farms, impacts on biodiversity, water resources and land use changes will need to be considered. A poorly thought through solar project may deforest, cause habitat loss, or collide with agricultural land use, compromising the sustainability aspirations.

Other than that, the socio-economic considerations are equally vital for solar farm site selection. Assessment of land acquisition, community acceptance and long-term socio-economic benefit is necessary to guarantee project success. Land insufficiency and competing land use demands especially for agriculture and urban development impedes solar farm expansion in Malaysia. Moreover, solar projects do not come without an element of opposition from the local community as it can generate resistance due to land displacement, aesthetic impacts and a belief that they bring no advantages for local communities. However, when community participation and equitable distribution of benefits is possible, public acceptance can be increased and long-term socio-economic development can also be facilitated.

Selection of sites of solar farms is a complicated process taking into account the technical feasibility only (Joseph et al., 2016). Suitability of a location for solar farm development depends on key factors include environmental conditions, land use, and socio-economic impact. This process is quite challenging in the case of Malaysia because it needs to mesh together a set of diverse and often inconsistent considerations, such as environmental conservation, legal regulation, restrictions related to climate conditions and the socio-economic needs of the local communities (Kereush & Perovych, 2017). Poor site selection further economically depletes solar projects in terms of cost, delays, environmental harm, and community resistance, all of which negatively impacts the feasibility and longevity of the projects (Akkas et al., 2017). Furthermore, poor planning could lead to inefficient land use, disturbance of native ecosystems and unintended socioeconomic effects like displacement of local people or loss of productive land.

On the other hand, the fact that there is no standard data driven framework to site selection worsens these problems, as it intensifies the inconsistency of project results and increases financial risk for investors and stakeholders. To address these issues, a structured procedure for identifying optimum sites of solar farm development has to be developed that merge environmental impact assessments with socio-economic evaluations.

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However, given these complexities, a holistic and consistent site selection approach to solar farms is needed. The purpose of this paper is to propose a conceptual framework for use in decision regarding Malaysia's solar energy sector which emphasizes integration of environmental, geographical and socio-economic factors. Then, the proposed framework aims to help policymakers, investors, and the stakeholders help promote solar energy projects that are also economically sound, environmentally sustainable and socially responsible. Adopting measures to overcome these site selection challenges of solar farms would allow Malaysia to increase its renewable energy resources and assist in achieving global reduction of carbon and lend to a cleaner and more sustainable future of energy (Joseph et al., 2016).

LITERATURE REVIEW

Solar farms, known as solar power stations, plants, or complexes, are largescale infrastructures composed of individual solar panels specifically designed to capture sunlight and convert it directly into electricity. Solar farms are predominantly established on agricultural land or unoccupied industrial sites, with an increasing trend of employing builders for their development, particularly in the south-west and southeast regions of England (Jones et al., 2014; Mackey, 2023). Factors like solar radiation, ambient temperature, and photovoltaic (PV) module qualities define the electricity output of a solar farm (Barani et al., 2020).

Solar, wind power and other forms of renewable energy sources have received a lot of attention in the world today. The implementation of Photovoltaic (PV) technology has been because of the increasing energy demands and the effects of greenhouse gases that result from the conventional energy generation. A photovoltaic system or solar power system use semiconducting materials in the photovoltaic process to convert sunlight to electricity thus providing an additional means of generating electricity (Zeman, 1987). According to the International Energy Agency in 2014, world's developed countries such as USA, Germany, Spain, Japan and UK have adopted the use of solar power and have put it to good use in every aspect either individually or integrated into the power grid. However, the growth rate of the utilization of solar energy in developing countries such as Malaysia is still relatively slow despite the country's having abundant physical resources of solar energy.

The drive that calls for the utilization of solar energy as an alternative source of power in Malaysia is informed by two factors. To begin with, global and local environmental news outlets reported that in 2013, the country released 226988.90 CO2-kt/yr of CO2 to the atmosphere (Emissions Database for Global Atmospheric Research - EDGAR, 2013). Research conducted by different authors (Ali et al., 2012; Chua and Oh, 2010; Noh, 2012; Ong et al., 2011) showed that Malaysia gets 95% energy form fossil fuel including oil, coal and natural gas.

The forecast is even more devastating; the release, according to the forecast is estimated at about 500 megatons of CO2 by year 2020 in the absence of any form of control measures (Ahmad et al., 2011; Ang et al., 2013; Wee et al., 2008).

Secondly, the demand for electrify rises than the capacity to supply it and this situation has evoked the above problem. The total power output in the year 2013 was 111,020 GWh according to the report of Energy Commission in 2014, to the maximum level of the national energy consumption in one year was 16,562 MW. From the research conducted by Ali et al. (2012) the rate of increase in power consumption was estimated to be at 4.7% per annum because of industrial and commercial development. The peak electricity demand is expected to reach near 274 TWh in the year of 2030. Sustainability of fossil fuel in generation of electricity has always been a critical issue mainly due to the expectation that the source of gas would be exhausted by 2046 (Ali et al., 2012; Ong et al., 2011). These factors have promoted precautionary activities and have encouraged the attempt to expand sources of renewable energy such as wind and solar energy.

The Malaysian energy policy also puts into consideration the generation of renewable energy with an achievement of 20% in 2025 mostly from solar energy. On the national level, by 2025 they seek to feed 1.25 gigawatts (GW) of solar power into the grid, matching about 14% of renewable energy generating capacity. To facilitate this goal, in 2015, the large scale solar (LSS) programme was initiated (Nguyen et.al, 2017).

In regards to achieve this goal, the selection of optimal sites for solar farm development has been extensively studied, driven by the growing global emphasis on renewable energy. In this regard, there are alternative renewable energy sources has been reviewed such as wind, hydro and biomass. Hence, it is suggested that solar energy is particularly viable in Malaysia due to its geographical positioning and policy support. However, inadequate site selection can lead to environmental degradation, community resistance and economic inefficiencies. Previous research highlights the multifaceted nature of solar farm site selection, involving technical, environmental, and socio-economic dimensions that vary depending on geographical context. This paper explores the main themes emerging from research on environmental, geographical, and socio-economic considerations in solar farm site selection, with a particular focus on studies relevant to Malaysia and other tropical regions.

Environmental Attributes

Environmental attributes have a major influence in site selection for a solar farm. Solar farm development can have large impacts on natural environment through land use, ecosystem and resource consumption. Ghimire & Johnston (2017) emphasize the substantial influence of climate condition, especially the solar

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irradiance as well as recommend the locations of solar farms should be aligned with areas that receive constant solar exposure. But they also say that solar farm development should stay away from sensitive ecologies to minimize the loss in biodiversity and habitat fragmentation. Soil quality and water availability are also relevant other environmental considerations. Moreover, Tsoutsos et al. (2019) pointed out that soil type can influence the performance and lifetime of solar panels as can access to water resources for cleansing and preservation of big solar plantations, particularly in arid regions.

A study by Liew et al. (2020) have demonstrated that tropical climate in Malaysia provides excellent solar irradiance for energy generation but challenges on environmental such as deforestation, habitat destruction, and water management, are still significant. Deforestation to clear land for solar farms can make up for the urge to create renewable energy; likewise, it can help take profit from the clean energy. Furthermore, Malaysia's rich biodiversity with many endangers species requires a planned implementation to avoid disrupting important habitats or ecological corridors when solar farm projects are developed.

Land deficiency is also a very important environmental consideration. Unprivileged site selection and land preparation practices may result in soil erosion, low soil fertility, and increased surface runoff which exacerbate local hydrological cycles. Additionally, climate resilience is closely tied to the long-term sustainability of solar farms. Heavy rainfall, strong winds and prolonged drought can play havoc on the performance and lifespan of solar infrastructure. Adaptive design, climate responsive maintenance and integrated with other renewable energy source strategies can increase the resilience of solar farms to environmental fluctuations.

As a result, these environmental complexities are necessary to be used in a holistic approach of framework development through environmental impact assessment, land suitability analysis and sustainable site planning. To maintain Malaysia's shift to renewable energy, energy production must be balanced with environmental conservation, keeping ecological damage to a minimum as coverage of clean energy maximization.

Geographical Attributes

One of the keys for the viability of solar farms are geographical attributes, including solar irradiance, land availability, topography and pipeline to infrastructure. Solar irradiance is an important factor in many of studies and is critical to the calculation of the energy output of solar farms. Al Garni and Awasthi (2017) developed a GIS based solar energy potential assessment model with a focus on geographical features, such as topography and land use, in addition to solar irradiance. Further they emphasize that solar farms should be installed on flat or gently sloping land because it reduces installation costs and

aids orientation of the panel. Roads and transmission lines, as well as access to infrastructure such as water, are also important not only to bring down costs but to make operations run on time. Nordin et al. (2021), in research conducted in Malaysia, suggest that solar farm development may be most efficiently situated in regions currently capable of supporting such development due to an existing level of good infrastructure (such as in Peninsular Malaysia) and high solar irradiance. The problem with competing interests, such as agriculture, urbanization and conservation are that land availability is a major obstacle. Hilly areas can offer more available land; however, the terrain of these areas is not parallel and hence are technically challenging to install solar farms (Liew et al., 2020).

Additionally, Geographic Information System (GIS) and remote sensing technologies could help improve site selection accuracy by supplying geospatial detailed data of terrain, land use and distance to infrastructure. A review into studies has indicated that analysis of geographical parameters at areas for a greenfield project can aid in identifying the most appropriate location by minimizing the conflicts of the developed land uses (Ahmed et al., 2022). Land conversion is also another important consideration since repurposing agricultural or forested land to solar farms open up to socio environmental trade-offs. Lucrative renewable energy development and food security through sustainable land use planning must be balanced.

Socio-economic Attributes

Besides socio-economic attributes, technical evaluations generally fail to take them into account in order to approximate a successful solar project. The long-term viability of solar farms is also stressed by a number of studies, in particular regulatory frameworks, public consultation and community engagement. According to Sgroi et al. (2014) when the concerns and interests of local communities are not being considered during the consultation regarding a solar farm, then public opposition will follow. They also note that licensing, zoning laws and land rights are equally important for the successful project execution, because unresolved land disputes may slow down or increase costs.

Abdul Hamid et al. (2021) note that public engagement and socio-economic factors such as job creation, local economic development and community benefits are important to get local support for solar farm projects in Malaysia. Additionally, public acceptance is greatly increased by transparent policies on revenue sharing and long-term economic contributions. Licensing processes in Malaysia have been more streamlined over the years, but are still being hampered by zoning regulations and land rights in rural areas. Additionally, through the National Renewable Energy Policy and Action Plan (2010), solar farm developments must follow national sustainability goals in order to help

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support the country's local economic growth while at the same time minimizing any adverse socio-economic impacts.

RESEARCH METHODOLOGY

This research utilized a Systematic Literature Review (SLR) using PRISMA guidelines to gather data from databases. The databases used are Emerald Insight, Scopus, and ScienceDirect. A broad range of studies addressing environmental, geographical and socio-economic aspects of solar farm site selection were analyzed to identify key factors relevant to Malaysia.

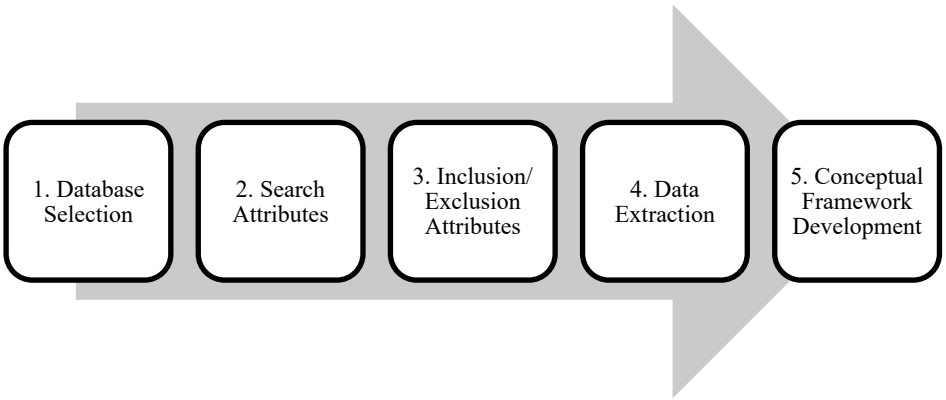


Figure 1: Systematic Literature Review (SLR) Using PRISMA Guidelines
Source: Moher, et al. (2015)

Figure 1 shows the steps of conducting SLR by using PRISMA guidelines There are five stages in PRISMA guidelines (Moher, et al., 2025) which are 1) Selecting Database; 2) Searching attributes; 3) Inclusion or exclusion attributes; 4) Extracting data; and 5) Developing conceptual framework. For the first stage, journal articles were traced from Emerald Insight, Scopus, and ScienceDirect. Then, followed by second stage which selected keywords such as "solar farm site selection", "renewable energy Malaysia", "Environmental Attributes", "Geographical Attributes" and "socio-economic attributes" were used for searching the right attributes specifically for solar farm development in Malaysia. After that, the articles were reviewed and the inclusion or exclusion process have been made to fit with solar farm development. In this process, only peer-reviewed journal articles, government reports and policy documents which related to solar farm development published between 2015 and 2023 were included. Non-English articles and non-relevant studies were excluded. Next stage is extracting data which all the relevant studies were categorized based on environmental, geographical and socio-economic attributes. Then, for the final stage is developing conceptual framework. In this process, the

findings were synthesized into conceptual framework integrating all key factors (Guillaume, 2019).

ANALYSIS AND DISCUSSION

Figure 1 shows a conceptual framework for solar farm development which emphasizes the importance of balancing environmental, geographical, and socio-economic factors to ensure the successful distribution of solar energy projects. This multi-dimensional approach is essential for creating a sustainable, economically viable, and socially accepted solution for the growing energy demands in Malaysia.

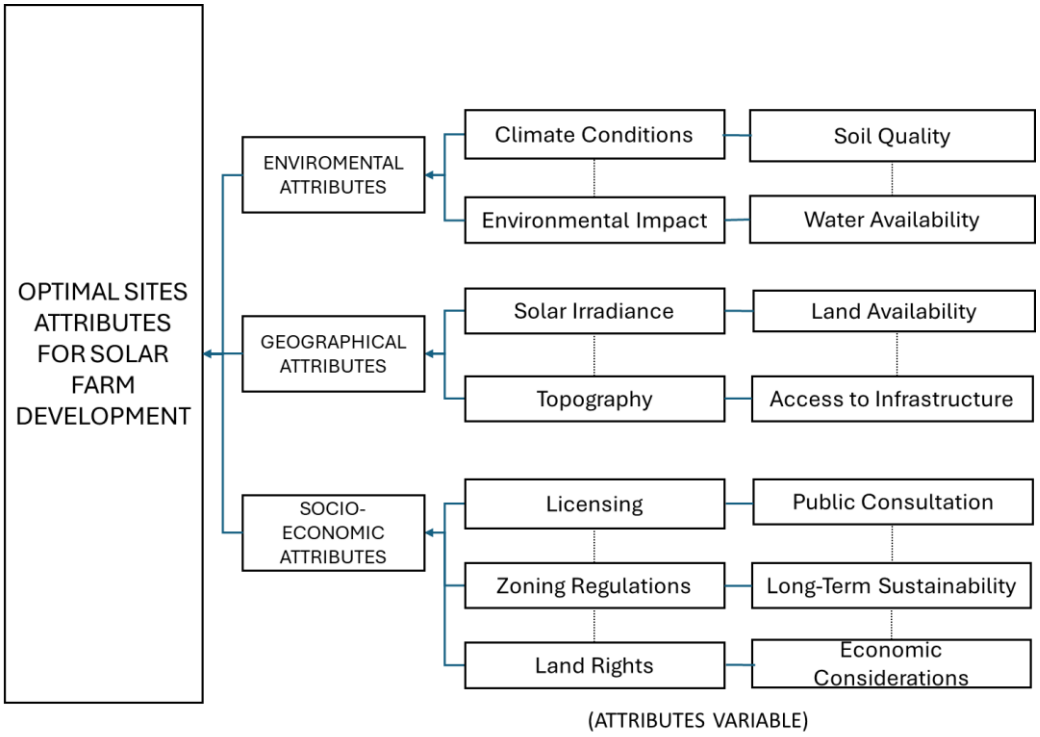


Figure 1: Conceptual Framework of Optimal Sites Attributes for Solar Farm Development
Source: Author (2024)

Based on this figure, there are a few elements that have been considered in order to develop the framework. The crucial elements that have been considered are as follows:

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Environmental Considerations

Some of the basic factors that can be used to make the ecological footprint of solar farms are environmental factors. Sites are also carefully selected to avoid environmentally sensitive areas, for example, rainforests, areas of protected wildlife; or wetlands. Solar farm development should impact biodiversity as much as possible, given that development could disrupt local flora and fauna, particularly where the system is sensitive to disruption.

In addition, the selection of a site should allow for the prevention of exploitation of vital natural resources, such as near water availability for cooling purposes or for irrigation of nearby agricultural land (for instance, in arid areas). The environmental sustainability of the energy produced by solar farms is a concern beyond land use. The efficiency of solar panels and the entire environmental footprint of the materials used in the construction, including rare earth minerals in production of solar panel, have to be assessed (Akkas et al., 2017).

Geographical Considerations

With high solar irradiance levels especially in the central and northern region of Malaysia, geographically the country provides a good opportunity for solar energy development. Malaysia is situated close to the equator and has high potential to utilise the solar irradiance (Vaka et al., 2020), which means that solar irradiance is the amount of solar power that comes per unit area. Moreover, the topography of Malaysia is highly favourable for the widespread deployment of solar panels due to the flat and expansive land areas in specific areas.

The ideal solar radiation levels, however, are not enough to make solar farms successful. Therefore, key geographical factors like land availability and accessibility are key to the feasibility of these projects. Given Malaysia's rapid process of urbanization, particularly along its west coast, competition for land between agricultural, residential, industrial and renewable energy areas is becoming imminent. Thus, there is great need to find locations that offer the highest solar energy potential with little impact on current land use. Moreover, being close to such infrastructure such as a road for transport and that for power grids. Lower transportation and connection costs, typically of considerable proportions in remote areas, are made more accessible due to roads and nearby electrical infrastructure. Vast amounts of land are needed for solar farms to be economically viable, which means there is a trade-off between optimal solar conditions and conflicts with land use. These constraints also pit them against the high upfront capital investment associated with solar farm construction.

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Socio-economic Considerations

Similarly, establishing a long term successful solar farm also hinges on the socio-economic factors. It is very crucial to the reduction of local resistance and the winning of the community support. Projects involving interested local communities early in the planning process with information that cites environmental benefits, energy security, and economic benefits (such as jobs created) are more likely to be accepted by surrounding communities. Also, worries about land use and local impacts can put resistance to discourage project approval and ease the process and avoid delays.

Besides, both legal and regulatory frameworks are also socio-economic factors. Clear zoning regulations can ensure that land rights are secured, then in this way avoid legal disputes. For projects, it is sometimes difficult to get zoning and legal support, and without it, projects can hit many potholes including land ownership issues and land use conflicts. Regulatory guidelines are clear to keep project execution smooth, and help safeguard investment through the minimization of unforeseen legal challenges (Akkas et al., 2017). In fact, solar farm developers particularly in Malaysia also face several significant challenges especially related to land use and legal framework. The challenges are in terms of land development approval, land use management and legal uncertainty (Sahid et al., 2021).

The economic sustainability of the project is another important socio-economic factor. Solar energy is a capital-intensive business and long-term profitability is required to sustain the financial viability of a solar farm project. The project must be economically feasible throughout its operational life, so it has to be assessed by factors such as profitability, risk and the cost of capital, and payback period. More specifically, job creation in the local community, together with the economic benefit created by infrastructure development (roads, utilities, etc), can serve to enhance public support and add to regional economic growth. But successful solar projects not only help to fuel the energy supply, they also generate jobs in construction, maintenance, and operation. Such an environment allows for local population engagement within the renewable energy sector possibility, which will additionally trigger the continuing support of the population to expansion in terms of project.

Integrated Approach for Successful Solar Farm Development

The framework has integrated these three factors – environmental, geographical and socio economic – in order to create a comprehensive strategy to determine the best locations for the development of solar farms in Malaysia. The interrelated nature of these attributes, points that the process for site selection should not be entirely dependent on any one attribute, as a whole picture is to be viewed. A particular site claims high solar irradiance but no access to the infrastructure.

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Such a site may be undesirable unless infrastructure is additionally developed. Then, a site with strong community support and desirable economics may be able to overcome more marginal irradiation results if located proximate to existing power grid infrastructure.

The framework's strength lies in its holistic approaches, which take into account factors like socio-economic balance, geographic advantage, and environmental impacts, all of which are necessary for the development of successful solar farms. A factor is also involved not only in determining the feasibility of a project, but also in guaranteeing that solar farms, once beyond the planning phase, will make a positive contribution to Malaysia's long term energy goals and promote local community and economic development.

Overall, the conceptual framework demonstrates the intricacy in the interconnected factors of the process of the development of solar farm in Malaysia. For a successful, sustainable and widely accepted solar energy project in the Country, the framework would consider environmental sustainability, geographical suitability and socio-economic considerations to come up with a thorough and integrated evaluation process.

CONCLUSION

The developed framework in this study conceptually integrates environmental, geographical and socio-economic attributes to propose framework for solar farm site, and is of great value to decision makers in Malaysia. It stresses the significance of taking account of not just the technical and environmental feasibility of solar farm projects as well as their long run sustainability and socio-economic impact. Unlike conventional approaches that primarily focus on technical and environmental feasibility, this framework emphasizes a holistic assessment that ensures the long-term sustainability and socio-economic viability of solar projects. By incorporating multiple critical factors, it provides decision-makers with a structured methodology to balance energy expansion with environmental conservation and societal well-being.

Apart from that, the framework presented here enables policymakers, future investors, and other stakeholders to take informed decisions in promoting the expansion of renewable energy in Malaysia without fighting against the environmental protection and people's well-being. This framework is the founding stone for solar farms that are both viable and sustainable in the long term. Besides, by laying a strong foundation for evidence-based decision-making, this framework contributes to a more resilient and sustainable energy infrastructure. It also provides a basis for future research and policy refinements, ensuring that Malaysia's renewable energy transition remains adaptive to evolving technological, economic, and environmental challenges.

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ENHANCING MUSEUM ACCESSIBILITY: LIGHTING STRATEGIES FOR VISITORS WITH LOW VISION

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Abstract

Museums must balance preservation with accessibility, yet lighting strategies for low-vision visitors in Indonesia remain underexplored. This study investigates the Jakarta History Museum through literature review, observational analysis, and calibrated lux meter measurements. Findings reveal that suboptimal illuminance and glare hinder accessibility, underscoring the need for layered lighting approaches integrating ambient, task, and accent illumination. These strategies enhance legibility, spatial perception, and visitor inclusivity while safeguarding artefacts. The study contributes to inclusive design discourse in Southeast Asia and calls for future research on adaptive technologies to optimise perceptual experiences under varying lighting conditions.

Keywords: Layering Light, Museum Design, Low Vision, Exhibition Display, Accessibility and Inclusivity

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INTRODUCTION

Recent demographic data from Indonesia (2022) indicates that approximately 8 million individuals live with visual impairments, including 1.6 million people over the age of 50 who are blind (Bandung, 2022). Despite these significant statistics, empirical research on the participation of visually impaired individuals in Indonesian museums remains limited. Since 2007, the International Council of Museums (ICOM) has underscored the obligation of museums to provide equal access for all visitors, particularly those experiencing permanent or age-related sensory decline (Vaz, 2020). Within this framework, lighting is crucial for accessibility, as it not only aids in interpretation and navigation but also intersects with conservation requirements that often limit lighting levels (Ajmat et al., 2011; Fortuna et al., 2023).

This study aims to deepen the understanding of museum inclusivity by redefining accessibility through the lens of lighting for low-vision (LV) visitors. Inclusivity is examined across three interconnected dimensions: navigation within museum spaces, the accessibility of visual information such as captions and labels, and the overall sensory experience, which includes comfort and the mitigation of visual strain. By analysing the lived experiences of low-vision visitors and evaluating current lighting practices, this article provides evidence-based recommendations to help museums implement lighting strategies that balance preservation priorities with the sensory needs of diverse audiences.

LITERATURE REVIEW

Lighting Strategy at the Museum

Museum lighting must balance artifact protection and visitor engagement (Ajmat et al., 2011; Hurlbert & Cuttle, 2020; Piana & Merli, 2020) by ensuring consistent illumination, minimizing glare and shadows, and supporting mobility, navigation, and wayfinding to enhance spatial perception and aesthetic experience (Che Mohd Nasir, 2024), yet must also meet preservation standards, making design decisions complex (Hassanizadeh & Noorzai, 2021). A widely adopted solution is **layered lighting**, which integrates ambient, task, and accent sources to create a balance between functionality and atmosphere (Hunt, 2009). This approach not only supports navigation and storytelling but also reduces risks to sensitive collections.

The shift from halogen and fluorescent sources to LEDs adds further complexity. Despite concerns regarding potential material degradation, LEDs offer energy efficiency, sustainability, and visual comfort when paired with high Colour Rendering Index (CRI) values (Lee & Yoon, 2021). CRI directly influences perceptual accuracy, though lower CRI levels may, in some contexts, improve contrast (Ajmat et al., 2011). Equally critical are illuminance and Correlated Colour Temperature (CCT). Guidelines recommend 100–300 lux for preservation and 200–250 lux for paintings, with acceptable CCT ranges of 2500–

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7000 K (Sholanke & Oyeyipo, 2023). Mid-range stability, such as 3600 K, is considered optimal (Hassanizadeh & Noorzai, 2021), while practical applications often combine general and accent lighting at 2700–4000 K (Gao et al., 2020; Odabaşioğlu & Olguntürk, 2015).

Lighting strategies must also adapt to the various types of exhibitions. Two-dimensional works benefit from uniform wall-washing, while three-dimensional artifacts require adjustable, targeted illumination (Hunt, 2009). Contrast ratios further shape visitor experience: high contrast can dramatise objects, whereas low contrast fosters openness (Schielke, 2020). Ultimately, effective museum lighting requires balancing **accessibility, conservation, and visitor comfort**. When executed thoughtfully, it becomes a cornerstone of inclusive and sustainable exhibition design, aligning technical standards with the goal of equitable cultural participation (Piana & Merli, 2020).

Lighting Strategy for Low Vision (LV) in the Museums

Museums often face significant accessibility challenges for LV visitors due to insufficient inclusive design measures. These challenges include inadequate lighting, limited auditory interpretation, and restricted tactile opportunities (Henrich et al., 2014; McMillen & Alter, 2017; Walters et al., 2021). Positive cultural experiences for visually impaired individuals rely on the integration of multiple senses to navigate spaces and access information (Vaz et al., 2020). However, museum practices predominantly focus on visual experiences, creating barriers to engagement and limiting access to interpretive content.

Poor lighting exacerbates these difficulties by obstructing navigation and diminishing opportunities for meaningful interaction with exhibits (Hunt, 2009). Walters et al. (2021) highlight that dim lighting obscures labels, while strategic lighting placement can enhance contrast without causing glare. Therefore, inclusive lighting must preserve artefacts while accommodating low-vision needs through high-contrast, glare-free solutions (Ajmat et al., 2011; Hurlbert & Cuttle, 2020; Schielke, 2020).

LV visitors require longer adaptation periods when moving between different lighting conditions, making controlled transitions in brightness essential (Jackson & Wolffsohn, 2007). Both CCT and illuminance play a critical role in this process: warmer CCTs tend to enhance comfort, whereas cooler tones improve visual clarity (Zhai et al., 2015). Inadequately managed lighting can increase visual fatigue, diminish perceptual sharpness, and impair overall performance (Lei et al., 2024). Empirical evidence indicates that optimal comfort is achieved with a CCT of approximately 4000 K combined with an illuminance level of 750 lux (Fu et al., 2023). Complementing these findings, accessibility guidelines, such as those issued by the Smithsonian Institution (2021), highlight the importance of maintaining circulation routes at a minimum of 100 lux,

ensuring gradual transitions, providing shadow-free labelling, and minimising glare for both seated and standing visitors.

The literature highlights three crucial technical parameters for inclusive lighting: a CRI of 100 for accurate perception, a CCT range of 2700–5000 K depending on context, and lux levels above standard museum practice, as low-vision visitors often require 400–800 lux. A balance of 300–400 lux is considered optimal for reconciling accessibility with conservation priorities (Oyeyipo et al., 2024). Despite these insights, research on tailored lighting strategies for LV visitors remains limited, particularly in Indonesia. Addressing this gap is essential for advancing inclusive museum practices and fostering equitable cultural participation.

Synthesis and Conceptual Framework

Overall, the reviewed literature converges on the notion that effective museum lighting must balance three interdependent goals: **(a) conservation of artefacts, (b) accessibility for diverse audiences, and (c) enhancement of experiential quality**. For low-vision visitors specifically, inclusive design requires higher illuminance thresholds, careful colour temperature management, and glare-free contrasts, as reinforced by international standards such as the Smithsonian Guidelines (2021). These findings underscore a research gap in the Indonesian context, where systematic studies on inclusive lighting remain scarce.

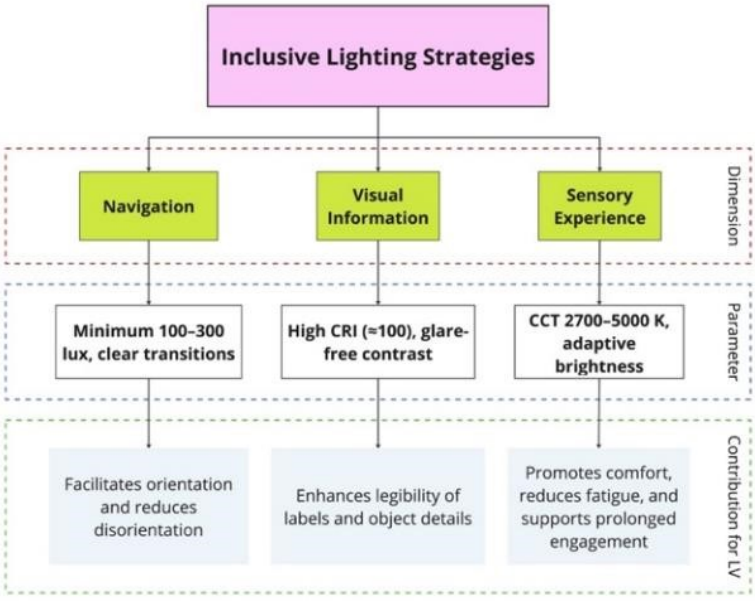


Figure 1: Inclusive Lighting Strategies Conceptual Framework
Source: Authors (2024)

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RESEARCH METHODOLOGY

To gather empirical data, this research employed structured observation to document lighting-related phenomena across the study site, complemented with pictorial evidence for spatial reference. The observation was conducted at the Jakarta History Museum (JHM), formerly Museum Fatahillah, located in Jakarta's Old Town. As a preserved colonial-era city hall, the museum was selected due to its cultural significance and the diversity of its collection, which offers varied spatial and curatorial contexts for testing lighting strategies. A floor plan was used to identify and map measurement points, enabling the documentation of spatial configuration in measurable terms (see Figure 1). The evaluation focused on visitor-accessible exhibition areas, circulation paths, and signage, while staff-only, toilet, and other supporting facilities areas were excluded to maintain the study's emphasis on visitor inclusivity. This delineation also opens a discussion on the future importance of employment accessibility within museums.

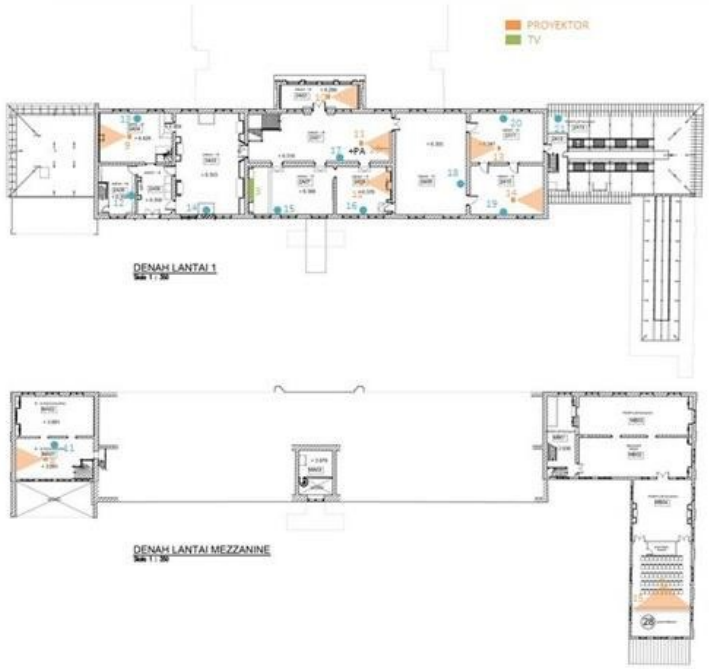


Figure 2: The Jakarta History Museum Plan 1st and 2nd floor for Lighting Observation
Source: Authors (2024)

Measurements were conducted at 30 predetermined points distributed across galleries and circulation zones. Using a calibrated Opple Light Master IV lux meter, data were collected between 10 am and 3pm in March 2025. The lux

meter was positioned horizontally and aligned with the measured plane to ensure consistency. Observed parameters included **illuminance levels (lux), contrast ratios, signage visibility, and label legibility**, as these directly affect navigation, comprehension of exhibits, and sensory comfort for low-vision visitors. These aspects were selected based on international standards, the Smithsonian Accessible Exhibition Design Guidelines (2021), which recommend minimum lux thresholds for circulation, glare control, and shadow-free presentation of interpretive materials. While natural light variations were not fully controlled, repeated measurements at different display points reduced observer bias, enhancing reliability.

To complement observations, expert interviews with museum staff and lighting designers were conducted using semi-structured protocols addressing technical constraints and accessibility. Direct observation of low-vision visitors added empathy-driven insights into navigation, comfort, and interpretive clarity. Triangulating expert perspectives, user experience, and technical measurements reinforced methodological rigour (Trochim et al., 2016). Data validity was strengthened through comparison with literature and guidelines, producing structured insights into inclusive lighting strategies that balance conservation and accessibility in heritage-based museum environments.

FINDINGS AND DISCUSSION

Findings reveal a persistent gap between museum lighting standards and the needs of visitors, who require higher illuminance and controlled contrast for full engagement. Hunt's (2009) layered lighting strategy offers a framework for balancing conservation and accessibility, yet its application at JHM shows operational shortcomings. An observation of 15 points measuring illuminance, CCT, and CRI highlighted inconsistencies: some spaces exceeded conservation thresholds, risking photodegradation, while others fell below minimum accessibility levels, particularly in circulation and digital displays.

Digital Display

Measured lighting levels across all four digital displays fell below the recommended 300–400 lux, with projection mapping and animation walls critically underlit (<50 lux). LV visitors frequently reported "dim text" and difficulty perceiving details, exacerbated by dark projection areas that complicated transitions into standard galleries. These findings support Jackson and Wolffsohn's (2007) view that LV visitors require extended adaptation between lighting conditions, underscoring the need for controlled brightness transitions. Staff noted limited ambient light control and non-functional accent lighting, consistent with Schielke (2020).

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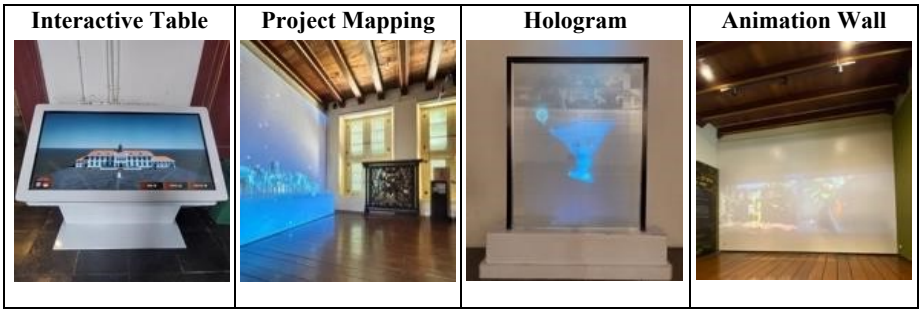


Figure 3: Digital Display in Jakarta History Museum
Source: Author's (2025)

3D Display without Case

For 3D displays without protective cases, lighting relied on ambient and accent illumination. Display A (original artefact) measured 417–498 lux, exceeding the 300-lux conservation threshold (Scuello et al., 2004; Sholanke & Oyipo, 2023), raising concerns over photodegradation. Display B (replica) reached 518 lux, below Gao et al.'s (2020) recommendation of 750 lux and 4000 K CCT for visual comfort. Interviews highlighted tensions: curators prioritised preservation, while low-vision visitors valued higher illuminance for improved detail visibility, underscoring conservation–accessibility trade-offs.



Figure 4: 3D Display without Case in Jakarta History Museum
Source: Author's (2025)

Although the CRI was exceptionally high (95.7), ensuring colour fidelity and supporting sustainability goals (Lee & Yoon, 2021), the warm CCT values (2894–2972 K) created suboptimal conditions for low-vision visitors, who require higher brightness and cooler tones for detail perception. This underscores the limits of relying solely on ambient and accent lighting. A layered strategy, as recommended by Smithsonian Guidelines (2021), can adjust illuminance by object type, balancing conservation needs with inclusivity for low-vision audiences.

3D Displays with Case

Accessibility challenges in the 3D displays with protective glass were pronounced due to glare and inadequate task lighting. Although all cases were originally equipped with task lights, only one remained functional with 114 lux, while others provided <50 lux, far below accessibility standards (Figure 5). This insufficient illumination reduced object visibility, making it difficult for low-vision visitors to perceive contours and details. Such conditions support Walters et al. (2021), who identify glare as a critical barrier, and Blind (2015), who note difficulties with underlit displays near brighter zones.

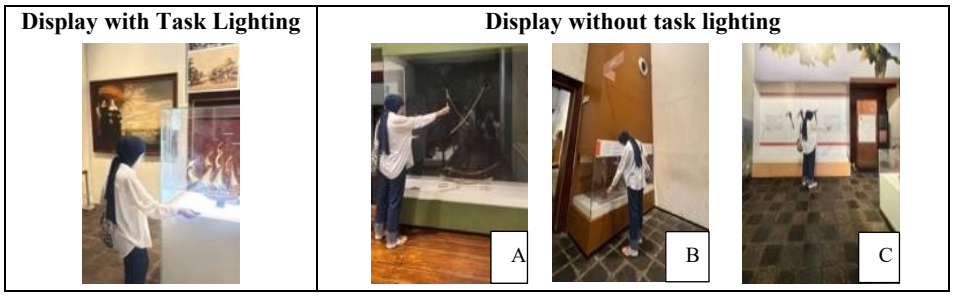


Figure 5: Lighting for 3D Display with Case in Jakarta History Museum
Source: Author's (2025)

Interview findings confirmed observational data: low-vision visitors struggled to perceive object outlines, while staff cited maintenance constraints limiting consistent lighting. Although CCT values (2851–3205 K) and CRI scores (90.2–95.9) indicate high visual quality, the absence of task lighting negated these benefits. Blind (2015) suggests integrating lighting into gallery furniture, provided reflective surfaces are minimised to reduce glare. Thus, accessibility in glass-encased 3D displays requires not only higher, consistent illuminance but also careful design balancing conservation, glare reduction, and inclusivity.

2D Display

The evaluation of 2D displays at the JHM highlights a misalignment between conservation, accessibility, and visitor experience. Historical paintings were illuminated at only 82 lux (CRI 95.5; CCT 2933K), far below the 200–400 lux recommended by Scuello (2004), Sholanke and Oyeyipo (2023), and the Smithsonian Guidelines (2021). While such low levels aid preservation, they hinder detail recognition for LV visitors, who reported difficulty perceiving tonal contrasts and captions in shadowed areas. Printed photographs, measured at 133 lux, also failed to meet the 400–800 lux threshold for LV accessibility. Despite high CRI values (95.5–96), uneven lighting and shadowing exacerbated readability issues. Interview data confirmed that under-illumination and poor

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distribution compromise engagement, underscoring the need for lighting strategies that balance conservation with inclusive accessibility.

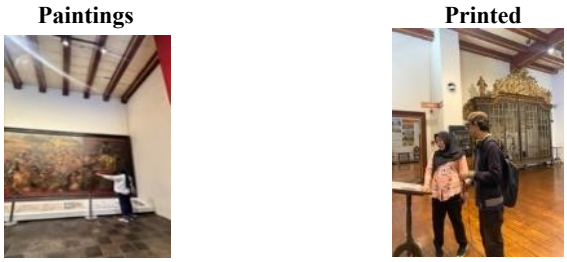


Figure 6: Lighting for 2D Display in Jakarta History Museum
Source: Author's (2025)

Caption or Labels

Captions and labels serve as critical mediators of interpretive accessibility in museums, yet findings from the Jakarta History Museum (JHM) reveal substantial shortcomings in their design, illumination, and placement. Transparent captions affixed to glass surfaces demonstrated the most pronounced accessibility barriers. Despite achieving a CRI of 96 and a CCT of 3089K, both generally acceptable for producing visual comfort, the recorded illuminance was only 133 lux, significantly below the Smithsonian's recommended 400–800 lux range. The reflective quality of the glass generated glare, a condition repeatedly cited by LV participants who described text as "nearly invisible." These observations corroborate Walters (2021) and Schielke (2019), who emphasise that insufficient illuminance, when combined with glare and poor contrast ratios, substantially diminishes text readability.



Figure 7: Lighting for Caption and Labels in Jakarta History Museum
Source: Author's (2025)

Printed captions placed on solid substrates with high-contrast backgrounds performed marginally better, registering 247 lux, a CRI of 95.9, and a CCT of 2936K. While the higher illuminance provided comparatively clearer visibility, values still fell short of accessibility standards. Furthermore, their

location behind glass display cases introduced shadowing and light reflection that obstructed clear viewing angles. This finding aligns with Blind's (2015) observation that obstructed or poorly positioned captions undermine visitor comprehension even when text quality is sufficient. In interviews, museum staff acknowledged the readability challenges but noted that interventions were not prioritised due to budgetary limitations, reflecting a broader institutional struggle to balance conservation, interpretive clarity, and resource constraints.

Background-integrated captions represented the most problematic format. Although typically larger in font size, they recorded illuminance as low as 27 lux, rendering them almost unreadable for LV visitors despite an optimal CRI of 97.2 and an acceptable CCT of 3166K. Participants frequently reported difficulty distinguishing letters, particularly in shadowed sections, underscoring Walters' (2021) claim that poor lighting placement exacerbates legibility issues regardless of font scale. This mismatch between design intent and accessibility outcomes highlights the limited effectiveness of background integration as a strategy for inclusive communication.

Taken together, these findings underscore the urgent need for a holistic approach to caption and label design, which combines adequate lighting levels, glare-free materials, and ergonomic placement. Without such interventions, museums risk excluding a significant demographic of visitors. Prioritising adaptive captioning strategies not only enhances accessibility but also supports broader inclusivity goals central to contemporary museum practice.

The integration of empirical measurements, visitor interviews, and staff insights reveals both systemic shortcomings and viable opportunities for enhancement. Although JHM officially implements a layered lighting strategy, operational challenges, such as maintenance issues, outdated systems, and inadequate adaptive controls, diminish its effectiveness. These observations highlight the pressing need for lighting solutions that are adaptive, glare-free, and dynamically controlled, striking a balance between conservation and inclusivity. By adopting a thematic, user-centred approach to lighting that combines quantitative data with lived experiences, we can create a model for advancing accessibility in Indonesian museums.

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Table 1: Summary of Lighting Application at the JHM

No	Space / Display Type	Illuminance (Lux)	CCT (K)	CRI	Standard Reference (LV)
1	Interactive Table	139	3952	91	300 – 750 lux 4000-5000K (CCT) CRI ≥ 90
2	Hologram Display	243	2888	90	
3	Projection Mapping	12	3868	92	
4	Animation Wall	31	3853	91	
5	Display Without Case A (artefact)	417	2894	95,7	400-750 lux 4000-5000K (CCT) CRI ≥ 90
6	Display Without Case B	518	2972	95.7	400–800 lux (LV) 2700–5000 K (CCT) ≥100 (CRI)
7	Display with case and Task Lighting	114	2944	91	
8	Display with case A	36	3205	93,1	
9	Display with case B	151	2851	90,2	
10	Display with case C	261	2943	95,9	
11	2D Painting	82	2933	95.5	200–250 lux 2500–7000 K (CCT)
12	2D Printed	133	3069	96	400–800 lux 4000–5000 K CRI ≥90
13	Transparent Caption	133	3089	96	
14	Caption on Solid Case	247	2936	95.9	
15	Background Caption	27	3166	97.2	

Meet the Standard Below the Standard

Comparative Context: Lighting Practices in Other Indonesian Museums
The accessibility challenges identified at the JHM are consistent with patterns observed in other Indonesian museums, particularly those housed in heritage buildings. For instance, Fort Vredeburg Museum in Yogyakarta exhibits similar constraints in achieving uniform illuminance due to reliance on natural daylight and minimal adaptive control. In contrast, contemporary institutions such as Museum MACAN in Jakarta have adopted adaptive LED systems with higher colour rendering indices and variable correlated colour temperatures, resulting in improved legibility and visual comfort. This comparison indicates that lighting strategy remains a key determinant of inclusive accessibility across Indonesian museums, highlighting the urgent need for national standards that balance conservation requirements with perceptual equity.

CONCLUSIONS

This study demonstrates that inadequate lighting within the JHM continues to restrict accessibility for visitors with LV. Triangulated findings from illuminance measurements, staff interviews, and field observations reveal systemic deficiencies, including substandard brightness levels, non-functional task lighting, and captions compromised by glare and low contrast. These constraints

are compounded by financial limitations and the spatial rigidity of colonial-era buildings that were never designed to accommodate inclusive museum functions.

A layered lighting approach is therefore critical to reconcile conservation and accessibility goals. Uniform, low-glare ambient lighting should establish visual coherence; accent lighting must be strategically refined to enhance artefact visibility; and functional task lighting reinstated to support close-range engagement. Integrating high-CRI LEDs, glare-reducing diffusers, and furniture-embedded lighting provides cost-effective and contextually adaptable solutions to improve visual legibility without compromising preservation.

Although this study emphasised empirical lighting evaluation, future research should advance participatory methods involving LV visitors through sensory walkthroughs and co-design workshops. Such engagement will deepen understanding of perceptual adaptation, inform adaptive lighting controls, and reinforce a user-centred approach within Indonesia's climatic and architectural constraints.

The findings also carry significant policy implications. Current Indonesian museum management frameworks tend to prioritise conservation, with limited provisions for inclusive design. Incorporating accessibility-oriented lighting benchmarks, aligned with ICOM's (2007) accessibility mandate and Indonesia's heritage management policies, will institutionalise inclusive practices. Routine lux audits, adaptive LED maintenance, and staff capacity-building should form part of these policies. Ultimately, inclusive lighting must be recognised not merely as a design intervention but as a foundation for cultural equity and sustainable museum development across Southeast Asia.

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URBAN HOUSING AFFORDABILITY: ANALYZING THE IMPACT OF AFFORDABLE HOUSING SCHEMES ON HOUSING PRICES

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Abstract

Housing affordability remains a critical issue in urban areas, where rising demand and limited supply drive property prices upward. Governments have introduced affordable housing schemes to address these challenges, but their effectiveness hinges on alignment with local market conditions and demand-side factors such as financial capability, government regulation on affordable housing, and location preferences. Despite their importance, few studies have examined the specific attributes of affordable housing schemes and their impact on housing prices. This study bridges this gap by investigating the relationship between affordable housing prices and housing demand, employing a mixed-methods approach and using correlation and regression analysis, an initial framework of 15 attributes was evaluated, categorized under financial approvals, government regulations, and location preferences. The results reveal that nine attributes significantly influence housing prices within affordable housing schemes. Key factors include credit history, down payment, loan margin, approval location, qualification requirements, and procedural complexities, all of which exhibit strong correlations with housing prices. These findings underscore the need for policymakers to refine regulatory mechanisms to better align with the financial capabilities of homebuyers. By addressing these factors, housing policies can be tailored to enhance affordability and promote sustainable housing development.

Keywords: Housing prices, affordable housing scheme, location preferences, financial approval, demand factors

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INTRODUCTION

The continuous increase in housing prices has emerged as a global challenge, affecting both developed and developing country. In Malaysia this trend has significant affected towards development and market prices of affordable housing scheme in urban areas (Saleh et al., 2024). Housing demand turned to exercise certain issues especially for low- and middle-income buyers to own houses nearby or in the city. While governments worldwide have introduced affordable housing schemes to mitigate these challenges, aiming to provide low- and middle-income households with access to decent and affordable homes. However, the effectiveness of these schemes is often undermined by the complex interplay between housing prices and demand-side factors, such as buyer preferences, regulation, and location attributes (Majid et al., 2023). In Kuala Lumpur, high demand of affordable housing scheme due to existence facilities and amenities in urban areas and land scarcity drive market dynamics especially on housing prices.

Furthermore, these challenges turn to the balance in between availability of the housing or land and types of homes that people want to proceed with the affordable housing scheme. For housing supply, stakeholders like financial institutions for providing housing loan together with housing developers and government plays a complex regulatory environment towards ownership, tenure and housing design (Saleh et al., 2022). These regulatory indirectly translate into higher development cost that passed on to the buyers. For instance, housing developers frequently offset losses from subsidized affordable units by increasing the prices of market-rate homes—a phenomenon known as "cost-shifting" (Urban Institute, 2020). Meanwhile for housing demand, preferences of buyers on financial approvals like interest rate, loan tenure, bureaucratic procedure to apply these types of housing, and location further shape fluctuation of housing market. Middle income housing buyers, for example, often prioritize proximity to jobs and public transit, while some emphasize space, school quality, and affordability (Julien et al., 2025).

Although extensive research on housing price determinants, significant gaps remain. Previous studies rely mostly on secondary data to analyze market trends and housing supply side (Darendra & Riyanto, 2025; Berawi et al., 2022; Batog et al., 2013; 2019). Earlier studies have systematically compared suburban markets, even though these geographies operate under distinct regulatory, economic, and social logics. For example, urban markets are characterized by high demand for limited land, whereas suburban markets face challenges related to infrastructure accessibility and sprawl (Saleh et al., 2016). While prior studies have addressed general macroeconomic variables (Malpezzi, 2002); geographical location (Mukhtar et al., 2025); Structural attributes (Saleh et al., 2024), they failed to focus on local regulations contexts. This research tends to fill the gaps by focusing on local regulatory context, which examining current procedure set

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by current government. Other than that, by understanding the impact between housing prices in certain areas recognised in Klang Valley and factors influence on housing demand it is critical for creating effective guiding principle for this research. The study highlighted these gaps by employing additional regulation attributes align with the local context used mixed methods integrating secondary data on housing prices and questionnaire feedbacks from housing buyer. The research takes to answer important key question: what factor impacts on housing demand that suitable with local context; how do housing demand preferences influence housing prices in urban areas and which mediate this relationship? By combining insights from analysis of market data transactions in Klang Valley specifically under housing that already been categories as affordable housing scheme and feedback through questionnaires from housing buyers, the study provides holistic understanding towards housing market dynamics and segmentation.

LITERATURE REVIEW

Affordable Housing

According to Cambridge Dictionary (2019) affordable housing define as houses that can be bought or rented by people who do not earn a lot of money. Globally, affordable housing is accepted that have financially accessible to low-and middle-income that costing not more than 30% of households gross income. (Majid et al., 2023; Glaeser & Gyourko, 2003). Unlike, term of housing affordability which describe as the relationship between housing expenditures and household income. For Malaysia, a list of projects that consider as affordable housing scheme were PR1MA, PPAM, Rumah Selangorku etc. Federal and state Governments often implement affordable housing schemes to ensure that such housing can meet housing needs, particularly in urban areas where high demand and limited supply drive prices upward (Malpezzi & Vandell, 2002). These schemes may include subsidies and incentives for housing developer that aimed to control price and reduce the financial burden of households (Quigley & Raphael, 2004). However, the effectiveness of these initiatives often depends on their alignment with local market conditions and demand-side factors, such as income levels and household preferences (Green et al., 2018).

Factors affecting housing prices

Previous research indicates that location, structural features and environment factors are the key attributes that affect property value (Riyanto et al., 2021). Other than that, Gyourko and Molloy (2015) argue that stringent government regulations—including affordable housing regulation, construction specifications, and zoning restrictions—result in increased building costs that are

subsequently transferred to homebuyers. These attributes may negatively and positively give impacts to property values (Kauko, 2003).

The first main and initial factors is the financial approvals and regulation of getting housing loan. The nature of local financial institution in order to approve housing loan are mostly dependent on the incomes of the applicant. From here, the decision for applicant on whether to proceed to buy an affordable housing scheme that has been offered to them usually been determined by the loan margin, in which refer to the percentage of the housing loan that has been approved. Typically, 100% for the first time homebuyers, however due to certain reason it might sometimes reduced to 90%. As the result, the remaining 10% has had to be paid in cash by the applicant to the housing developers. Other attributes in this financial regulation have also included loan tenure, credit history and financial procedures themselves (Saleh et. al., 2024).

The second factors affecting housing prices is the regulation subjected to affordable housing itself. In Malaysia, different affordable housing scheme has different approach to apply. Projects for PPAM (Perumahan Penjawat Awam Malaysia) for example are purposely for government servant. Meanwhile, project for Rumah Selangorku only for those who categorised as Selangor residents. Applicant must either be born in Selangor or have lived in Selangor for certain period (LPHS, 2020). Other than that, attributes inside this second factors, that might influence housing demand was selling price levied for affordable housing, condition executed for affordable housing, current procedure to apply affordable housing and approval location for affordable housing (Majid et al., 2023; Saleh et al., 2017)

Lastly, geographical location. Location is arguably one of the critical determinant of housing prices. Properties situated in city centers or near to major employment hubs, transportation nodes, and quality educational facilities typically command in high value of property. Cheshire and Sheppard (2004) argue that the spatial location of a property is intrinsically linked to its market value, as proximity to economic opportunities and essential amenities increases housing demand. Saleh et al. (2022) expand on this view by demonstrating traffic conditions, accessibility of highway, amenities and facilities. Most studies previously try to measure the relationship between property prices and their distance to others places (Crespo & Gret-Regamey, 2013; Dai et al., 2020; Darendra & Riyanto, 2025), but often overlooking the locational accessibility (Mukhtar et al., 2025).

Empirical Models in Housing Price Analysis

Empirical analysis in housing economics has increasingly adopted hedonic pricing models to disentangle the effects of various determinants on housing prices (Darendra & Riyanto, 2025). It all started with the widespread

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development of housing models by several scholars, including Lancaster (1966) and Rosen (1974) which have been widely used to evaluate the attributes influencing product prices, based on the assumption that housing supply and demand are in equilibrium. Meanwhile, Leong, Preston, and Rice (2005), in contrast, successfully identified different concepts for measuring housing gaps. Rosen's (1974) foundational work laid the groundwork for subsequent studies that employ regression techniques to isolate the influence of regulatory, product, and locational factors. Meanwhile, previous researchers have used the same model to understand the factors contributing to house price gaps. This paper seeks to bridge that gap by providing empirical evidence that quantifies the specific impacts of these factors on urban housing prices over the past decade. By comparing housing prices and demand factors is crucial for understanding affordability challenges and market dynamics towards those people who lived in this scheme.

RESEARCH METHODOLOGY

The mixed methods were conducted to determine the significant factors influencing housing demand and housing prices. A questionnaire survey was randomly distributed to 400 homebuyers across various affordable housing schemes in urban areas of Klang Valley, Malaysia. For the sample size based on data gathered from Dewan Bandaraya Kuala Lumpur (DBKL) approximately 47,009 residents represented as homebuyers were recorded in several areas selected within Klang Valley. According to Krysik and Finn (2013), the common research for social science standard for the confidence level is 95%. For this research, with a confidence level of 95% and a margin of error of ±5%, the required minimum sample size is 398 respondents at least. Other than that, to assess this relationship, several areas in Klang Valley were selected as a sample study area for this research. These areas were chosen based on the existing projects of affordable housing in those areas. Additionally, the transaction prices that were collected from National Property Information Centre (NAPIC) on 2024 as a reference to measure the relationship. The location and market data were compiled in table below;

Table 1: Average prices according to areas in Klang Valley

Area	Average Price Sqft (RM)	Built up areas (psf)
AS1	341.9	530.66
AS2	338.7	688.89
AS4	316.8	527.86
AS5	485.4	1302.43
AS6	476.9	1399.31
AS10	252.9	534.97

Previous studies on methodology of housing prices analysis employed from simple correlation analysis to wide range of approaches like econometrics (Hadavandi et al., 2011). Traditional methods include corelation analysis mostly explores basic determinant between housing prices with income (Malpezzi, 2002). However, regression methods remain the most widely used in managing data of structural, location and local attributes. Meanwhile, for this research, the collected data was analyzed using the Statistical Package for Social Sciences (SPSS) to assess the relationships between housing demand factors and price levels through regression analysis. The study measured the significance of demand-side factors by evaluating the strength of the relationship through correlation (r), coefficient of determination (R^2) value, path Coefficient (β), effect size (f), P-value (Sig.) and Significant coefficient. In the light of the following research, the hypothesis included;

- H^1 – *Housing price have a significant impact on homebuyers' perspectives when purchasing affordable houses*.

In addition to develop the model, this study combines a few relevant attributes to justify the relationship between housing prices as dependent variables and factors influencing housing demand as independent variables. The attributes were gathered through past studies and relevant features that subjected to the context of affordable housing scheme in Malaysia. The initial conceptual framework is shown in Figure 1.

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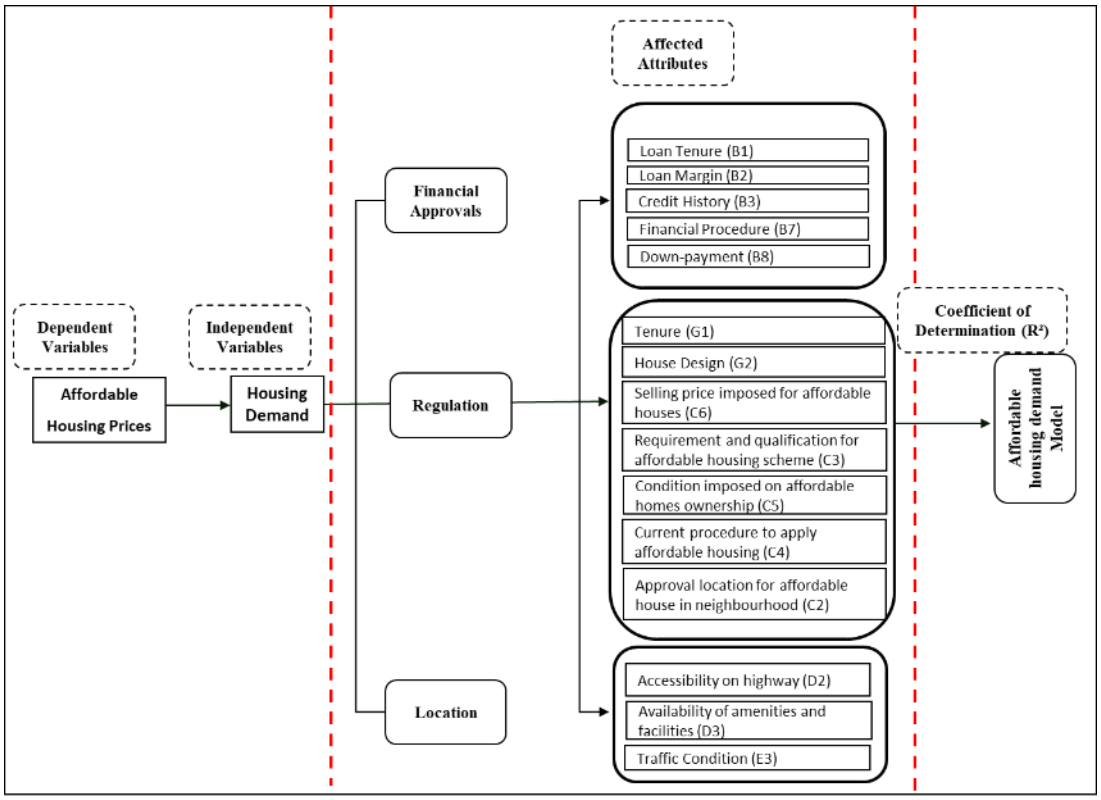


Figure 1: Conceptual and Research framework *(Author Self-compilation)*

The figure above presents the initial research framework, which was put together after considering various factors relevant to the local context in Malaysia. Three main factors that included totalled of 15 attributes. The regression model formula for this research can be outlined as below;

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \ldots + \beta\,\gamma\,X\,\gamma + \varepsilon$$

Where;

Y = Dependent variable; House Prices
X = X1*, X2*, X3*, .. Xγ = *Independent variable; Attributes of housing demand*
β0, β1, β2, β3, ...βγ = *Parameters of the variables*
Ɛ = *Error estimation*

A previous study stated that key norms to be considered prior to conducting regression analysis include normality result, homoscedasticity,

residual patterns, missing data, and the number of outliers in variables (Pallant, 2005). Based on this, the researcher selected some recommendation to ensure viability of data were accomplished. With a large sample, if only a few outlying residuals are found, taking corrective action may not be necessary (Pallant, 2005). Therefore, the researcher will proceed to the next step of conducting normality tests.

RESULT AND DISCUSSION

Normality test

Table 2 show the result whether the residuals (errors) follow a normal distribution, which is an assumption in many regression models;

Table 2: Normality Result

Variable	**Normal distribution**		**Status**
	Skewness	**Kurtosis**	
Financial Approvals	-1.386	.551	Normal
Government Regulation	-1.440	.542	Normal
Location	-1.583	1.071	Normal
House Price	1.025	1.782	Normal

In the result presented above, the skewness and Kurtosis were purposely to measure the normal distribution for the data within the sampled areas. Julie Pallant (2005) highlights that if the distribution is perfectly normal, the result from skewness and kurtosis might obtain value of 0. However, based on Hair et al. (2011) the minimum substantial for skewness and kurtosis is below ±2, respectively. Therefore, from the result above the data can declared as normally distributed.

Correlation analysis with dependent variables

Table 3 show the correlation between housing prices and factor influence housing demand. According to Cohen (2013) the negative sign refers only for the path of the relationship not the strength;

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Table 3: Correlation of Housing demand on house price

Variables	Pearson Correlation (*r*)	Sig.2-Tailed	Relationship
House Price			
Financial Approvals	-0.501	0.000*	Negative and Strong
Government Regulation	-0.511	0.000*	Negative and Strong
Location	-0.373	0.000*	Negative and Moderate

Cohen et al. (2013) provide a guideline for interpreting correlation strength: correlations between ±0.10 to ±0.29 are considered weak, ±0.30 to ±0.49 are moderate, and ±0.50 and above are strong. This helps determine the strength of relationships between variables in statistical analysis. The correlation results indicate that financial approvals (-0.501) and government regulations (-0.511) have a strong negative impact on house prices, meaning stricter loan approvals and tighter regulations lead to lower prices. Location (-0.373) has a moderate negative effect, suggesting that less desirable locations are indirectly lead to lower house prices, but other factors also play a role. From the result above, direction of correlation plays the significant reason in which suggesting; *The more increasing in house price they have, the less housing demand they experience* or vice versa. It indirectly suggests that attention should be focus on government regulation and financial approvals in which government should consider balancing regulatory measures and credit accessibility to ensure a stable affordable housing market being apply. All relationships are statistically significant ($p = 0.000$), highlighting that demand-side constraints significantly influence house prices, with financial and regulatory factors being the most impactful. From this strong result, the coefficient results will be continuing to explore the data.

The standardise coefficient of the fifteen attributed will be explain in Table 4;

Table 4: Coefficient result of Housing demand attributes with house prices

Regression Analysis between House Price				
House Price	***Beta***	***t***	**Sig. A**	**Ranks**
House Design (G2)	**-.141**	**-2.080**	**.004**	**9**
Tenure (G1)	.128	1.882	.058	Not Sig.
Loan Margin (B2)	**.244**	**3.374**	**.001**	**3**
Credit History (B3)	**-.408**	**-5.255**	**.000**	**1**
Loan Tenure (B1)	-.045	-.574	.567	Not Sig
Down Payment (B8)	**-.299**	**-3.652**	**.000**	**2**
Financial Procedure (B7)	**.148**	**2.092**	**.002**	**4**
Requirement and qualification for affordable housing scheme (C3)	**-.174**	**-2.414**	**.004**	**7**
Current procedure to apply for affordable houses (C4)	**.159**	**2.135**	**.004**	**8**
Condition imposed on affordable homes ownership (C5)	.097	1.430	.153	Not Sig.
Approval location for affordable houses in the neighbourhood (C2)	**-.224**	**-2.979**	**.003**	**5**
Selling price imposed for affordable houses (C6)	.002	.025	.980	Not Sig.

Regression Analysis between House Price				
House Price	***Beta***	***t***	**Sig. A**	**Ranks**
Availability of amenities and facilities (D3)	.042	.555	.579	Not Sig.
Accessibility to highways (D2)	-.051	-.733	.464	Not Sig
Traffic Condition	**-.201**	**-328**	**.001**	**6**

A closer observation of the specific variables shows that only nine attributes were significantly associated with house price (below p-value) and comprising both negative and positive relationship. The highest prediction value were score by factor in financial approval which are credit history (β = -0.408, t-test=-5.255, $p< 0.05$), followed by down payment (β = -0.299, t-test=-3.652, $p< 0.05$) and loan margin (β = 0.244, t-test=3.374, $p< 0.05$) with financial procedure provided positive relation with house price (β = 0.148, t-test=2.092, $p< 0.05$). If there are positive correlation, the result revealed that when there is an increase of 1 percent for loan margin and financial procedure, the house price will increase by 0.244 percent and 0.148. Whilst, if there are negative reaction like credit history and downpayment, the result predicted that when there is an increase of one percent for both, the house price will decrease at 0.408 percent and 0.299 percent.

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Next, the result was then indicated government regulation as a second main factors that has high dependency with house price. The attributes begin with, approval location for affordable houses in neighbourhood (β = -0.224, t-test=-2.979, $p< 0.05$), but followed with different main factors that comes from location which is traffic condition at (β = -0.201, t-test=-3.328, $p< 0.05$). The score then indicated requirement and qualification for affordable housing scheme (β = -0.174, t-test=-2.414, $p< 0.05$) and current procedure involve to apply for affordable houses (β = 0.129, t-test=2.135, $p< 0.05$) which the only attributed in government factors provided positive reaction. Since most the attributes provided negative correlation with house price, the result theoretically portrays that when there is an increase of one percent for approval location, traffic condition, requirement and qualification for affordable houses, the house price will decrease by 0.224 percent, 0.201 percent and 0.174 percent. Whilst the lowest prediction value shows house design at β = -0.129, t-test=-2.135. Even, from government regulation 'tenure' has provided high score of correlation with housing demand profiles the coefficient result provided difference interpretation which above then significance value. Tenure provided a positive result of β = 0.128, t-test=1.882, $p> 0.05$, followed with condition imposed on affordable homes (β = 0.097, t-test=1.430, $p>0.05$), Access to highway (β = -0.051, t-test=-0.733, $p> 0.05$), loan tenure (β = -0.045, t-test=-0.574, $p> 0.05$), availability of amenities and facilities (β = -0.042, t-test=-0.555, $p> 0.05$), and lastly, selling price imposed for affordable houses at β = 0.002, t-test=0.025, $p> 0.05$).

From the findings, the highest attributes give impact to decrease or increase of affordable housing price had come through factors of financial approvals from financial institution and government regulation. As instance can be seen from positive attribution for loan margin. Government has approved up until 100% for financial institution to worked with those 1st homebuyers as mentioned in literature review. However, because of this positive reaction by homebuyers (demand) it might lead for housing developer for increasing the house prices seem purchasing power are increase. Yet, it vice versa with downpayment which provided negative reaction towards people or demand. Majority of people doesn't have any choice but must provide deposit for 10% which dissatisfied them for purchasing any affordable houses, this supposedly make a private developers reconsider their decision in providing high-end houses which might lead to decreasing in housing prices.

After data cleaning and determine the highest correlation attributes that suit with regression analysis, the analysis provided only nine attributes out of fifteen attributes that fit with the model fit with the model. The selected nine attributes are Credit History (B3), Downpayment (B8), loan Margin (B2), Financial Procedure (B7), Approval location for affordable houses in the neighbourhood (C2), Traffic condition (E3), Requirement and qualification for

affordable scheme (C3), Current Procedure to apply affordable houses (C4) and Housing design (G2). From table 5 below, the potential regression model was identified;

Table 5: Regression analysis of Housing demand with house prices

Regression Analysis between House Price and attributes of housing demand				
	E3, B2, B7, C3, B3,	***R***	***Std. Error***	***Sig.***
House Price	G2, C4, C2, B8	0.672	43.56334	0.000
	R²	.431		
	F	21.072		

From the Table 5 above, regression analysis was performed to determine the relationship between house price and attributes from housing demand. The result revealed that the model collectively explains at 43 percent of the variance found in house price, with R^2=0.431, F=21.072, $p<0.05$. Based on ruled of thumbs of coefficient of determination (R^2) Cohen (2013) stipulated R^2 greater than 0.26 are considered as substantial. A closer aspect the variables that fit with the model of house prices provided with nine attributes.

Respectively, this would indicate about 43% of positive variation for house prices had explained this attributes. This result is consistent with previous research made by Saleh et al. 2024 and Majid et al. 2023. Their research consistently highlighted that financial and regulation attributes also part of significant impacts in housing demand. The researcher can summarized from the R^2, the strength of new attributed of affordable housing demand is positively correlated and has a substantial relationship with the housing price in the sampled areas.

CONCLUSION

As conclusion, the findings indicate that financial approval factors and government regulations play the most significant roles in influencing housing prices for affordable housing. Financial elements such as credit history, down payment, and loan margin exhibit strong correlations with price variations, emphasizing the impact of buyers' financial capacity on market trends. Specifically, an increase in loan margin and financial procedures results in higher housing prices, while stricter credit history and down payment requirements tend to reduce affordability. Similarly, government regulations, including government approval locations, traffic conditions, and qualification requirements for affordable housing, predominantly show negative correlations with price, suggesting that regulatory measures can influence housing accessibility (Saleh et al., 2024; Gyourko & Molloy, 2015; Glaeser & Gyourko, 2018). Although, the final model above contributed to 43% impact towards housing demand aligning

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with Al Shawabkeh et al. (2020), their study emphasized challenges in services provision and maintenance of affordable housing but did not examine regulation in local context.

Additionally, location attributes contribute to price determination in Klang Valley, but their influence is relatively less significant compared to financial and regulatory factors. However, previous studies have shown that locational attributes are significantly influenced by property buyers in north region (Mukthar et al., 2025). This indicates that locational attributes are largely dependent on characteristics of places and demographic profiles of buyers.

The findings suggest that policies aimed at improving access to affordable housing should focus on balancing financial accessibility with regulatory efficiency. By refining approval processes, optimizing financial loan structures, and ensuring strategic location planning, policymakers can help stabilize housing prices and enhance affordability for a broader segment of buyers (Quigley & Raphael, 2004; Hilber & Vermeulen, 2016). Finally, further study is required to investigate how sustainability factors may give impact to affordable housing prices for future direction of affordable housing market. This is important for affordable housing to move forwards with the existing policies and adopt the application of sustainable development practices like solar energy and Building Information Modelling (BIM).

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GEOMETRIC ANALYSIS OF MUQARNASES IN CENTRAL ASIA (BASED ON THE ARCHITECTURAL SCROLL "DAFTAR-I GIRIH")

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Abstract

This study examines the geometry and architectural significance of muqarnas in Islamic architecture, with a particular focus on historical manuscripts and scrolls such as the Daftar-i Girih. Muqarnas, a distinctive element of Islamic ornamentation, are explored through their etymology, classification, structural composition, and geometric principles. The research adopts a multidisciplinary approach combining comparative, chronological, experimental, and geometric analyses with 3D modelling to unravel the complexities of design and construction. By analysing manuscript sources from Uzbekistan, Central Asia, and the Middle East, including the works of traditional architects, the study identifies key structural elements of muqarnas such as the shams, kosa, poya, and taxt. The findings also highlight the importance of two-dimensional construction drawings (taxbins) for interpreting three-dimensional forms. Beyond historical analysis, the study emphasizes the potential of these principles in contemporary design, suggesting their value in restoration practices and modern architectural innovation.

Keywords: Muqarnas, Islamic architecture, Timurid dynasty, Geometric analysis, 3D modelling, Heritage conservation, Restoration, Contemporary applications

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INTRODUCTION

Muqarnas, a unique element of Islamic architectural decoration, has long fascinated both scholars and architects for its intricate geometric patterns and structural complexity (Muhammad Usman Ghani & Usman Ghani, 2021). Islamic art and architecture, enriched with geometry and calligraphy, play a vital role in shaping the cultural and aesthetic identity of historic cities. Their preservation is therefore crucial not only for heritage conservation but also for cultural tourism and sustainable urban development (Baydoun et al., 2023, 2024; Dariyadi et al., 2022). Originating in the early Islamic period, muqarnas developed into a highly sophisticated art form that embodies the fusion of mathematics, craftsmanship, and architectural design. Despite their widespread use, the origins, classification, and underlying geometric principles of muqarnas remain contested topics in scholarship (Muhammad et al., 2025).

The purpose of this study is to address these research gaps through the analysis of historical manuscripts and archival sources from Uzbekistan, Central Asia, and the Middle East. It aims to safeguard traditional techniques of muqarnas construction that are at risk of disappearing with the decline of master builders and limited documentation of their knowledge. Using comparative, chronological, experimental, and geometric methods, this research uncovers the principles of muqarnas design and evaluates their applications in both historical and modern contexts.

The scientific contribution of this research lies in its systematic approach to classifying muqarnas. It also highlights the importance of two-dimensional construction drawings (*taxbins*) in understanding three-dimensional muqarnas structures a concept often overlooked in previous studies. By combining manuscript analysis with 3D modeling, the study creates a framework that not only enhances scholarly understanding but also supports conservation and contemporary architectural practice.

LITERATURE REVIEW

Important insights into the creation and restoration of muqarnas in Islamic architecture can be found in the treatises of encyclopaedic scholars, as well as in manuscripts written by master architects from Uzbekistan, Central Asia, and the Middle East. Many of these are preserved in national archives and major libraries worldwide (Asiva Noor Rachmayani, 2015; Dold-Samplonius & Harmsen, 2015; Fukami, 2017; Zer & Reyhan, 2023). These sources contain valuable geometric diagrams and practical methods, though in many cases the information is incomplete or scattered across texts.

Scholarly interest in muqarnas has grown significantly in recent decades. Earlier studies provided important foundations for understanding girih and muqarnas, yet they often remain general in scope and do not fully address

issues such as typology, modular development, and restoration challenges (Basiri, 2024; Safaeianpour & Valibeig, 2024). For example, while these works shed light on construction methods, they frequently overlook the practical difficulties faced by craftsmen or the role of regional variations in shaping design. Manuscript sources from Central Asia, particularly those held in Bukhara and Tashkent, have also received less attention and rarely been subjected to detailed geometric analysis.

History of studying Muqarnas, classification, and theories of analysis

Research on the etymology and classification of muqarnas is diverse. Some scholars suggest the term derives from the Arabic "qurnas" or "qirnas," meaning vaulted ceiling (Dinçer & Yazar, 2021). Others connect it to the Greek *korōnís* or the English *cornice* (Carrillo, 2016). Despite differences in terminology, most agree that muqarnas consist of a common set of structural elements: the *shams* (sun), *kosa* (bowl), *poya* (stem), and *taxt* (scaffold), which occur in various combinations and subtypes such as *toranj*, *taseh*, *parak*, and *shaparak*. Understanding these basic elements is crucial, as they form the building blocks of increasingly complex three-dimensional compositions.

Historical Evolution of Muqarnas Geometry

Before the Timurid era, Muqarnas were mainly constructed using modular systems, especially the *rectangular type*, while irregular forms were rare. These structures were typically designed from regular octagons, rectangles, and triangles, and examples remain preserved in Bukhara, Samarkand, Kunya-Urgench, and partly in Termez. Although no manuscripts from Uzbekistan explicitly document this typology, comparative studies have identified parallels in neighboring regions. One of the earliest known examples is the 13th-century Muqarnas at Takht-e Sulayman in Iran (Röhrs et al., 2022) (Figure 1).

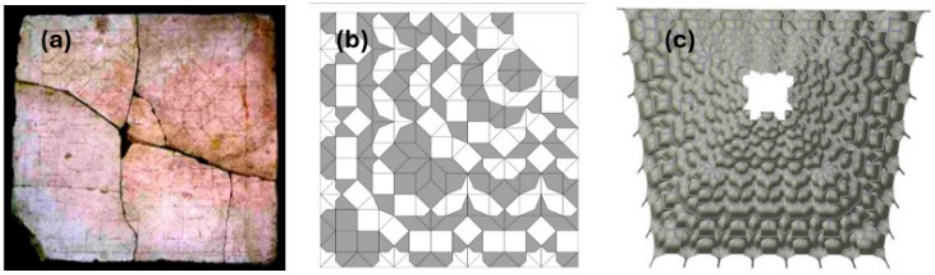


Figure 1. Muqarnas Plan Found at Takht-i Sulayman (Iran, 13th century)
Source : https://www.geogebra.org/m/dmwdvmxm .

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Geographic Comparisons

While studies of muqarnas in Uzbekistan are relatively limited, broader research reveals rich regional traditions across the Islamic world. In Iran, Safavid-era manuscripts such as those from Isfahan and Yazd illustrate advanced polygonal methods (Koliji, 2016). In Anatolia, Ottoman architects employed muqarnas extensively in portals and domes, with examples like the Sultanhanı caravanserai showing both structural and decorative functions (Dinçer, 2022). Egyptian Islamic architecture also demonstrates innovative uses of muqarnas in transitional dome zones, particularly during the Mamluk period (Fukami, 2017). In Andalusia, the Alhambra in Granada represents one of the most celebrated examples, where muqarnas not only embellish interiors but also symbolize cosmological order. These comparative perspectives highlight the adaptability of muqarnas to different cultural and structural contexts, enriching our understanding of their global architectural role.

Contemporary Scholarship

Modern researchers continue to analyze muqarnas using digital and mathematical approaches. The analysis of early “taxbins” (construction diagrams) shows their connection to vault-building traditions. Giyasaddin al-Kashi’s *Miftah al-Hisab* remains one of the most detailed historical sources, proposing modular calculation methods for rectangular-based muqarnas (Kāshī et al., 2022). Recent studies using 3D modeling and parametric design have further advanced this field (Brotherton, 2023). However, scholars note that while manuscript analysis offers valuable insights, it also risks narrowing focus to texts alone. Additional case studies from monuments provide a necessary balance, linking theoretical diagrams with real-world construction (Ganikhodjaev & Husain, 2018).

Recent publications in Planning Malaysia Journal highlight the cultural and design principles of Islamic architecture in contemporary contexts. Baydoun et al. (2023) examined the role of Islamic art and design in shaping Putrajaya, Malaysia, while Baydoun et al. (2024) explored placement principles of calligraphy in historic palaces. These studies demonstrate how Islamic decorative traditions including muqarnas remain relevant to modern architectural identity, offering useful frameworks for linking heritage knowledge with urban design practice.

RESEARCH METHODOLOGY

This study employs a multidisciplinary methodology that combines comparative analysis, chronological study, geometric examination, and experimental reconstruction. These approaches are supported by two main types of sources: **historical manuscripts** and **architectural sites**. Manuscripts such as the *Daftar-i Girih* provide detailed construction drawings, while fieldwork at monuments in

Bukhara, Samarkand, and other Central Asian cities offers physical evidence of how these diagrams were translated into built form. The inclusion of site-based observations ensures that the research is not limited to textual sources but also engages with architectural practice.

A key feature of this methodology is the integration of **3D modeling**. Digital tools were used to reconstruct muqarnas from historical drawings, allowing researchers to visualize how two-dimensional diagrams (*taxbins*) become three-dimensional architectural elements. This process not only validates the accuracy of manuscript instructions but also reveals hidden geometric relationships that are difficult to detect on paper. By comparing digital reconstructions with surviving architectural examples, the study bridges the gap between theoretical design and practical construction.

The scope of the research includes four main areas:

1. **Origins and etymology** – tracing how the term and concept of muqarnas developed across different regions.
2. **Classification and structure** – identifying recurring geometric modules and categorizing them into groups (rectangular, radial, and mixed).
3. **Manuscript analysis** – decoding historical texts and diagrams, particularly the Bukhara and Tashkent scrolls, to recover lost construction knowledge.
4. **Site comparisons** – examining surviving muqarnas in Uzbekistan, Iran, Turkey, and Egypt to validate and contextualize manuscript findings.

Interviews with traditional craftsmen further enriched the methodology, providing practical insights into materials, tools, and step-by-step construction processes. This combination of textual, digital, and field-based evidence ensures that the study offers not only theoretical classifications but also practical applications relevant to heritage conservation and contemporary architecture.

RESULTS AND DISCUSSION

Analysis of Muqarnas Based on the *Daftar-i Girih* Manuscripts

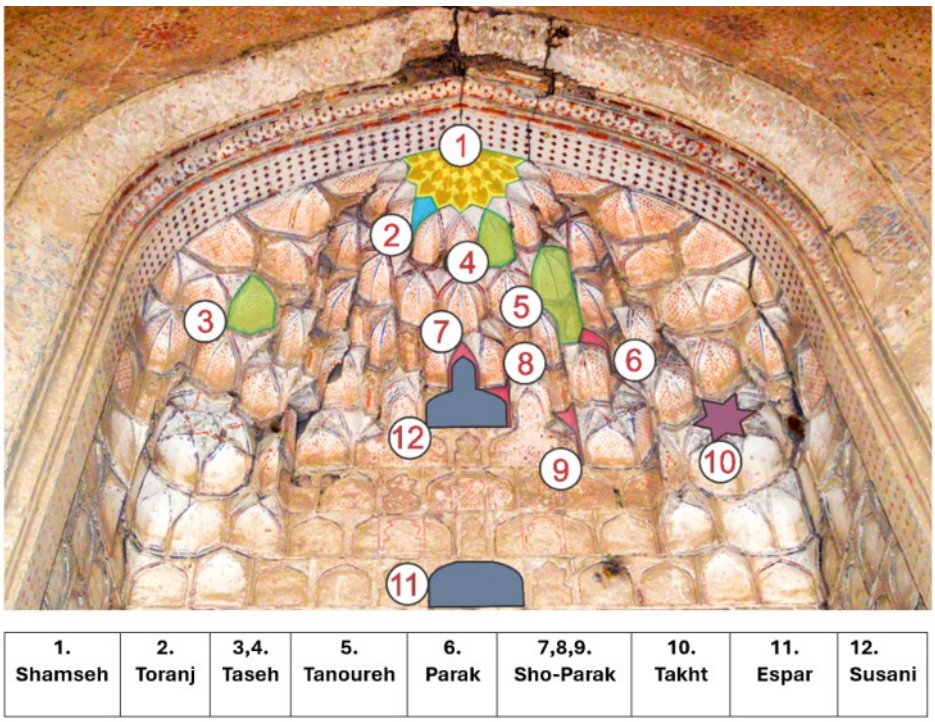
The *Daftar-i Girih* manuscripts preserved in Bukhara and Tashkent offer some of the most detailed historical diagrams for constructing muqarnas. These texts illustrate how craftsmen used two-dimensional drawings (*taxbins*) as the foundation for complex three-dimensional forms. For example, Figure 2 shows the basic structural elements *shams* (sun), *kosa* (bowl), *poya* (stem), and *taxt* (scaffold) arranged in rhythmic patterns. Such diagrams allowed master builders to determine the number of rows, proportions, and decorative rhythm of a muqarnas vault.

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Our study identified several types of **Muqarnas** and found that, despite their variations, they all share a common structural system composed of four basic elements:

1. **Shams** (sun),
2. **Kosa** (bowl) – also known as *kosagi* in Persian,
3. **Poya** (stem), and
4. **Taxt** (plank or scaffold).

Each of these elements has its own variations, such as *toranj*, *taseh*, *parak*, *shaparak*, *g'ozpoya*, and others (Figure 1).



1. Shamseh	2. Toranj	3,4. Taseh	5. Tanoureh	6. Parak	7,8,9. Sho-Parak	10. Takht	11. Espar	12. Susani

Figure 2. The constituent elements of muqarnases
Source: According to Sh.Sh. Mustafayev.

Geometric Principles and Simplification

The geometry of muqarnas often appears intimidating because of its many layers and repetitions. However, manuscripts reveal that these designs are based on simple geometric shapes such as squares, hexagons, and octagons. By dividing circles into equal segments and linking points with straight lines, craftsmen

generated star polygons that formed the backbone of the design. Figure 3 demonstrates how a rectangular base can be divided into modular cells, later "stacked" into three-dimensional niches.

This simplification makes muqarnas more understandable: what seems like a highly complex vault is in fact a repetition of a few geometric modules carefully scaled and combined.

A key point is that the essence of Muqarnas construction lies in the taxbin (construction drawings). Skilled craftsmen rely on taxbins to understand the type of Muqarnas, determine the number of rows, and design the rhythmic composition of taxts that create the overall flow of the structure (Figure 3).

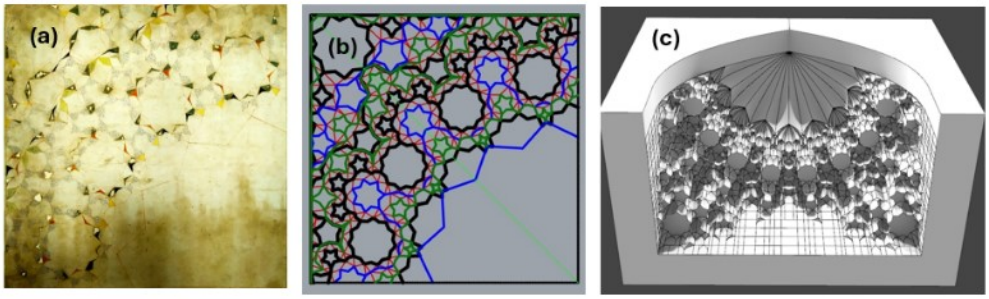


Figure 3. From two-dimensional taxbin to three-dimensional niche form. Structure, analysis, and three-dimensional view based on "taxt" of muqarnas
Source: Daftar-i Girih" No. 2/1, according to Sh.Sh. Mustafayev.

Integration of Site Evidence

While manuscripts are invaluable, relying solely on them creates a limitation. To address this, we compared manuscript diagrams with **architectural sites**:

- **Uzbekistan (Samarkand, Bukhara):** The Registan's Sher-Dor Madrasa and Bukhara's Abdulaziz Khan Madrasa show direct applications of manuscript-based diagrams, with muqarnas decorating iwans and domes.
- **Iran (Isfahan):** The Sheikh Lotfollah Mosque demonstrates how Safavid builders transformed polygonal diagrams into elaborate domed transitional zones.
- **Egypt (Cairo):** The Sultan Hasan Mosque and later Mamluk structures employed muqarnas in dome transitions, proving their adaptability in different structural contexts (Fukami, 2017).
- **Spain (Granada):** The Alhambra's Hall of the Two Sisters illustrates the decorative potential of muqarnas, where geometric order is transformed into symbolic cosmology.

These comparisons demonstrate that although the visual styles vary, the underlying geometric logic remains consistent across regions. This validates the

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Daftar-i Girih as not just a local but a broadly applicable guide to muqarnas construction.

In global scholarship, works by Shiro Takashi and Hamidreza Kazempour are particularly notable. They classified Muqarnas into three categories: (1) Rectangular-based Muqarnas, (2) Radial-ring Muqarnas, and (3) Mixed Muqarnas (Figure 4.) (Brotherton, 2023; Kamyab et al., n.d.).

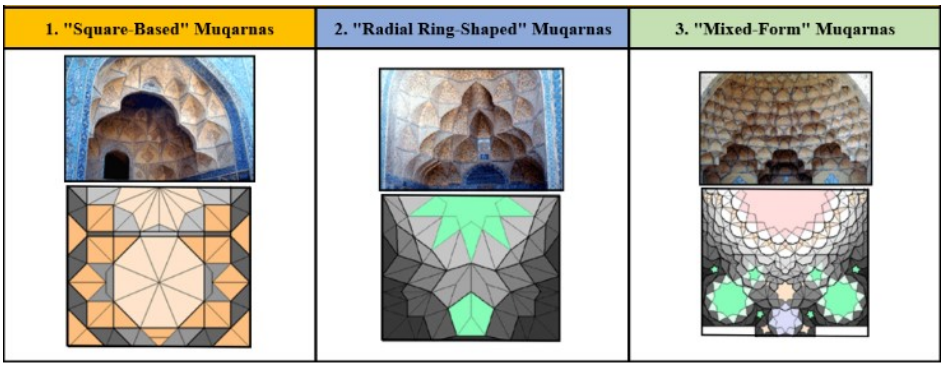


Figure 4. Square, radial and mixed muqarnas
Source : http://www.shiro1000.jp/muqarnas/default-.htm .

Building on historical manuscripts and surviving monuments, our study also proposes dividing Muqarnas into three groups and subgroups. While additional subgroups may be identified in different regions, this study focuses on Uzbekistan only. These groups are illustrated in Figure 5.

Comparative Analysis of Muqarnas in Manuscripts of the Islamic World

Understanding the geometry of **muqarnas** the intricate three-dimensional decorative elements of Islamic architecture requires both design knowledge and an awareness of construction techniques. This section compares manuscript sources that explain muqarnas design, with examples from Uzbekistan, Iran, Turkey, and beyond. By broadening the scope, we place these traditions within the wider context of Islamic art, linking them to developments in the Middle East, North Africa, and even parts of Europe where Islamic architectural influence spread.

Early Origins and Manuscript Traditions

The use of geometric patterns in architecture has deep roots. According to the Metropolitan Museum of Art (2004), some of the earliest examples may trace back to Byzantium and the Sassanian Empire (Bartman, 2022). Later, in the Islamic world, scholars such as mathematicians and astronomers refined these geometric systems, laying the groundwork for muqarnas.

Historical manuscripts including those by **Ghiyāth al-Dīn al-Kāshī** and **Abu'l-Wafā' Būzjānī** demonstrate the careful arithmetic behind muqarnas. These texts reveal how simple tools like a compass and straightedge could generate highly complex patterns. Al-Kāshī's *Miftāḥ al-Ḥisāb* (The Key to Arithmetic) remains one of the most important works, valued not only for mathematics but also for its architectural applications (Kale, 2020).

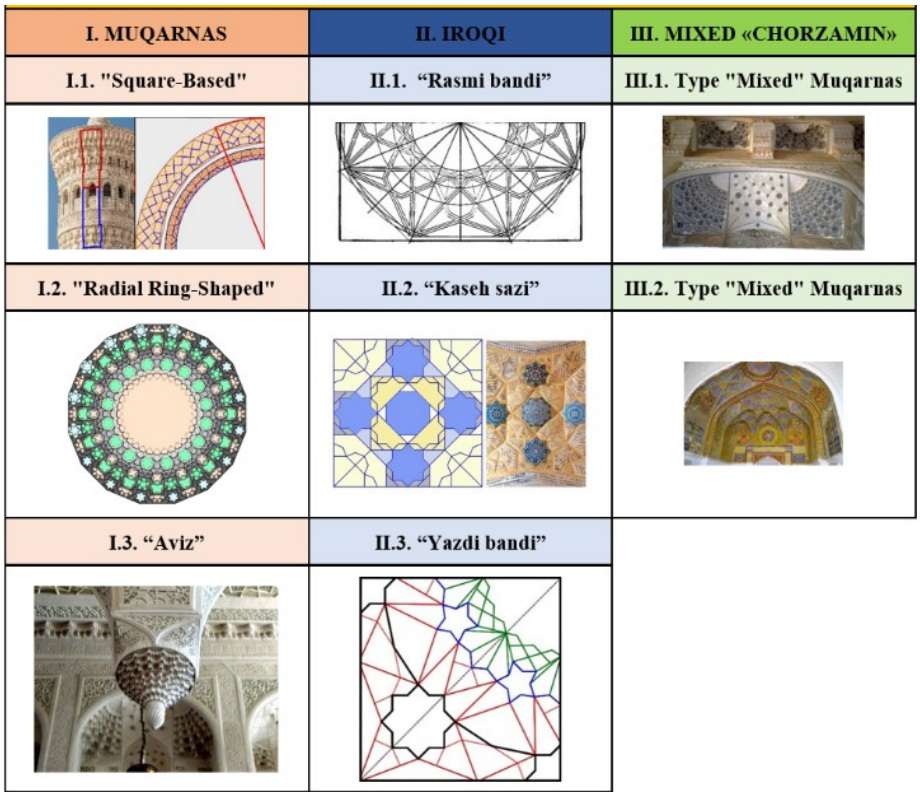


Figure 5. Structural groups of Muqarnas
Source: According to Sh.Sh. Mustafayev.

Geometric Groups of Muqarnas
Researchers often classify muqarnas into three main groups:

1. **Muqarnas Group** – Based on polygons such as 12-, 7-, and 5-sided stars. Their designs rely on precise ratios and careful layering of rows, as seen in Al-Kāshī's manuscripts (Figure 6).

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2. **Iraqi Group** – Simpler in form, often constructed from squares and octagons. Rotational symmetry plays a key role, producing structures that could easily be raised into three-dimensional forms (Figure 7).
3. **Chorzamīn or Mixed Group** – Formed by blending principles of the previous types. These often reduce the depth of arches and introduce ellipsoidal rays, asymmetry, and more complex three-dimensional cavities (Figure 9).

Through these methods, scholars codified the hidden rules of proportion that guided craftsmen across the Islamic world.

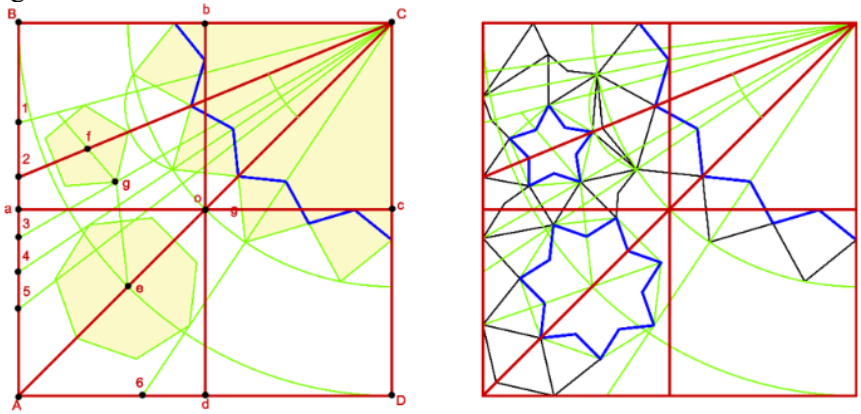


Figure 6. Method of Geometric Analysis of plans for the "Muqarnas" Group
Source: According to Sh.Sh. Mustafayev.(Manuscript of Giyath al-Din al-Kashi and A. Sharbaf)

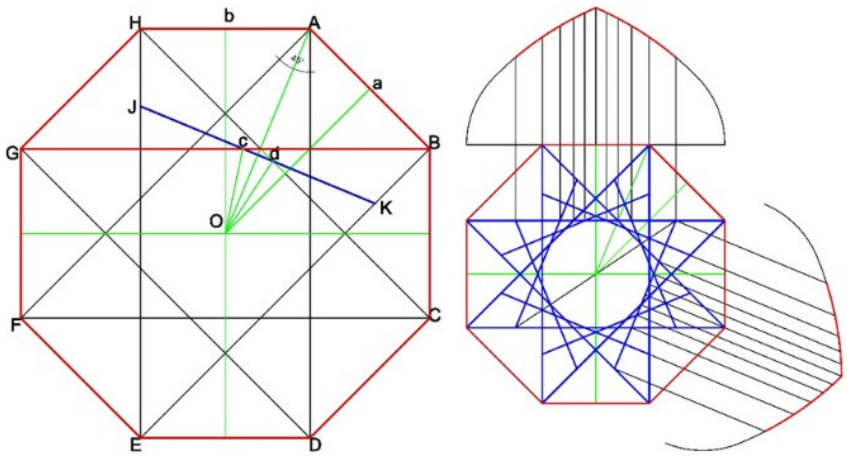


Figure 7. Method of Geometric Analysis of plans for the "Iroqi" Group
Source: According to Sh.Sh. Mustafayev (Manuscript of Giyath al-Din al-Kashi and A. Sharbaf)

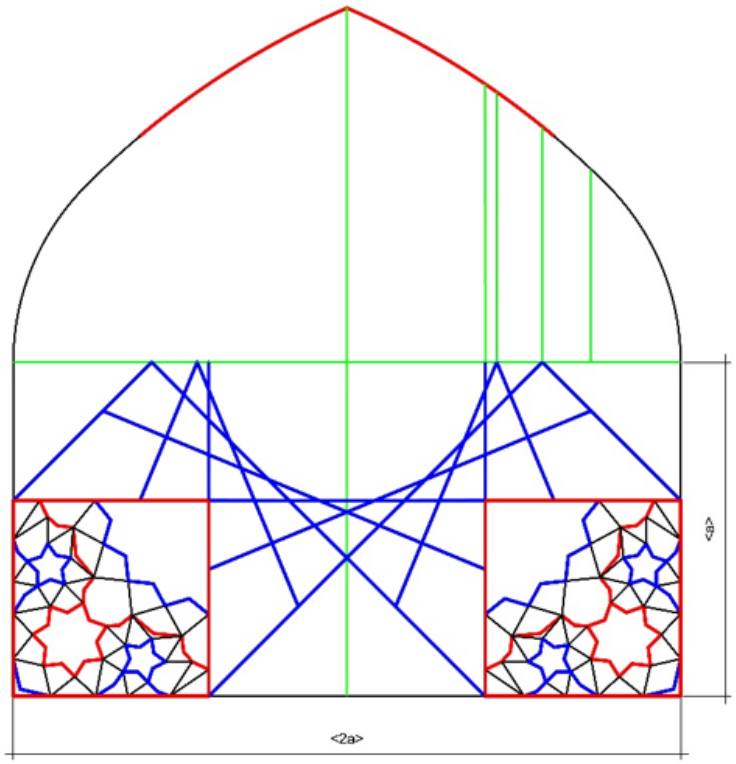


Figure 8. Method of Geometric Analysis of plans for the "Chorzamin or Mixed" Group
Source: According to Sh.Sh. Mustafayev (Manuscript of Giyath al-Din al-Kashi and A. Sharbaf)

Broader Geographical Context

While manuscripts from Uzbekistan, Iran, and Turkey are especially detailed, similar traditions appear across a much wider area:

- **Egypt and North Africa** – The muqarnas of the Fatimid and later Mamluk periods show local adaptations of the geometric principles recorded in manuscripts.
- **Al-Andalus (Spain)** – The Alhambra in Granada contains some of the most celebrated examples, showing how the science of muqarnas traveled westward.
- **Central Asia and India** – Timurid and Mughal architecture integrated muqarnas into monumental gateways and domes, proving their importance along the Silk Road.
- **Modern Conservation Practices** – Today, manuscripts like those in the Topkapi Palace (Necipoğlu, 1986) are not only studied by historians but also guide digital restoration and conservation worldwide.

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By comparing these regions, it becomes clear that muqarnas were never isolated to one cultural center. Instead, they formed part of a shared scientific-artistic language across the Islamic world, later influencing European Gothic vaulting and other global traditions.

Significance for Research and Practice

Al-Kāshī and other scholars did more than preserve knowledge they systematized it, making it usable for builders. Their diagrams helped craftsmen calculate row sequences, star patterns, and even parabolic surfaces for domes.

Archaeological evidence shows that even when manuscripts were lost such as during the Mongol invasions builders still relied on sketches and geometric knowledge. The **Topkapi Manuscript** (15th–16th century) stands out with over 100 geometric patterns, including 83 muqarnas diagrams. Written in a single hand and richly illustrated, it highlights how artisans from Iran to Anatolia created a unified system of design.

Together, these manuscripts confirm that muqarnas design combined art, mathematics, and a degree of secrecy. They remind us that Islamic architectural heritage was global in scope, continuously evolving across regions and centuries.

Contemporary Applications

Understanding the geometric basis of muqarnas also has **practical relevance today**. For instance:

- **Restoration projects based on UNESCO grants** have employed digital reconstructions of *taxbins* to repair damaged niches, ensuring fidelity to original design principles.
- **Modern architecture** such as proposal projects for interior and exterior decoration of the Islamic Civilization Center (Tashkent).
- **Parametric design** tools now allow architects to generate muqarnas-like patterns for façades, ceilings, or even urban installations, preserving traditional aesthetics while embracing modern materials.

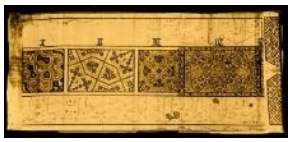
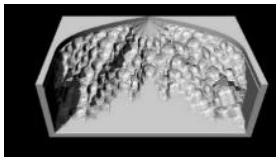
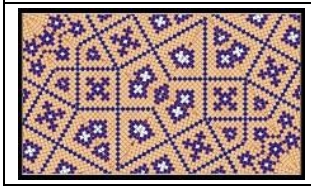
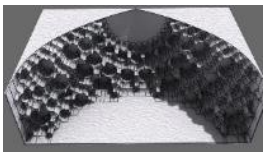
These applications show that muqarnas are not confined to history; they continue to inspire innovative approaches to design and conservation **Table 1.**

CONCLUSION

This study clarified the geometry, classification, and cultural significance of muqarnas by combining manuscript analysis with site-based evidence and digital modeling. The research confirms that all types of muqarnas are based on takhbin(plans), which are based on simple geometric modules. If we translate

these 2D plans to 3D through taxbins, we form the foundation of highly complex three-dimensional vaults. Comparative examples from Uzbekistan, Iran, Turkey, Egypt, and Andalusia demonstrate both shared principles and regional adaptations. Beyond historical scholarship, the findings show how muqarnas knowledge can support restoration, digital reconstruction, and innovative applications in modern architecture. Future research should extend geographic comparisons and employ advanced technologies to further connect traditional methods with contemporary practice.

Table 1

Contemporary Applications		
Restoration projects	**Modern architecture**	**Parametric design**
		
		

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MINIMIZING THE RISK OF COST OVERRUN IN BUILDING CONSTRUCTION PROJECT DURING PRE-CONTRACT STAGE

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Abstract

Cost overruns are a major challenge in Malaysian building construction projects, leading to delays, budget increases, and financial losses. This study investigates pre-contract factors that contribute to cost overruns and evaluates strategies to mitigate these risks. The objectives are to identify key factors, assess their impact, and determine effective mitigation strategies for stakeholders during the pre-contract stage. A quantitative approach was used, employing a structured questionnaire survey of construction firms in Selangor. Data were analyzed using descriptive and inferential statistics. The findings indicate that inaccurate cost estimation, poor planning, contractor inexperience, and financial constraints are the most significant factors influencing cost overruns. Effective strategies include careful contractor selection, risk assessment, pre-contract cost control, detailed planning, and the adoption of Building Information Modeling (BIM). The study provides practical insights for stakeholders to manage pre-contract risks, improve cost control, and enhance project outcomes. It also contributes to the literature by quantitatively validating the impact of pre-contract factors and strategies in Malaysian construction projects.

Keywords: cost overrun, pre-contract stage, risk, building construction project

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INTRODUCTION

The construction industry is a key driver of Malaysia's economy, employing approximately 1.38 million people in 2021 (8.6% of the national workforce) and generating a GDP of RM 13.6 billion in Q3 2022 (Department of Statistics Malaysia, 2022). Despite its economic importance, cost overruns remain a persistent challenge, threatening project success and stakeholder confidence. Atkinson (1999) described project success using the "iron triangle" of time, cost, and quality, where cost represents financial constraints and adherence to budget. Hinze et al. (1992) defined cost overrun as the difference between the original contract sum and the awarded contract sum.

Project costs are typically estimated at contract award; however, design changes, market fluctuations, and logistical challenges often cause budget deviations (ElSahly, Ahmed, & Abdelfatah, 2023). Innovative practices, such as modular construction integrated with Building Information Modeling (BIM), have been shown to reduce costs by 22% and shorten project timelines by 35% (Gómez & Sánchez, 2024). Globally, cost overruns are significant: for example, the China-Indonesia high-speed rail exceeded its budget by US$1.2 billion (Nikkei, 2023), while in Ghana and Nigeria, 72% and 84% of projects experienced overruns, respectively (Asiedu & Alfen, 2016, as cited in Asiedu & Adaku, 2020; Ameh et al., 2010, as cited in Kamaruddeen et al., 2020). More recently, Hesna et al. (2021) reported that the COVID-19 pandemic further disrupted construction projects, with actual costs heavily affected by variances between market prices and planned budgets.

In Malaysia, cost overruns frequently occur, with projects exceeding budgets by 5–10% of the total contract sum (Kamaruddeen et al., 2020). For instance, the upgrading of the Malaysian Parliament building exceeded RM 100 million, demonstrating the significant financial implications for stakeholders (Rahim, Ibrahim, & Nelson, 2022). Evidence suggests that the majority of cost overruns originate in the pre-contract stage, which includes project inception, feasibility studies, detailed design, tendering, and pre-contract planning (Hackett & Robinson, 2003). Decisions made during this stage, such as contractor selection, project scheduling, and cost estimation, have a direct impact on the likelihood of cost escalation.

Although several strategies, such as risk assessment, pre-contract cost control, comprehensive planning, scope management, BIM adoption, quality monitoring, and effective communication, have been proposed to mitigate cost overruns (Ikechukwu et al., 2017; Abusafiya & Suliman, 2017; Sánchez et al., 2022), there is a lack of quantitative studies evaluating their effectiveness in the Malaysian context. Addressing this gap is critical to provide practical guidance for stakeholders and improve project outcomes.

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This study aims to identify the pre-contract factors that contribute to cost overruns in Malaysian building construction projects, evaluate their impact on project costs, and assess strategies that stakeholders can implement to minimize these risks. By achieving these objectives, the study seeks to provide actionable recommendations for construction professionals and contribute to the body of knowledge on cost overrun management.

BACKGROUND

Cost overruns remain a global challenge in the construction industry, including in Malaysia, and occur when actual costs exceed budgeted amounts (Jackson, 2002). Contributing factors include poor contract management, inaccurate cost estimation, design changes, ineffective planning, inadequate communication, weak tender documentation, inflation, and political interference (Ahady et al., 2017; Aljohani et al., 2017; Durdyev, 2020). Other studies have also identified limited innovation, weak financial management, and client-initiated change orders as drivers of cost overruns (Kawmudi et al., 2021; Famiyeh et al., 2017).
In Malaysian construction projects, cost overruns are prevalent in both residential and non-residential sectors. Examples include a government building project in Kuala Lumpur, which experienced a 33% overrun due to site conditions, design changes, and permit delays (Mamat & Zainal Abidin, 2018), and a Selangor low-cost housing project that exceeded its RM 15 million budget by 30%, largely because of design changes, material price fluctuations, and labour shortages (Rahim, 2020). Global reviews also confirm the persistence of cost overruns across project types and regions (Sepasgozar et al., 2022), with early project stages such as design and procurement being the most critical points for intervention (Love et al., 2018; Tennakoon et al., 2022). Mahmud et al. (2021) underscored the persistent issue of cost overruns and the urgency for deeper analysis. If left unchecked, cost overruns can become unmanageable for project stakeholders (Odeck, 2018).

According to the World Bank Group and Economic Planning Unit of Malaysia (2021), average industry overruns are estimated at 20–30%. This study, therefore, targets project developers, contractors, and quantity surveying consultants to develop pre-contract strategies that clarify critical factors and support best practices for minimizing cost overruns.

Cost overruns in building construction projects arise from a variety of factors across different stages. Focusing on the pre-contract stage is particularly important, as early interventions can prevent these causes from escalating. Studying strategies to mitigate cost overruns during this stage is crucial for construction stakeholders, as prevention is more effective than remediation. By addressing potential risks before they materialize, practitioners can safeguard organizational profitability, create growth opportunities, and protect

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stakeholders' interests. Furthermore, minimizing cost overrun risks supports project execution within budget, ultimately contributing to project success in terms of deliverables, client satisfaction, and return on investment.

PRE-CONTRACT IN THE CONSTRUCTION INDUSTRY

The construction process, from conception through design, contracting, and execution, has become increasingly time- and cost-intensive. The pre-contract stage, or the preparatory phase prior to contract award, is critical in shaping project outcomes and preventing errors that could escalate costs and delays (Ashworth, 2002). Effective management during this stage ensures alignment with client requirements, stakeholder expectations, and project objectives.

According to Hackett and Robinson (2003), the pre-contract stage begins with the initial brief and continues through procurement, detailed design, programming, design team coordination, creation of drawings, specifications, and bills of quantities (BQ), engagement of specialised subcontractors and suppliers, quality assurance measures, and, finally, the request for tenders. The initial brief typically includes a feasibility study, sketch scheme, and preliminary cost estimate. Construction procurement, the framework through which a project is conceived, acquired, or executed, varies depending on the chosen procurement route (Sharif & Morledge, 1996, as cited in Morledge et al., 2021). Each procurement method carries distinct priorities regarding time, cost, and quality, and pre-contract programmes can only be finalised once the procurement approach is determined. This structured preparation lays the foundation for the subsequent design and programming activities, which are essential for aligning project goals with practical execution.

When the sketch scheme is developed into a feasible solution, the detailed design is produced (Hackett & Robinson, 2003). The design team is responsible for creating a solution that meets client requirements, considers the building's expected lifespan, integrates structural and architectural elements, and addresses end-user needs if not fully specified by the client. After submission of final design proposals, the team reviews and adjusts the initial program as necessary, taking into account the chosen procurement method and any financing conditions. Programming activities help organise pre-contract processes in a logical and efficient sequence. Regular design team meetings ensure the integration of updated project information, structural and architectural coordination, expert input, health and safety compliance, and program monitoring. These design and programming processes are critical for identifying potential risks early and minimising costly adjustments during construction.

Drawings and specifications are equally important for conveying the detailed information required for construction. Without clear and precise drawings and specifications, cost estimates may be inaccurate (Hatamleh et al.,

2018). Bills of quantities (BQ) are typically prepared to standardise client and design team specifications, providing a consistent basis for pricing. It is also standard practice for the design team to consult specialist subcontractors or suppliers to obtain quotations for specific works. Additionally, quality assurance ensures that project deliverables meet acceptable standards (Hackett & Robinson, 2003). Together, these measures demonstrate that comprehensive pre-contract planning, including feasibility studies, procurement selection, detailed design, programming, preparation of drawings and specifications, engagement of specialists, and quality assurance, is essential for mitigating risks, controlling costs, and enhancing the likelihood of project success. Table 1 summarises the key pre-contract activities in building construction projects.

Table 1: Summary of Pre-Contract Activities (Author's Compilation)

Pre-contract Activity	Description/Key Points
Initial Brief	Feasibility study, sketch scheme, preliminary cost estimate (Hackett & Robinson, 2003)
Procurement	Selection of the procurement route determines time, cost, and quality priorities
Detail Design	Integration of structural and architectural elements; considers client and end-user requirements
Programming	Organizing pre-contract processes in a logical sequence (Hackett & Robinson, 2003), including scheduling design team meetings, coordinating production information, obtaining statutory approvals, completing legal agreements, negotiating with service providers, incorporating specialized design components, receiving quotes, preparing pre-tender documents and estimates, administering contract documents, briefing site inspectorate, and nominating subcontractors and suppliers.
Design Team Meetings	Reviewing updated project information, coordinating structural and architectural integration, incorporating expert input, ensuring health and safety compliance, and monitoring program progress
Drawings and Specifications	Provides detailed construction information; basis for cost estimation (Hatamleh et al., 2018)
Bills of Quantities	Standardizes specifications for pricing; consults specialist subcontractors/suppliers
Specialist Subcontractors & Suppliers	Obtaining provision and quotations for specific works; ensures accurate cost estimation and resource planning

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Pre-contract Activity	Description/Key Points
Quality Assurance	Ensures deliverables meet acceptable standards (Hackett & Robinson, 2003)
Tendering	Request for tenders; finalizing project requirements and documentation

FACTORS OF COST OVERRUN IN CONSTRUCTION PROJECTS

Project cost overruns in construction are generally influenced by financial risks; however, the factors causing cost overruns are often more complex and multifaceted. Table 2 presents a synthesis of common cost overrun factors in construction projects, based on the frequency of their occurrence across the reviewed literature (e.g., Ahady et al., 2017; Aljohani et al., 2017; Durdyev, 2020; Mahmud et al., 2021).

Table 2: Common Cost Overrun Factors in Construction Projects (Author's Compilation)

Factors	Sources	Frequency
Client's Financial Difficulty	Lee et al. (2022); Kuware (2021); Durdyev (2020)	3
Contractors' Financial Difficulties	Ahady et al. (2017); Aljohani et al. (2017); Lee et al. (2022); Durdyev (2020); Niazi & Painting (2017)	5
Contractor's Poor Site Management and Supervision	Ahady et al. (2017); Adam et al. (2017); Amini et al. (2023); Lee et al. (2022); Gaurang (2020)	5
Corruption	Babalola et al. (2022); Niazi & Painting (2017)	2
Delayed Payment to Contractors or Consultants	Adam et al. (2017); Aljohani et al. (2017); Niazi & Painting (2017)	3
Frequent Design Change or Frequent Change Order	Adam et al. (2017); Amini et al. (2023); Aljohani et al. (2017); Babalola et al. (2022); Durdyev (2020); Niazi & Painting (2017)	6
Ground or Soil Conditions	Adam et al. (2017); Kuware (2021); Durdyev (2020)	3
Inaccurate Estimation	Amini et al. (2023); Aljohani et al. (2017); Babalola et al. (2022); Durdyev (2020)	4
Inflation	Ahady et al. (2017); Adam et al. (2017); Amini et al. (2023); Kuware (2021); Durdyev (2020); Niazi & Painting (2017)	6

Factors	Sources	Frequency
Insufficient Contractor Experience	Ahady et al. (2017); Amini et al. (2023); Aljohani et al. (2017); Lee et al. (2022); Durdyev (2020)	5
Inappropriate Managerial Skills	Adam et al. (2017); Aljohani et al. (2017)	2
Wrong Planning and Scheduling	Ahady et al. (2017); Adam et al. (2017); Amini et al. (2023); Lee et al. (2022); Gaurang (2020); Durdyev (2020)	6
Information and Communication Barriers	Ahady et al. (2017); Adam et al. (2017); Amini et al. (2023); Kuware (2021); Gaurang (2020); Durdyev (2020)	6
Poor Monitoring and Control	Adam et al. (2017)	1
Poor Tendering Documents	Aljohani et al. (2017); Durdyev (2020); Niazi & Painting (2017)	3
Process Inefficiency	Adam et al. (2017); Gaurang (2020)	2
Incorrect Project Duration	Adam et al. (2017); Babalola et al. (2022)	2
Rework	Adam et al. (2017); Amini et al. (2023); Lee et al. (2022); Kuware (2021)	4
Shortage of Equipment	Adam et al. (2017); Kuware (2021)	2
Weather	Adam et al. (2017); Babalola et al. (2022); Durdyev (2020)	3

The findings indicate that four factors, frequent design changes or change orders, inflation, inaccurate planning and scheduling, and information and communication barriers, consistently rank as the most frequently reported among the twenty identified factors. Contractors play a crucial role from tender submission through project handover; however, many studies also report that cost overruns can result from contractors' financial issues, poor site management, and insufficient expertise (Ahady et al., 2017; Aljohani et al., 2017; Durdyev, 2020).

Cost overruns have significant implications for all construction stakeholders. According to Asiedu and Ameyaw (2020), overruns can lead to project abandonment and delays in construction activities. For clients, overruns reduce returns on investment and may cause financial losses. For contractors, incomplete or delayed projects can damage their reputation and affect future business opportunities. For professionals such as architects, quantity surveyors, and engineers, cost overruns reflect an inability to provide reliable services, potentially undermining client confidence.

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Table 3 summarizes the strategies to minimize the risk of cost overruns in construction projects. Among these, proper pre-project planning was the most frequently mentioned strategy. Effective communication was also emphasized across the literature as a key factor for controlling costs (Ahady et al., 2017; Mahmud et al., 2021). Other strategies include the adoption of suitable techniques and tools, such as scheduling software, risk assessment methods, resource management systems, and Building Information Modeling (BIM). Additionally, selecting qualified contractors, appropriate construction methods, and high-quality materials were highlighted as essential tactics. Overall, the most frequently cited strategies focus on project planning, followed by the adoption of tools and techniques, and the management of people.

Table 3: Strategies to Minimize Cost Overruns (Author's Compilation)

	Ikechukwu et al. (2017)	Abusafiya & Suliman (2017)	Durdyev et al. (2017)	Aljohani et al. (2017)	Ahady et al. (2017)	Ullah et al. (2018)	Al-Keim (2017)	Sánchez et al. (2022)
Adopt a suitable project management scheduling tool	/						/	
Staying within the project-planned scope	/							
Proper project activities planning before project execution	/		/			/	/	
Selection of contractors takes account of expertise, financial capability and experience.	/					/		
Effective communication	/			/		/		
Risk Assessment during project estimating		/				/		
Pre-contract cost control		/						
Use mainly local construction material during the selection of the construction methodology and materials			/			/		

	Ikechukwu et al. (2017)	Abusafiya & Suliman (2017)	Durdyev et al. (2017)	Aljohani et al. (2017)	Ahady et al. (2017)	Ullah et al. (2018)	Al-Keim (2017)	Sánchez et al. (2022)
Effective resource management system (human, technical, material)			/	/				
Keep updating material prices and labour rates					/			
Quality Monitoring by consultants and quality professionals					/			
BIM adoption							/	/
Managing and completing the Design Stage before construction							/	

METHODOLOGY

This study employed a quantitative research design to identify strategies that stakeholders can use during the pre-contract stage to minimize cost overruns in Malaysian building construction projects. The research focused on three key objectives: (1) identifying pre-contract factors that contribute to cost overruns, (2) assessing the impact of these factors on project costs, and (3) evaluating strategies to mitigate these risks effectively.

Data was collected using a structured questionnaire survey, developed based on the literature review of pre-contract cost overrun factors. The survey included closed-format questions to ensure consistency and reliability of responses. A pilot study was conducted to validate the questionnaire before it was distributed to respondents.

The survey targeted construction firms in Selangor, Malaysia, which recorded the highest value of construction work at RM 6.9 billion as of the third quarter of 2022 (Department of Statistics Malaysia, 2022). The study focused on building projects, which accounted for 55.5% of total construction work, with 37.7% non-residential and 17.8% residential buildings. The collected data were analysed using descriptive statistics, inferential statistics, and reliability analysis to evaluate the significance and impact of the identified factors and strategies. This methodology ensures the study's findings are quantitative, evidence-based, and directly linked to practical pre-contract decision-making.

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ANALYSIS & DISCUSSIONS

The survey findings provide insights into the pre-contract factors contributing to cost overruns and the strategies adopted to minimise these risks.

FACTORS OF THE PRE-CONTRACT STAGE CAUSING COST OVERRUN IN BUILDING CONSTRUCTION PROJECTS

Analysis revealed that inaccurate cost estimation is the most critical factor, often caused by insufficient historical data, unclear project requirements, and market fluctuations. This results in discrepancies in labour, material, and equipment costs, which can lead to disputes and project delays. Similarly, poor planning and scheduling were identified as a major contributor, with inadequate sequencing, resource allocation, and consideration of interdependencies causing cascading delays and cost increases.

Other significant factors include poorly prepared tender documents, leading to miscommunication and inaccurate contractor bids; contractor inexperience, affecting accurate estimation and execution efficiency; and ineffective communication between stakeholders, which can disrupt negotiations and project alignment. Financial difficulties among contractors or clients, frequent design changes, and inefficiencies in project processes also emerged as notable contributors, consistent with prior studies (Adam et al., 2017; Amini et al., 2023; Lee et al., 2022; Kuware, 2021) and confirm that multiple interrelated factors drive cost overruns in the pre-contract stage.

STRATEGIES DURING THE PRE-CONTRACT STAGE TO MINIMIZE THE RISK OF COST OVERRUNS IN BUILDING CONSTRUCTION PROJECTS

Survey results highlighted several effective strategies during the pre-contract stage. Careful contractor selection, based on expertise, experience, and financial stability, was the most frequently cited strategy, ensuring reliable project execution and minimising risk (Ikechukwu et al., 2017; Ullah et al., 2018). Comprehensive risk assessment allowed stakeholders to proactively identify and mitigate potential challenges, while pre-contract cost control and detailed project planning helped develop realistic budgets and optimize resource allocation.

Advanced project management tools, including Building Information Modeling (BIM), scheduling software, and resource management systems, improved coordination, minimized errors, and enhanced productivity (Sánchez et al., 2022; Al-Keim, 2017). Other important strategies included clear scope management, finalised designs before construction, quality monitoring, and effective communication, all of which contribute to reducing cost overruns and improving project outcomes (Abusafiya & Suliman, 2017; Amini et al., 2023).

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The results confirm that addressing pre-contract factors proactively is essential for minimizing cost overruns. By combining careful planning, robust risk management, competent contractor selection, and adoption of modern project management tools, stakeholders can improve cost control, ensure timely delivery, and maintain quality standards.

CONCLUSION

This study identifies key pre-contract factors contributing to cost overruns in Malaysian building projects, including inaccurate cost estimation, poor planning, contractor inexperience, and financial constraints. Survey results highlight that careful contractor selection, risk assessment, pre-contract cost control, detailed planning, and BIM adoption are the most effective mitigation strategies. These findings provide practical guidance for stakeholders to manage pre-contract risks, enhance project outcomes, and support informed decision-making. By quantitatively validating the impact of these factors and strategies, the study contributes to the literature on cost overrun management. Future research could expand to other regions and project types to further refine these pre-contract strategies.

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PASSIVE COOLING IN EARTH-SHELTERED HOMES: NATURAL STRATEGIES FOR ENERGY EFFICIENCY IN COOBER PEDY, AND YAODONG

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Abstract

The growing demand for energy-efficient architecture has led to renewed interest in passive cooling techniques, particularly in earth-sheltered homes. These structures, built partially or entirely underground, leverage the thermal stability of the earth to maintain comfortable indoor temperatures with minimal energy consumption. This study examines underground homes in Coober Pedy, Australia, and Yaodong, China, focusing on their natural cooling mechanisms and architectural strategies. Using a mixed-methods approach, including a literature review, architectural analysis, and interviews with architects familiar with these structures, the research identifies key design elements such as thermal mass, subterranean depth, and ventilation systems that contribute to their energy efficiency. The findings reveal that these strategies effectively reduce temperature fluctuations, making them a sustainable alternative to conventional cooling systems. Additionally, the study discusses the feasibility of adapting these passive cooling techniques to modern urban settings. The research concludes that underground architecture offers significant potential for energy conservation and sustainable housing solutions in a warming climate.

Keywords: Earth-Sheltered Homes, Energy Efficiency, Natural Ventilation, Passive Cooling, Sustainable Design, Thermal Mass, Underground Architecture.

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INTRODUCTION

As global temperatures rise and energy consumption escalates, the quest for sustainable architectural solutions becomes increasingly critical. Buildings account for a significant portion of global energy use, with cooling demands contributing substantially to carbon emissions and environmental degradation (R. Baydoun & Sapian, 2022a, 2022b). While extensive research exists on passive cooling in conventional buildings, few studies have examined the long-term efficiency of underground dwellings in extreme climates. Earth-sheltered homes are buildings that are constructed partly or entirely below ground to use surrounding soil as natural insulation, those buildings offer an alternative approach to temperature regulation by reducing reliance on mechanical cooling systems (Milanović et al., 2018). Despite their potential to enhance energy efficiency and sustainability, these strategies remain underutilized in contemporary construction practices.

This study aims to bridge this research gap by examining two well-established underground housing typologies: Coober Pedy (Australia) and Yaodong (China). Coober Pedy's underground residences, developed in response to extreme desert conditions, the strategy of underground structures is characterized by the high leverage thermal mass which refers to the capacity of a material to absorb and store heat. Which some earth sheltered structures are classified as subterranean structures which refers to the insulation and the protection provided by surrounding soil layers to maintain stable indoor temperatures. Similarly, Yaodong dwellings, constructed within loess soil, utilize high thermal mass and natural ventilation to achieve passive cooling with minimal energy consumption. While both cases illustrate the potential of underground architecture for energy-efficient cooling, there is limited comparative research analyzing their architectural strategies within the broader context of contemporary sustainable design. To address this gap, the study investigates the following research objectives:

1. Examine how underground homes maintain cool temperatures without artificial cooling.
2. Identify key architectural techniques that enhance their energy efficiency.
3. Explore the applicability of these passive cooling methods to modern sustainable housing.

By analyzing these case studies, this research aims to extract valuable design principles that can inform contemporary architecture, particularly in regions experiencing extreme climate variations. Findings from this study will contribute to a deeper understanding of how earth-sheltered homes can serve as

a viable solution for reducing energy consumption while ensuring indoor comfort, aligning with global sustainability efforts.

LITERATURE REVIEW

Underground Architecture and Thermal Performance

Earth-sheltered buildings utilize the insulating properties of soil whose high thermal resistance limits heat transfer, those properties help to maintain stable indoor temperatures, thereby reducing reliance on mechanical heating and cooling systems. The high thermal mass of soil buffers temperature fluctuations, leading to improved energy efficiency. While Ashrafian et al. (2011) argue that underground housing primarily relies on thermal inertia to regulate indoor climates, Milanović et al. (2018) emphasize that air ventilation strategies play an equally significant role. This study examines both perspectives through real-world cases.

Thermal stability in earth-sheltered structures depends largely on depth. According to Ashrafian et al. (2011), temperatures between zero- and 10-meters underground exhibit seasonal fluctuations, whereas beyond 10 meters, thermal conditions remain stable throughout the year as shown in figure 1. This principle underlies the cooling efficiency of underground dwellings, such as Coober Pedy's sandstone homes and Yaodong's loess-soil dwellings. However, Alwetaishi (2021) challenges this notion, arguing that depth alone is insufficient and must be complemented by strategic ventilation placement to optimize indoor comfort.

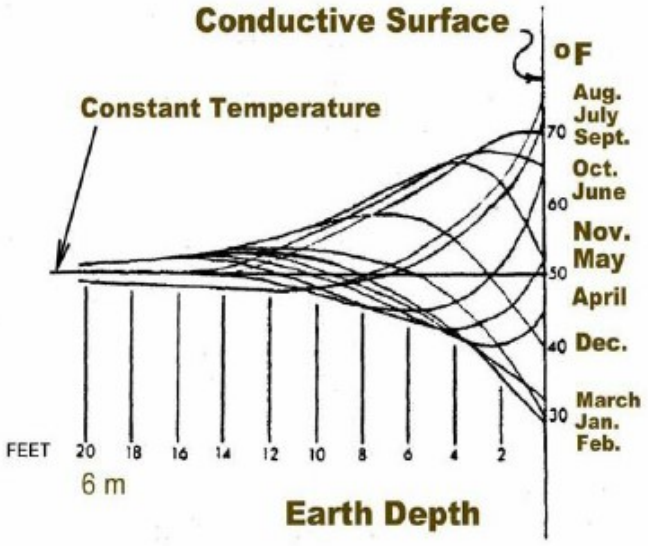


Figure 1: thermal stability in earth sheltered houses (Ashrafian et al., 2011)

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Comparative Analysis of Passive Cooling Strategies in Earth-Sheltered Homes

Passive cooling refers to natural design techniques that minimize indoor heat gain and enhance heat dissipation without relying on mechanical systems. In earth-sheltered architecture, such strategies include optimizing thermal mass, ventilation systems, and surface insulation to improve indoor comfort (R. Baydoun & Sapian, 2022a). However, the effectiveness of these strategies varies depending on climatic conditions, soil composition, and construction methods. The comparative analysis highlights that while both Coober Pedy and Yaodong successfully employ earth-sheltered design that is defined as architecture that integrates the building envelope with the ground for insulation and temperature stability, their effectiveness is shaped by local geology, climate, and culture. In Coober Pedy, sandstone excavation ensures thermal buffering against extreme desert heat, a method that would be impractical in regions without stable rock formations. By contrast, Yaodong dwellings leverage the insulating qualities of loess soil to withstand both summer heat and winter cold, though soil fragility limits long-term durability. These findings underscore that the success of passive cooling strategies is context-dependent; transferring them to other climates or urban areas requires adaptation to local material availability, climatic conditions, and regulatory frameworks.

Thermal Mass vs. Ventilation Efficiency

One of the primary debates in passive cooling strategies concerns whether thermal mass or ventilation strategies contribute more significantly to indoor temperature regulation. Meir & Gilead (2002) assert that thermal mass is the dominant cooling factor in Coober Pedy's underground homes, where sandstone absorbs heat during the day and slowly releases it at night. This results in stable indoor temperatures ranging from 19°C to 25°C, even when external temperatures exceed 40°C. However, Liu et al. (2011) contend that in China's Yaodong dwellings, cross-ventilation mechanisms play a more critical role in maintaining indoor comfort. Due to the porous nature of loess soil, air circulation through well-positioned openings prevents excessive heat accumulation.

These contrasting findings suggest that passive cooling strategies must be adapted to local climatic conditions. Table 1 compares the cooling effectiveness of different strategies in Coober Pedy and Yaodong, highlighting their reliance on either thermal inertia or ventilation efficiency.

Table 1: Comparative effectiveness of passive cooling strategies in underground homes.

Cooling Strategy	Effectiveness in Coober Pedy	Effectiveness in Yaodong
Thermal Mass	High	Moderate
Cross-Ventilation	Low	High
Green Roofs	Limited	Moderate
Solar Chimneys	Requires adaptation	Effective in hot seasons

The Role of Green Roofs and Solar Chimneys in Passive Cooling

In modern applications, passive cooling strategies integrate green roofs, solar chimneys, and perforated screens to enhance indoor thermal comfort. Delaney Nolan (2024) highlights that green roof not only reduce indoor temperatures but also contribute to stormwater management and urban heat island mitigation. Similarly, solar chimneys utilize heat absorption principles to drive natural ventilation, expelling warm air and drawing in cooler air from lower levels. However, Al-Shamkhee et al. (2022) argue that while these methods enhance cooling efficiency, their effectiveness depends on climatic conditions and careful design considerations.

Adaptation of Earth-Sheltered Design in Modern Architecture

The he principles of underground architecture closely align with traditional Islamic cooling techniques, including badgirs (wind catchers), qanats (subterranean water channels), and mashrabiya screens (Z. Baydoun et al., 2023; Dariyadi et al., 2022). These techniques demonstrate an advanced understanding of passive cooling and natural ventilation, making them relevant for contemporary sustainable design. Badgirs, for example, harness wind currents to direct cool air into buildings, while qanats leverage underground water channels to cool surrounding spaces through evaporative cooling. Additionally, Mashrabiya screens regulate solar heat gain while allowing airflow, reducing internal temperatures.

Modern architectural applications of these principles emphasize the integration of passive house standards, which focus on airtight construction, superinsulation, and heat recovery ventilation (Al-Shamkhee et al., 2022). Hybrid models that combine underground dwellings with solar-driven cooling technologies have demonstrated 30–50% energy savings, underscoring the potential for blending traditional passive strategies with contemporary innovations (R. Baydoun & Sapian, 2022b) Table 2 presents a comparison between traditional and modern passive cooling methods and their respective applications.

Table 2: Traditional Islamic cooling methods adapted into modern architecture.

Traditional Cooling Method	**Modern Application**
Wind Catchers (Badgirs)	Stack ventilation in underground homes
Qanat Water Channels	Evaporative cooling integration
Mashrabiya Screens	Perforated facades for shading

The literature presents contrasting perspectives on the effectiveness of passive cooling in underground architecture. While some studies highlight thermal mass as the primary cooling factor, others emphasize the role of ventilation in maintaining indoor comfort. The comparison between Coober

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Pedy's sandstone dwellings and Yaodong's loess-soil homes reveals that the dominant passive cooling strategy varies depending on climate, soil properties, and design approach. Additionally, the integration of Islamic passive cooling techniques with modern sustainable architecture suggests that underground dwellings remain highly relevant for contemporary energy-efficient construction. Future research should explore hybrid ventilation systems, material innovation, and climatic adaptation to enhance underground dwelling performance. Additionally, a deeper investigation into historical passive cooling strategies in Islamic architecture may provide further insights into sustainable architectural solutions for contemporary challenges.

RESEARCH METHODOLOGY

This study employs a qualitative research methodology, integrating case study analysis and semi-structured interviews to explore natural cooling mechanisms in earth-sheltered homes (Z. Baydoun et al., 2024). The focus is on two prominent examples: Coober Pedy in Australia and Yaodong in China. These sites are recognized for their passive cooling strategies, which allow underground dwellings to maintain stable indoor temperatures despite extreme external climatic conditions.

Case Study Selection

The selection of case studies for this research is based on their distinct approaches to earth-sheltered architecture and their effectiveness in passive thermal regulation. Coober Pedy, Australia, was chosen due to its extreme desert climate, where summer temperatures frequently exceed 40°C. To counteract these harsh conditions, residents have developed an extensive network of subterranean dwellings which capitalize on the insulating properties of the sandstone substrate. These underground homes maintain stable indoor temperatures ranging between 19°C and 25°C throughout the year, significantly minimizing the need for artificial cooling and demonstrating the viability of earth-sheltered housing in arid environments.

Similarly, Yaodong, China, was selected as a representative example of semi-subterranean architecture in a semi-arid climate. Constructed from compacted loess soil, Yaodong dwellings utilize the high thermal mass of earth to regulate indoor temperatures, remaining cool in summer and warm in winter. The inherent insulation properties of loess soil contribute to energy efficiency by reducing dependence on mechanical heating and cooling systems. By examining these two case studies, this research aims to compare their passive cooling mechanisms and evaluate their applicability in modern sustainable housing design.

Data Collection Methods

This study employs a multi-faceted approach to data collection, integrating both qualitative and analytical methods to ensure a comprehensive understanding of underground homes and their passive cooling strategies. A literature review was conducted to analyze open-access academic articles, and architectural studies on earth-sheltered dwellings, passive cooling techniques, and energy efficiency. This review provided a theoretical foundation for assessing the effectiveness of underground architecture in maintaining thermal comfort.

Additionally, semi-structured interviews were conducted with two architects and researchers who have either studied or visited these underground settlements regarding their comfort levels and adaptive cooling behaviors.

The interviews aimed to gather expert insights on the observed performance of passive cooling mechanisms, challenges associated with adapting these techniques to modern urban environments, and recommendations for integrating underground housing principles into contemporary sustainable architecture. This triangulated methodology ensures a well-rounded evaluation of the subject matter, combining theoretical knowledge with practical observations. To clarify the workflow of this study, a schematic diagram in figure 2 is provided, illustrating the sequence of research steps from literature review and case study selection to expert interviews and comparative analysis of cooling strategies.

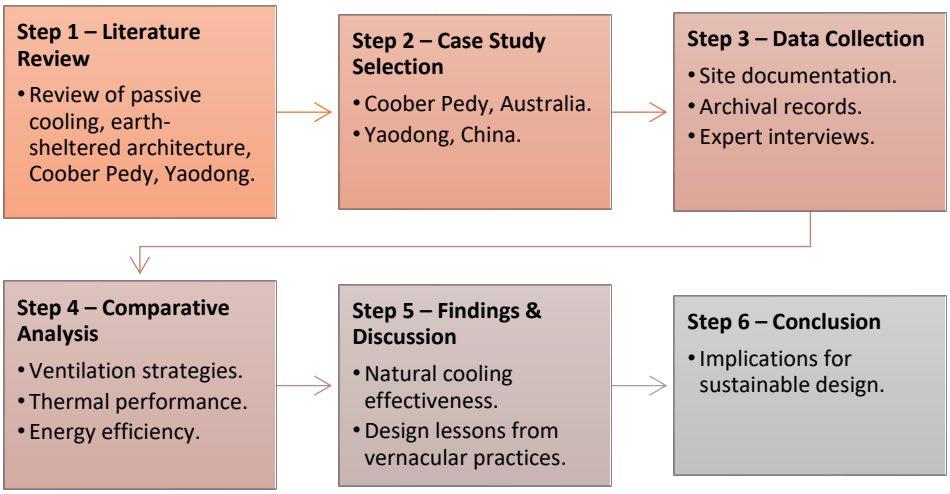


Figure 2: Research Methodology Process

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Limitations

1. Data Availability: The study relies on existing literature and expert opinions, which may limit access to first-hand empirical data.
2. Interview Scope: The number of professionals familiar with these underground homes may be restricted, potentially narrowing the perspectives gathered.
3. Generalizability: Findings from Coober Pedy and Yaodong may not be universally applicable, as climatic, cultural, and geological conditions differ across regions.
4. Beyond methodological constraints, broader limitations include regulatory barriers, cultural preferences for above-ground living, and the high initial costs of excavation, which may hinder the adoption of earth-sheltered cooling strategies in modern urban contexts.

ANALYSIS AND DISCUSSION

This section presents the key findings from the case studies of Coober Pedy and Yaodong homes, supported by insights from the literature review and two architects' validations. These underground dwellings demonstrate how thermal mass, ventilation strategies, and material selection contribute to passive cooling, reducing reliance on artificial climate control. The architects' input further supports the practical applicability of these strategies in modern sustainable housing.

As shown in figure 3 and 4, Coober Pedy's underground residences and China's Yaodong dwellings provide significant insights into the effectiveness of earth-sheltered homes in maintaining thermal comfort with minimal energy use. The analysis of Coober Pedy's underground homes and Yaodong dwellings directly addresses the study's objective of evaluating passive cooling in earth-sheltered architecture. Both case studies demonstrate that leveraging thermal mass, strategic ventilation, and natural insulation significantly reduces energy consumption, key principles that can inform modern sustainable housing designs.



Figure 3: Coober Pedy underground structure (Erinna Giblin, 2018)

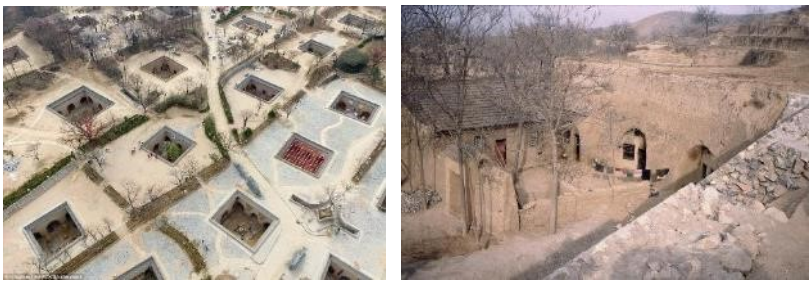


Figure 4: Yaodong dwellings courtyards (Kaushik Patowary, 2018)

In Coober Pedy, Australia, residents have adopted underground living to cope with extreme desert heat. The sandstone substrate acts as an insulating layer, keeping interiors cool during scorching summers and retaining warmth in winter (Zaria Gorvett, 2023). Similarly, in China, Yaodong homes, constructed within compacted loess soil, exhibit superior thermal regulation by maintaining stable indoor temperatures despite external climate variations. The thick earthen walls absorb heat during the day and release it at night, effectively mitigating temperature fluctuations.

To systematically compare these two underground housing typologies, analytical table 3 has been developed, summarizing their key characteristics, environmental adaptation strategies, and architectural techniques. This comparative analysis provides a structured evaluation of how each case study achieves energy-efficient cooling and highlights their relevance for modern sustainable housing solutions.

Table 3: Analytical table summarizing key characteristics

Criteria	Coober Pedy (Australia)	Yaodong (China)
Year Established	1915	Over 2000 years ago
Location	Hot desert climate, South Australia	Semi-arid/temperate regions, Northern China
Typology	Underground town	Semi-subterranean cave dwellings
Material Used	Sandstone	Loess soil
Thermal Strategy	Thermal mass insulation; stable underground temperatures	High thermal mass; soil insulation for passive cooling
Cooling Mechanism	Protection from extreme heat via earth coverage	Natural ventilation and heat absorption from thick walls
Energy Use	Minimal air conditioning needed	Little to no reliance on artificial cooling
Sustainability	Reduces energy consumption, adapts to harsh climate	Passive cooling reduces energy demand

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Natural Cooling Mechanisms in Underground Homes Thermal Mass and Insulation

One of the most critical takeaways from the study is that thermal mass plays a dominant role in passive cooling, reinforcing Givoni's (1994) "thermal buffering" concept, which argues that materials with high heat storage capacity help regulate indoor temperatures by absorbing excess heat during the day and releasing it at night as shown in figure 5.

- Coober Pedy: Homes are carved into sandstone, a material with high thermal inertia. Indoor temperatures remain between 19–25°C, even when external temperatures exceed 40°C (Meir & Gilead, 2002).
- Yaodong: These cave dwellings, built into loess soil, utilize thick earth walls to maintain thermal stability, keeping interiors cool in summer and warm in winter (Liu et al., 2011).

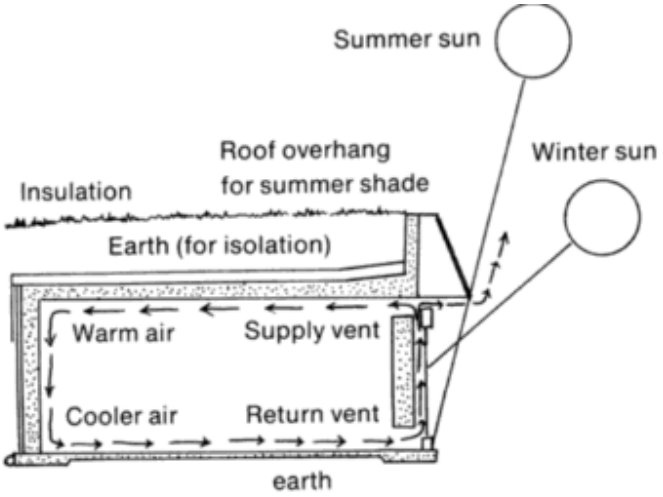


Figure 5: Sectional diagram of a traditional earth bermed dwelling showing passive cooling features, including earth insulation, ventilation shafts representing thermal stability (Terman, 2012)

Architect A highlighted that thermal mass is a crucial element in passive cooling strategies. Sandstone in Coober Pedy and loess soil in Yaodong exemplify how indigenous materials regulate temperature without mechanical systems. These principles are highly relevant for contemporary sustainable design.

Depth and Orientation

The effectiveness of passive cooling in underground homes is influenced by excavation depth and site orientation, which minimize heat gain.

- Coober Pedy: Dugouts are typically constructed 5–10 meters underground, reducing exposure to extreme temperature fluctuations (Meir & Gilead, 2002)
- As shown in figure 6, Yaodong dwellings are often partially or fully embedded in hillsides, leveraging natural shading to reduce heat absorption (Liu et al., 2011).

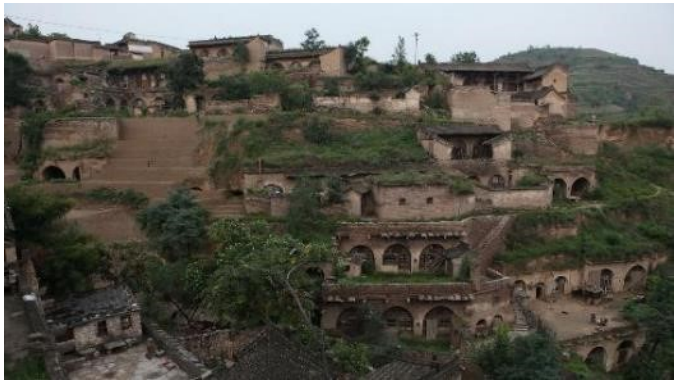


Figure 6: Yaodong cave dwelling (Mariabruna Fabrizi, 2021)

Architect B noted that strategic ventilation placement in underground homes is key to their energy efficiency. Coober Pedy's stack effect and Yaodong's wind-aligned openings showcase how passive ventilation can be optimized for different climates. These techniques should be incorporated into modern urban housing to reduce cooling energy demands.

Architectural Strategies for Energy Efficiency

Natural Ventilation and Airflow

Strategically placed ventilation shafts and openings facilitate natural ventilation, a passive process where air movement driven by pressure differences replaces indoor warm air with cooler outdoor air, reducing heat build-up.

- Coober Pedy: as shown in figure 7, many homes feature narrow shafts that promote stack ventilation, allowing cooler air to enter from below while expelling warm air from above (Meir & Gilead, 2002).
- Yaodong: Openings are aligned with prevailing winds, enhancing cross-ventilation and passive cooling (Liu et al., 2011).

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Architect A emphasized that effective passive cooling relies not only on material properties but also on strategic ventilation design. The stack ventilation in Coober Pedy optimizes airflow in enclosed underground spaces, while Yaodong's cross-ventilation approach takes advantage of natural wind movement, making both systems highly adaptive to their respective climates.
Architect B highlighted that modern architecture could incorporate similar principles by designing buildings with passive ventilation strategies, such as atriums and stack ventilation systems, which significantly reduce the need for mechanical cooling.



Figure 7: Coober Pedy shafts (Chris Weller and Erin McDowell, 2020)

Material Properties and Adaptability
Locally sourced building materials enhance the energy efficiency of underground homes.

- Coober Pedy: Sandstone is naturally porous, retaining moisture and further cooling interior spaces (Meir & Gilead, 2002).
- Yaodong: Loess soil has high thermal resistance, reducing heat transfer and stabilizing indoor temperatures (Liu et al., 2011).

Architect A stated that sandstone and loess soil are prime examples of materials that inherently regulate heat flow, reducing the dependency on artificial cooling. These materials should inspire modern sustainable architecture by integrating high thermal mass alternatives, such as rammed earth and bio-based insulation.

Architect B noted that beyond insulation, material selection in sustainable architecture should also prioritize moisture management, as underground structures require adequate waterproofing to balance humidity levels without compromising thermal efficiency.

Applicability to Modern Sustainable Housing
Adaptation of Passive Cooling Techniques
Lessons from underground homes can inform modern architecture, especially in regions with extreme climates.

- Earth-sheltered housing can integrate underground thermal mass principles.
- Green roofs and bermed structures replicate the insulating effect of subterranean homes, mitigating urban heat island effects (Xie et al., 2023).

Architect A suggested that incorporating underground thermal mass strategies into modern urban housing can significantly reduce cooling demands. Techniques such as semi-subterranean dwellings, courtyard designs, and bio-climatic earth integration are viable adaptations.

Architect B emphasized that designers should explore hybrid solutions, such as integrating phase change materials (PCMs) with earthen walls, to achieve more dynamic and adaptable thermal performance.

Challenges and Considerations

- Structural challenges: Underground homes require advanced waterproofing to prevent moisture-related issues.
- Cultural adaptation: Many regions lack familiarity with earth-sheltered housing, necessitating public awareness campaigns and regulatory support.

Architect A highlighted that modern architect must balance the advantages of earth-sheltered design with contemporary building codes and urban development policies, ensuring that moisture control, ventilation efficiency, and cultural acceptability are adequately addressed.

Architect B noted that adapting underground housing to urban environments requires a shift in perception governments and architects need to advocate for alternative housing models that embrace energy-efficient earth integration rather than relying solely on conventional construction practices.

Summary of Findings
The comparative analysis of Coober Pedy's underground homes and Yaodong dwellings highlights the effectiveness of thermal mass, passive ventilation, and

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natural insulation in maintaining indoor comfort while reducing energy demand. These strategies align with the study's objective of evaluating passive cooling techniques in earth-sheltered architecture and their relevance to modern sustainable housing. The findings demonstrate that locally available materials, excavation depth, and ventilation design play a crucial role in achieving thermal efficiency in underground dwellings.

Table 2: Summary of the key insights from the study

Feature	Coober Pedy (Australia)	Yaodong (China)	Modern Adaptation
Thermal Mass	Homes carved into sandstone, a material with high thermal inertia, absorbing and slowly releasing heat.	Thick loess soil walls provide natural insulation, stabilizing indoor temperatures.	Rammed earth and high thermal mass concrete can replicate these effects in contemporary buildings.
Ventilation Strategy	Stack ventilation shafts facilitate airflow by drawing in cooler air and expelling warm air from the top.	Wind-aligned openings optimize cross-ventilation, leveraging natural air currents.	Hybrid ventilation systems, including passive air wells and atrium designs, can be integrated into modern buildings.
Cooling Effectiveness	Indoor temperatures remain between 19–25°C, even when external temperatures exceed 40°C.	Interiors maintain comfortable conditions throughout the year, keeping warm in winter and cool in summer.	Energy-efficient designs incorporating natural shading, thermal buffering, and ventilation zoning can improve indoor comfort while reducing reliance on HVAC systems.
Material Properties	Sandstone is porous, retaining moisture and aiding in cooling.	Loess soil has high thermal resistance, reducing heat transfer.	Bio-based insulation materials, phase change materials (PCMs), and green building technologies can enhance passive cooling.
Sustainability	Reduces reliance on artificial cooling and integrates well with the natural landscape.	Low-energy, time-tested housing strategy that remains culturally significant.	Earth-sheltered homes, green roofs, and bermed structures can replicate underground cooling mechanisms in modern urban environments.

The findings of this study align closely with its research objectives, providing a comprehensive evaluation of passive cooling mechanisms in underground architecture. This research aimed to analyze energy-efficient strategies employed in the underground dwellings of Coober Pedy and Yaodong, assess their applicability to modern sustainable housing, and highlight the role of

natural insulation and ventilation in reducing energy consumption. The study confirms that both Coober Pedy and Yaodong effectively utilize passive cooling strategies, significantly minimizing reliance on mechanical air conditioning. The high thermal mass of sandstone in Coober Pedy and loess soil in Yaodong plays a crucial role in regulating indoor temperature fluctuations, ensuring stable indoor climates, and preventing extreme variations.

Architectural strategies further reinforce the effectiveness of passive cooling in these underground dwellings. Coober Pedy employs stack ventilation, which facilitates airflow and removes excess heat, while Yaodong integrates wind-aligned openings that enhance cross-ventilation. Additionally, excavation depth and strategic site orientation contribute to reducing heat gain, demonstrating the importance of thoughtful spatial planning in energy-efficient building design. These principles, deeply embedded in the traditional architecture of underground homes, have significant implications for contemporary sustainable design (Givoni, 1994). Lessons from these dwellings can be applied to modern architecture through the integration of earth-sheltered housing, green roofs, and insulated structures. Moreover, advancements in construction materials, such as phase change materials (PCMs) and rammed earth, can further enhance the thermal performance of buildings, reinforcing the benefits of passive cooling systems.

Architectural validation supports the study's conclusions. Architect A emphasized that sandstone and loess soil regulate temperature effectively, while Architect B highlighted the importance of ventilation and suggested hybrid systems to enhance adaptability in modern housing. Together, their insights demonstrate the wider applicability of underground passive cooling to sustainable design.

This study confirms earth-sheltered housing as a viable, energy-efficient approach for extreme climates. The precedents of Coober Pedy and Yaodong show how thermal mass, insulation, and ventilation can reduce energy use and improve comfort, offering valuable strategies for contemporary sustainable architecture.

CONCLUSION

This study examined passive cooling in earth-sheltered dwellings in Coober Pedy, Australia, and Yaodong, China, demonstrating how thermal mass, orientation, and ventilation work together to maintain stable indoor conditions with minimal reliance on mechanical systems. Both case studies reveal the effectiveness of vernacular solutions in addressing climatic extremes. The findings highlight clear opportunities for modern architecture: underground and semi-underground housing strategies can inform sustainable design, particularly in regions facing rising energy costs and heat stress. Integrating elements such as

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earth berms, optimized orientation, and selective natural ventilation can reduce energy demand while improving thermal comfort. Future research should expand to include quantitative simulations of energy performance, cross-cultural comparisons with other vernacular models, and assessments of user comfort and acceptability in modern contexts. Such work can bridge traditional knowledge with contemporary building technologies, advancing sustainable housing solutions in diverse climates.

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Glossary of Terms

Key technical terms used in this study are defined as:

- Thermal Mass: Ability of materials to store and release heat, moderating indoor temperatures.
- Subterranean Depth: Extent a structure is built below ground, influencing thermal stability.
- Passive Cooling: Natural methods (e.g., ventilation, shading, thermal mass) that reduce indoor heat without mechanical systems.
- Earth-Sheltered Housing: Buildings partly or fully below ground, using soil for insulation.

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TOWARDS SELF-ACTUALISATION: A REHABILITATION PROGRAM MODEL FOR HOMELESSNESS IN KUALA LUMPUR

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Abstract

Homelessness in Kuala Lumpur remains visible despite numerous supports and initiatives from governments and NGOs. Current rehabilitation programs are providing short-term relief, but how can these models help the homeless achieve self-actualisation? The objectives are to explore how current rehabilitation programs address the various needs of the homeless and to identify the gap between the charity model and the co-production model in providing a long-term, integrated approach. Adopting Maslow's hierarchy of needs theory as a guide, this study examines the rehabilitation needs of homeless individuals in transit centres around Kuala Lumpur. Data were collected through semi-structured interviews, field observations and document analysis for a qualitative method. Results from this study indicated that to achieve self-actualisation, rehabilitation should reintegrate basic needs, psychological needs, self-fulfilment needs, and transition needs. The charity model, which emphasises short-term relief but offers limited long-term impact, and the co-production model, which promotes empowerment and long-term outcomes, are the two programs that support the homeless journey towards self-actualisation. This paper proposes a hybrid rehabilitation model that integrates two existing programs and additional structured pathways, aiming to provide continuous support in shaping a more inclusive policy and enhancing rehabilitation practices in reducing homelessness in Kuala Lumpur.

Keywords: homelessness, rehabilitation, temporary shelter, self-actualisation, charity model vs. co-production model, transition needs

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INTRODUCTION

Kuala Lumpur's rapid urbanisation and high numbers of low-income earners have led to significant issues, including homelessness (Badrudin et al., 2022). According to reports, there are estimated to be around 1,000 to 2,000 homeless people, and the numbers are increasing as a result of socio-economic pressures (Amir et al., 2024). These highlighted the urgency in addressing homelessness in Kuala Lumpur. The government and non-governmental organisations (NGO) have initiated programs to help the homeless population. These include essential necessities, soup kitchens and temporary shelters. However, these interventions often focus on providing short-term relief, which is ineffective (Hisham & Amin, 2023).

In Kuala Lumpur, food and well-being treatment were provided by non-governmental organisations (NGOs) such as Pertiwi and Kechara Soup Kitchen (Aizuddin et al., 2019). These NGOs focus on the Charity Model. However, it is just a short-term approach that does not reduce the problem of homelessness (Sprake et al., 2013). Meanwhile, the Co-Production Model promotes social participation and public management collaboration to enhance the service (Park, 2020). The current transit centres in Kuala Lumpur employ the co-production model by addressing various aspects of needs, including accommodation, medication, and job opportunities for the homeless (Aizuddin et al., 2019).

Nevertheless, the existing transit shelter services in Kuala Lumpur, which are offered for both programs and facilities, are insufficient (Aizuddin et al., 2019). Interventions that address the specific needs of homeless individuals have significantly improved the efforts to eradicate homelessness (Keenan et al., 2021). The main research question is: *How can rehabilitation models in Kuala Lumpur enable progression toward self-actualisation for homeless individuals?* Therefore, the main objective of this study is to investigate the approach implemented in the homeless transit centres in Kuala Lumpur using Maslow's theory as an indicator, to compare the charity and co-production models applied in the existing homeless transit centres in Kuala Lumpur and to find the appropriate of rehabilitation model that encourages the development of self-actualisation. Considering the lack of comparative research, a study that explores needs and challenges across different transit centres may help guide decision-making for intervention programs and facilities.

LITERATURE REVIEW

Deficit, Charity, and Co-production Model for Homelessness

The models of Deficit, Charity, and Co-Production (Fig. 1) offer a unique perspective on addressing homelessness in Kuala Lumpur. Each model also presents limitations and challenges, which make a more comprehensive hybrid rehabilitation model.

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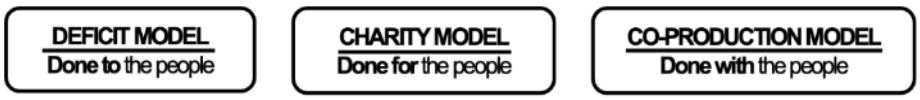


Figure 1: Different service models and approaches with varying levels of empowerment (Author, 2021).

The Deficit Model characterises homelessness as a failure that is frequently caused by personal failings such as addiction or lack of responsibility. This model somehow overlooks other factors, including systemic issues such as social exclusion, poverty, and housing market dynamics. These factors are particularly relevant in Kuala Lumpur, where homelessness is often viewed as a personal failure rather than a social problem (Lio et al., 2022).

The Charity Model focuses on providing immediate relief, including food, temporary shelters, medical, and hygiene facilities. This model is especially needed during crises and effectively meets the basic physiological and safety needs outlined in Maslow's Hierarchy of Needs theory. This model inadvertently encourages homelessness and prevents individuals from achieving self-sufficiency (Mejía-Lancheros et al., 2020). While the Co-Production Model promotes teamwork and empowerment, it encourages homeless individuals to participate in the development and implementation of the rehabilitation program. Finland and the Netherlands have effectively adopted this model in homelessness interventions, which promotes community engagement, integration, and self-sufficiency (Cornes et al., 2021). However, these models require a more comprehensive policy, and existing initiatives in Malaysia lack these strategies. The integration of Charity and Co-Production models, with a transition need, will provide a more efficient hybrid rehabilitation model in Kuala Lumpur. This hybrid model will foster a long-term empowerment framework that considers both short-term and long-term relief. This has been proven in past studies that a combination of immediate and long-term goals may serve the homeless better (Gutman & Raphael-Greenfield, 2017).

Maslow's Hierarchy of Needs

The hierarchy of needs, a theory of motivation in psychology, was constructed based on five conceptual categories (Fig. 2). According to Maslow (1970), the theory involves a five-level model of human needs, regularly portrayed as progressive levels inside a pyramid. Progressing from phase 1, which is the basic needs, to phase 3 of self-fulfilment needs, the needs stated are as such: physiological, safety, love, esteem, and self-actualisation. The basic needs should be fulfilled before attending to the needs that follow. Basic needs can be divided into two sub-categories, namely 'physiological needs' and 'safety needs. Physiological needs are the biological prerequisites for human survival, including

air, food, water, clothing, shelter, warmth, and sleep. Safety needs are individual and demand order, consistency, and control.

Psychological needs are divided into two classes. First, love and belonging needs include feelings of belongingness and the need for interpersonal connections. Examples include friendship, trust, acceptance, intimacy, receiving and giving love and affection. Second, esteem needs are divided into two classes: (i) esteem for oneself (pride, accomplishment, mastery, freedom) and (ii) the longing for reputation and respect from others (e.g., name, standing).

Self-fulfilment need is the highest stage in Maslow's hierarchy. It denotes the realisation of a person's potential, self-actualisation, pursuit of individual growth and top experiences. This stage was depicted by Maslow (1943) as the longing to achieve all that one can and to become the greatest that one can be.

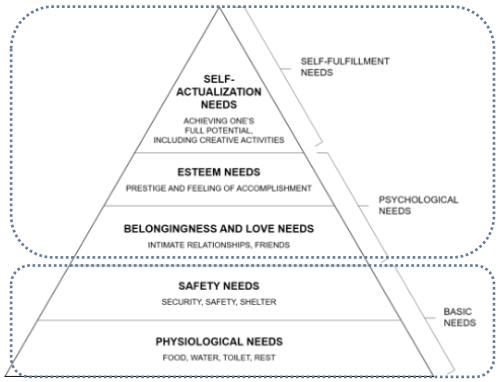


Figure 2: Maslow's hierarchy of needs (1943).

As shown in Figure 2, by offering immediate relief that includes food, shelter, and protection, the charity model aligns with Maslow's lower levels in the Hierarchy of Needs Theory. While the Co-Production Model emphasises empowerment, community participation and self-sufficiency, which is reflected in higher levels of the hierarchy. However, neither of the two models addresses the transition needs, which is the novel category in this study.

Beyond Maslow: Contemporary Frameworks in Homelessness Rehabilitation

Recent research indicates that a trauma-informed care strategy (Huber et al., 2020) is more successful in addressing psychological barriers to reintegration, even though Maslow's Hierarchy of Needs (1943) offers a helpful psychological

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framework. A comprehensive support system that goes beyond basic necessities is necessary for homeless individuals who struggle with mental health and social isolation. According to the Housing First concept, permanent housing should be the top priority (Tsemberis, 2010), as stable housing enhances mental health and job retention. Both the Hierarchy of Needs and Housing First are the current frameworks for addressing homelessness issues that focus on survival and empowerment (Sundin et al., 2019). However, these frameworks do not capture the reintegration phase, where the homeless transition out of homelessness. The reintegration phase into society is often considered a secondary concern rather than an essential component in rehabilitation and post-rehabilitation efforts (Chasciar et al., 2025).

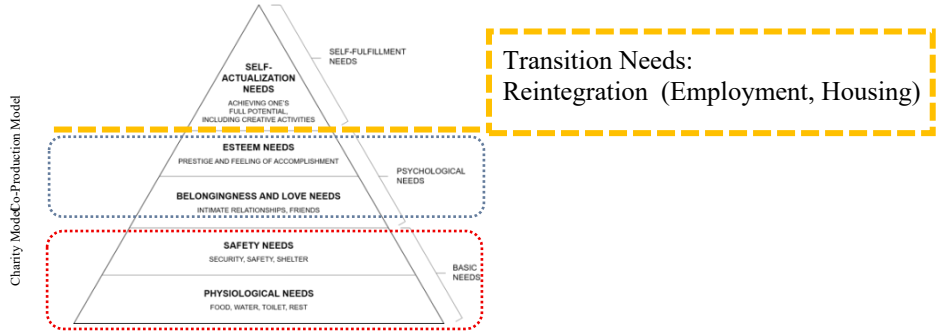


Figure 3: Transition Needs connect Charity and Co-Production Models

In Figure 3, the conceptualisation of transition needs to act as the connection after the combination of both the short-term Charity Model and the long-term Co-Production Model, before achieving self-actualisation and strengthening the development of the hybrid rehabilitation model. The hybrid rehabilitation model will address the issues and challenges in the reintegration of the homeless individuals (Chasciar et al., 2025).

RESEARCH METHOD

This study adopted a qualitative exploratory approach based on semi-structured interviews, field observation and document analysis to understand the rehabilitation process in homeless transit centres in Kuala Lumpur.

Case Study Selections

Two centres in Kuala Lumpur namely, Anjung Singgah (ASKL) and Pusat Transit Gelandangan (PTGKL), were chosen as they represent government-led rehabilitation initiatives with varying service delivery models (charity vs co-production approach). Their selection allows a comparative analysis of how

different rehabilitation models impact self-actualisation outcomes among the homeless population in Kuala Lumpur. Data collection was conducted in October 2020 during the COVID-19 Movement Control Order (MCO). MCO restricted researchers from having physical access and limited engagement and interactions with participants. Nevertheless, the MCO provide insights into how the centres operated during these crisis conditions, and highlights the resilience and limitations.

Data Collection and Analysis

Semi-structured Interview with the Selected Respondents

As above Anjung Singgah Kuala Lumpur (ASKL) and Pusat Transit Gelandangan Kuala Lumpur (PTGKL) were chosen as case studies. Almost 250 homeless people were transiting at both places at the time of the visit. Both transit centres are mid-term accommodation (usually 3 to 4 months). Interview participants included the centre's management staff (N=10 from each centre) and beneficiaries (the researchers used the term' clients', N=20 from each centre). The interview session began with the centre management staff, followed by an interview with the centre's beneficiaries (clients). Clients were recruited by service staff according to the inclusion criteria, i.e., those aged 18 years or above, Malaysian, able to communicate with the interviewer, with current or previous experience of homelessness, and not aggressive. Participants were interviewed face-to-face using a semi-structured interview method. Ethical Approval for this study was obtained from the University of Malaya Research Ethics Committee (UMREC). All participants provided informed consent and were given the right to withdraw before the interviews

The questions for the semi-structured interviews with ASKL and PTGKL management staff and the clients of the centres included four open-ended questions on: 1) *What are the immediate needs provided at the transit centres*? 2) *What are the programs or activities at the centres that support clients' well-being, relationships or sense of belonging*? 3) *How do the programs and training provided at the centres help to prepare for independence and employment?* 4) *What are the challenges expected after leaving the centres, and the supports provided to help reintegration into society?*

Data analysis followed a five-step process: 1) Interviews were transcribed verbatim and coded using NVivo software. 2) The researcher independently re-read the transcript of the interviews, identified attributes, and interpreted based on the homeless needs adapted from Maslow's model as shown in Figure 4. 3) Data were tabulated into met/ unmet needs. 4) A comparative analysis was produced across the two transit centres' (ASKL and PTGKL). 5) Finally, the most important elements of met and unmet needs were described, and

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suggestions were given to improve the quality of programs and facilities that should be provided at the homeless transit centre.

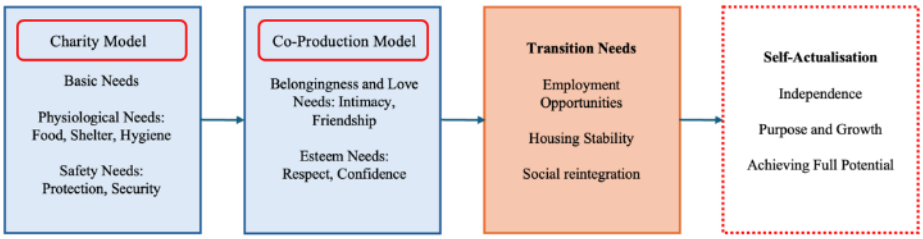


Figure 4: Attributes based on Maslow's Hierarchy of Needs (Authors, 2025)

RESULTS AND FINDINGS

The results are based on a comparative study between two case studies namely Anjung Singgah Kuala Lumpur (ASKL) and Pusat Transit Gelandangan Kuala Lumpur (PTGKL), on 1) the facilities and programs offered at (see Table 1); 2) rehabilitation needs of the clients based on Maslow's model (see Table 2) and models practiced in both centres (see Table 3).

Table 1: Facilities and Programs offered at ASKL and PTGKL

Feature	ASKL	PTGKL
Year Established	2011	2016
Location and Type	7 storey shop lot, Jalan Hang Lekiu	3-storey building with courtyard, Jalan Pahang
Capacity	2 dorms (Men/ Women) 38 beds each	4 dorms (Men only) 37 beds each for 150 clients
Food Services	Dining hall and Soup Kitchen led by NGO	Larger Dining Hall and soup kitchen led by NGO
Rehabilitation Focus	Tangible (Facilities) + Intangible (Programs, Counselling)	Long-term empowerment with wider outdoor and community space and activities
Special Facilities	Leisure rooms for indoor games, multipurpose hall	Garden (psychological therapy), courtyard for outdoor activities
Programs	Counselling, motivational talks, financial seminars, skills training (organised by Giat Mara)	Religious/motivational programs, community visits and skills training (Organised by Giat Mara)
Strengths	Privacy, indoor engagement, motivational and skills programs	Spacious dining and outdoor facilities, community activities and religious support
Weaknesses	Limited space (shop lot building) and reliance to NGO	Space constraints for training, limited post-training job support

Table 2: Rehabilitation Needs of Clients

Maslow's Hierarchy of Needs	ASKL Findings	PTGKL Findings	Observed Unmet Needs
Physiological Needs	Dorms with beds, lockers, bathrooms, food from NGO	Dorms with larger capacity, food from NGO	Overcrowding in dorms, reliance on food supply by NGO
Safety Needs	Dorm privacy between Men and Women, lockers for personal belongings	Dorm privacy, security within center	Limited long-term housing security after exit
Belonging and Psychological	Indoor games for bonding, peer sharing, community events	Garden therapy, social dining hall, community visits	Limited post-rehabilitation support networks
Esteem Needs	Motivational talks, financial management seminars	Community recognition through NGO / university visits	Confidence issues (especially finding jobs after training)
Self-Actualisation	Skills training via Giat Mara, guidance to enter workforce	Skills training via Giat Mara, some client intents for small businesses	Some training does not match with real job opportunities
Transition Needs (Gaps)	Not systematically addressed	Identified Gap: obtained skills, but no employment pathways and limited monitoring	Employment, housing and absence of reintegration support

Table 3: Models Practiced at ASKL and PTGKL

Model	Evidence in ASKL	Evidence in PTGKL	Observed Limitations
Charity Model	Food/clothing donations, soup kitchens and dorms	Soup Kitchen, large dining hall	Meets immediate needs, but raise dependency
Co-Production Model	Skills training, motivational seminars, peer counselling	Skills training, community engagement, NGO collaborations	Limited scale, dependent on NGOs and external partners
Transition Needs (Gaps)	Not systematically included	Clients express need of employmentand reintegration pathways	No structured monitoring after exit

DISCUSSION

Comparing Rehabilitation Models: Charity vs. Co-Production

The findings indicates that ASKL and PTGKL follow a traditional charity-based model, focusing on short-term relief (food, shelter, and hygiene services), and a Co-Production model, emphasising long-term empowerment (skills training, psychological support, and integration programs). Services provided by charities, such as food and shelter, help meet basic survival needs. This model somehow fails to promote self-sufficiency, which often leads to cycles of dependency and a high likelihood of the homeless remaining homeless (Thamrin et al., 2025). International studies also support that the Charity Model is insufficient for a long-term solution (Chan et al., 2022). Research by Omérov et al. (2019) highlights that shelters focusing solely on basic needs often create dependency rather than

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fostering self-sufficiency. For an effective rehabilitation model, it is essential to adopt the Co-Production Model. These programs help improve their self-esteem and social connections. Although it is evident that these programs aid in skill development, they rarely lead to secure employment opportunities (Lam et al., 2024). Evidence from the case studies highlights a lack of support after exit from the centres. Thus, the effectiveness of the rehabilitation model may decrease without follow-up support strategies (Chan et al, 2021).

The Need for a Hybrid Model

The analysis reveals that the needs of the homeless are not adequately met by either the Charity Model or Co-Production alone. Charity may offer short-term relief, but it often lacks the long-term empowerment that is truly needed (Castaldelli-Maia et al., 2022). In contrast, Co-Production aims to improve individual self-sufficiency, but lacks a formalised process that connects to the survival basics of an individual. As a result, there is strong evidence for the development of a hybrid rehabilitation model that combines the strengths of both Charity and Co-Production Models. This model will provide immediate relief while also ensuring long-term empowerment through community engagement, employment opportunities, housing, and ongoing support (Lam et al., 2024). Integrating continuous transitional support will ensure the reintegration of homeless individuals into society and promote sustainable self-sufficiency (Castaldelli-Maia et al., 2022).

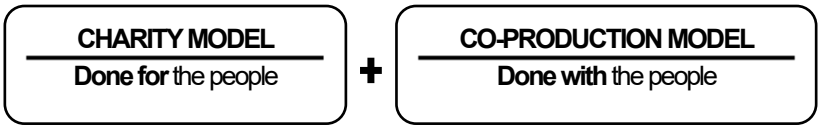


Figure 5: Integrating Charity and Co-Production Approaches in Developing a Comprehensive Rehabilitation Model for Self-Actualisation in Homelessness (Author, 2021)

Rehabilitation Needs

The rehabilitation needs are explained in 4 categories: i) Basic needs, ii) Psychological needs, iii) Self-fulfilment needs, and iv) Transition needs.

i) Basic Needs. Both case studies, ASKL and PTGKL, offer programs and facilities that cater to the empowerment needs of their clients, aligning with the Co-Production model. Food provided through soup kitchen activities will be distributed to all homeless individuals, regardless of whether they participate in the program at the transit centre. This is identified as the Charity model. Other

basic needs, such as temporary shelter, toilets, and medical care, are prioritised for clients who participate in the program at the transit centre.

ii)Psychological Needs. Both case studies provided programs and facilities that meet the clients' psychological needs for safety and a sense of belonging. Clients at the transit centres have been provided with individual beds and lockers. Both case studies use the concept of a large dormitory and shared toilets for temporary accommodation. Research by Dunbar (1992) has emphasized the importance of social networks, indicating that smaller living units foster interactions among residents (see Figure 6 and Figure 7).

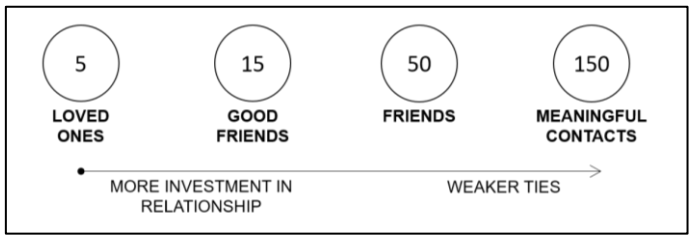


Figure 6: Dunbar's theory of the limits of human relations (Dunbar, 1992)

Dunbar suggested placing individuals in a smaller group to get to know each other. Therefore, it will foster friendships in which to fulfil the needs for belonging and love. Instead of a dorm with shared toilets and bathrooms, a smaller unit with only 3 to 5 occupants in each room might be more valuable. This approach is known as *Adlerian Therapy*, focuses on fostering a sense of belonging within the context of one's community and society (Erbaş, 2023).

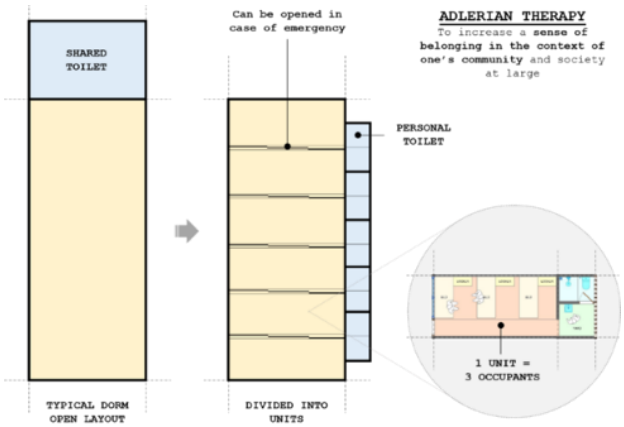


Figure 7: The suggestion for using the small unit approach instead of the dormitory system for the future Homeless Transit Centre (Dunbar, 1992).

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iii) Self-Fulfillment Needs. The programs provided at ASKL and PTGKL have a maximum duration of 6 months. During their stay, they will undergo a process of self-recovery and self-development, both psychologically and physically. However, due to space constraints, neither centre provided facilities for skills development. Due to this, both homeless transit centres have collaborated with Giat Mara Malaysia to provide skill development programs to their clients. Only PTGKL provides programs and facilities related to gardening. Gardening has been shown to enhance self-esteem and promote a sense of self and independence, which are vital in mental health treatment (Scott et al., 2020), as they contribute to fulfilling self-actualisation needs (Canadian Mental Health Association, 2012).

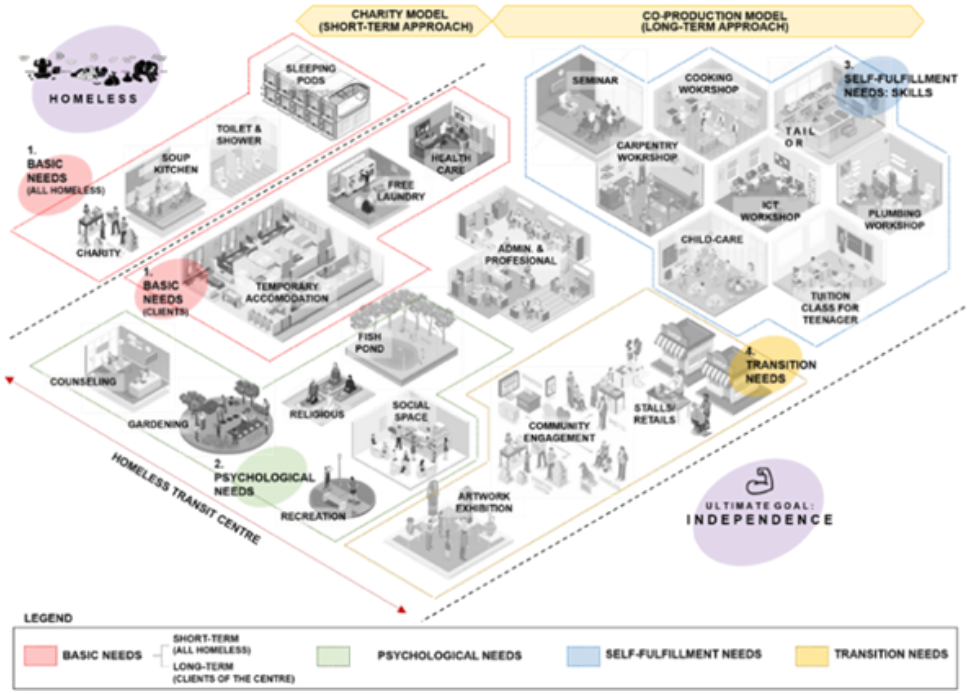


Figure 8: Illustration of the proposed design for the Homeless Transit Centre based on the Hybrid Rehabilitation Model combining both the Charity and Co-Production Model. (Authors, 2025).

iv) Transition Needs. The findings show that the clients from both centres expressed their worries about their post-rehabilitation futures, highlighting issues such as employability, despite being equipped with skills, as well as finding a place to stay and reintegration into society. This highlights the importance of

Transition Needs, which encompass the requirements for ongoing support, assistance, and social participation (see Figure 8). Social participation is defined as 'involvement in activities that provide social interaction with others in society or the community' (Levasseur et al., 2022). This means that homeless individuals should have opportunities to interact with others and build new relationships, for example, through participation in activities, which can serve as a starting point for social engagement. The transition needs not only to benefit the clients' economies and foster interaction between clients and society, but also to help clients gain self-confidence, thus regain the trust and support of society. Huber et al. (2020) state that individual empowerment is possible only in a social environment by offering supportive social relations and opportunities for development.

CONCLUSION

This study addresses the question: *How can rehabilitation models in Kuala Lumpur enable progression toward self-actualisation for homeless individuals?* Findings show that transit centres in particular, ASKL and PTGKL, are using both Charity and Co-Production Models by providing short-term relief and long-term empowerment. Although both models have advantages, neither alone may effectively help homelessness sustainably. Improving an individual's ability to reintegrate into the community could have a significant impact on their quality of life. The Hierarchy of Needs remains the fundamental framework for addressing homelessness, but it is essential to recognise the significance of transition needs as an additional component that binds all needs, enabling the homeless not only to survive but also to achieve self-actualisation. Skill trainings and empowerment programs will not be effective in producing a long-term solution if the transition needs are not addressed. For this reason, this study proposes a hybrid rehabilitation model that ensures short-term survival through the Charity Model, fosters self-sufficiency through integration with the Co-Production Model, and provides structured pathways to support continuous reintegration into society. Overall, this study contributes valuable insights that can inform evidence-based decision-making in the development of targeted intervention programs and the design of more responsive transit facilities for the homeless.

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SACRED SPATIAL PLANNING IN EARLY MEDIEVAL SOUTHERN KAZAKHSTAN: THE CASE OF THE TENGRIAN SANCTUARY COMPLEX OF MERKE

САКРАЛЬНОЕ ПРОСТРАНСТВЕННОЕ ПЛАНИРОВАНИЕ В РАННЕСРЕДНЕВЕКОВОМ ЮЖНОМ КАЗАХСТАНЕ: НА ПРИМЕРЕ ТЕНГРИАНСКОГО КОМПЛЕКСА СВЯТИЛИЩ МЕРКЕ

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Abstract

The article is devoted to the analysis of sacred spatial planning in early medieval Southern Kazakhstan using the example of the Merke sanctuary complex. The influence of the Tengrian worldview on the architectural organization of ritual spaces reflecting the cosmological principles and social structures of nomadic societies is considered. The research methodology is based on the interpretation of archaeological, topographic, and symbolic data, as well as on the systematization of monuments by architectural features (shape, size, orientation, material). Particular attention is paid to the concept of sacred landscape, the axial and hierarchical organization of objects, as well as their symbolic content. The importance of further study of the Merke complex as a unique element of cultural heritage on the Great Silk Road and a potential UNESCO World Heritage Site is emphasized. In the context of the reviving national identity and priorities voiced in the messages of the President of the Republic of Kazakhstan, this study actualizes the need to rethink cultural space as a key factor in historical identity.

Keywords: sacred space, Merke, Tengrism, South Kazakhstan, architecture, planning, cultural heritage.

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INTRODUCTION

Sacred space in traditional Central Asian cultures acts not only as a place of ritual practice but also as an embodiment of cosmological order, cultural memory, and territorial identity. For nomadic societies, sacred topography is a means of symbolic exploration of the world, establishing a connection between the natural environment and metaphysical reality. In the conditions of early medieval Southern Kazakhstan, an important section of the Great Silk Road, such objects as the complex of sanctuaries of Merke played the role of not only ritual centres, but also city-forming elements in the sacred geography of the steppes.

In the modern conditions of rethinking national identity and interest in historical and cultural heritage, reflected in strategic documents such as "Seven Facets of the Great Steppe" and annual messages of the President of the Republic of Kazakhstan, the significance of such monuments is increasing. However, archaeological complexes like Merke remain poorly studied, precisely in the aspect of architectural and spatial planning, and their symbolic content is rarely understood through the prism of the worldview system of Tengrianism.

The word "Tanri" (found in ancient Turkic texts and in Mahmud Kashgari) is of proto-Turkic origin and means "heavenly deity". It consists of the roots "tan" - "sky" and "ir" - "man" (man, hero). Similar forms are found among the Altai ("Tanri"), Yakuts ("Tanra"), Mongols ("Taner"), Buryats ("Taneri"), and in Kazakh - "Tanir". It is interesting that "Tan" also meant "dawn", "sunrise", and later - "equal", "half", which reflects the idea of pairing as the basis of the universe. There is also a version of borrowing from the Chinese "tian di" (天帝) - "heavenly ruler". (Aupov N.G., 2012)

The purpose of this study is to identify the architectural and spatial principles of the organization of the Merke complex and show how they relate to the religious and cosmological ideas of the Tengrian tradition. The main attention will be paid to the issues of planning, symbolic orientation, typology of monuments, and their interaction with the landscape. The study is also aimed at systematizing objects according to key features (shape, size, material, functions) and developing methodological approaches to the study of sacred spaces of nomadic cultures. Thus, this work actualizes the Merke complex of sanctuaries as the most important archaeological and architectural monument, deserving inclusion in international research and conservation programs, including under the auspices of UNESCO.

Studies of sacred landscapes around the world, from Neolithic ritual terrains in Europe (Antonello et al., 2013) to the Andean ceque system centred around Cusco (Bauer, 1998), and the sacred groves of East and West Africa (Christin Adongo, 2016) (Adeyanju, 2020) demonstrate how ancient societies inscribed cosmological principles into spatial organization. Within this global discourse, the sanctuary complex at Merke in Southern Kazakhstan presents a

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distinctive Central Asian manifestation of sacred spatial planning. Despite its architectural and cosmological significance, the Merke complex remains underexamined in comparative studies of indigenous sacred geographies. This research addresses this gap by situating Merke within broader global patterns of sacred landscape formation.

LITERATURE REVIEW

Research into the sacred space and architectural organization of nomadic cultures in Central Asia covers a wide range of topics, from archaeological descriptions to philosophical and cosmological interpretations. However, a comprehensive approach that combines planning principles, religious and ideological foundations, and architectural typology remains underdeveloped.

The work of (Ayazbekova S, 2017) emphasizes the importance of circular and square planning in the Tengrian tradition, linking architectural form with the idea of cosmic order. She also points to the symbolism of the unification of circle and square in the structure of settlements and sacred sites, including such monuments as Arkaim, Koy-Krylgan-kala, and Chatal-Guyuk. Of particular interest is her concept of "fortified settlements with residential walls" as a sign of a collective sacred way of life.

Research on the cultural and spatial organization of early medieval Turkic sites in Kazakhstan has been significantly shaped by the works of Baipakov K.M., who emphasized the symbolic role of mountains, valleys, and watershed lines in the formation of sacred landscapes. In his studies of medieval urban and ritual complexes along the Silk Road, he demonstrated that Turkic sacred spaces were closely integrated with natural topography and ritual pathways, often marked by kurgans, stone steles, and memorial enclosures. (Baipakov K.M., 1986) (Baipakov K.M., 1998)

In the article Medieval mausoleums of Kazakhstan: Genesis, architectural features, major centres, the authors analyze the development of mausoleums of Medieval Kazakhstan, identify their original features, and main distribution centres. The key compositional types of mausoleums and features of regional architectural schools are determined.(Baitenov et al., 2019)

Research from other cultural contexts also emphasizes the relationship between spatial orientation, landscape, and traditional belief. For example, the work done by (Farhana et al., 2020) analyzed the orientation of buildings in the Malay settlement of Kg Seri Tanjung and found that social and environmental factors played a crucial role in shaping traditional layouts. This cross-cultural perspective helps to better understand how cultural principles and traditional beliefs may have influenced spatial planning.

Recent studies have demonstrated how digital technologies can enhance the documentation and analysis of traditional urban forms. For instance, (Noor et

al., 2019) constructed a 3D model of traditional Malay spatial identity. The technological approaches like this could also be applied to the study of sacred sites in Southern Kazakhstan to visualize their spatial logic and orientation patterns.

Comparative scholarship on sacred landscapes highlights a remarkable convergence in spatial principles across diverse cultural traditions. In Europe (Antonello et al., 2013) show how prehistoric sanctuaries in Daunia were aligned with celestial and topographical features. In South America (Bauer, 1998) demonstrates that the ceque system of Cusco organized shrines and ritual pathways according to cosmological and social hierarchies integrated into the landscape. African studies, such as those by (Christin Adongo, 2016) and (Adeyanju, 2020), underscore the role of sacred groves as mediators between human communities, ancestral spirits and the natural environment.

In conclusion, the existing literature fragmentarily covers various aspects of sacred space, but there is no systematization of the architectural and spatial characteristics of such objects as Merke in the context of the worldview tradition of Tengrianism. This study seeks to fill this gap.

COSMOLOGICAL FOUNDATIONS OF TENGRIANISM AND SACRED THINKING

The worldview of Tengrism forms a holistic model of interaction between man, nature, and space. It is based on the idea of the trinity of the world: the Upper World (Tengri - Sky), the Middle World (Umai - Earth), and the Lower World (Erlik - Underworld). These levels are not isolated, but interact through a sacred vertical, often embodied in the images of a sacred mountain, tree, or center of space.

The cosmological structure of the world was reflected in architecture and landscape organization. Thus, the vertical division of space (height, mountains, open horizon) symbolized the aspiration to Heaven and connection with higher powers. Horizontal axes, especially the east, set the direction of life and the cycle of time. The east was associated with sunrise, renewal, and beginning. The spatial planning of sanctuaries was often subordinated to these axes.

The veneration of natural objects - mountains, rivers, springs, rocks - as receptacles of spirit and energy enhanced the sacred perception of the landscape. Unlike the temple architecture of sedentary civilizations, in the Tengrian tradition, sacredness was fixed not so much in buildings as in the landscape itself. Religious objects - stone steles, burial mounds, altars, tamgas - did not disturb the natural environment, but emphasized its significance. Thus, sacred thinking within the framework of Tengrianism sets a specific spatial logic, where each element - form, orientation, location - has a metaphysical meaning. These

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principles form the basis for the analysis of the architectural and spatial structure of the Merke complex.

The cosmology of Tengrianism, which integrates celestial, terrestrial and ancestral realms, resonates with broader patterns observed in indigenous sacred geographies. In the Andes, the spatial organization of shrines documented by (Bauer, 1998) illustrates how cosmology was materially embedded within the landscape. African sacred groves such as Kaya Mudvi Muvya (Christin Adongo, 2016) and Osun-Osogbo (Adeyanju, 2020) likewise reflects a worldview in which natural landscapes function as ritual and cosmological interfaces. European prehistoric sanctuaries described by (Antonello et al., 2013) similarly, demonstrate symbolic alignments connecting human ritual activity with celestial phenomena. Within this framework, the Merke sanctuary expresses a uniquely Central Asian articulation of sacred geography, where Tengrian cosmology shapes the spatial logic of mountain-steppe landscapes and cult architecture.

ARCHITECTURAL AND PLANNING STRUCTURE OF THE MERKE COMPLEX

The Merke complex of sanctuaries, located in the Zhambyl region of southern Kazakhstan, is one of the most striking examples of sacred planning formed under the influence of the Tengrian worldview. Stretching along the mountain slopes at altitudes from 1800 to 3000 meters, it includes more than 170 objects: sanctuaries, balbals (stone steles), burial mounds, carved tamgas (family signs), and runic inscriptions.

The spatial distribution of objects demonstrates the principles of sacred geography, where orientation, altitude, and openness of the horizon play a key role.

Architectural analysis allows us to highlight the following characteristics:

Table 2: The characteristics of objects

Criterion	Description
Form	Predominantly circular and oval platforms (symbolizing the sun and cyclicality); rectangular and square structures also occur (earthly order).
Size	Diameter of stone circles: 4–16 m; height of steles and balbals: 0.5–2 m.
Material	Local stone: granite, sandstone, pebble. Evidence of processing includes polishing, notches, and carving.
Orientation	A significant number of objects are aligned along the east axis, emphasizing cosmological direction (sunrise, renewal, beginnings).

Source: Author's Calculation

The typology of objects indicates their ritual and social function. Thus, the presence of paired balbals and altars indicates a gender and hierarchical structure. The concept of an "invisible center" - a central force not expressed architecturally, but defined symbolically and by the natural environment is the key to understanding Merke. Here, the landscape itself becomes a structuring element, determining how sacredness is perceived and distributed in space.

The relationship between objects and natural forms (streams, rocks, hills) indicates a fine-tuning of sacred space: architecture does not replace nature, but enhances its symbolism. Such integration is characteristic of the Tengrian model of sacred landscape. Thus, the architectural and spatial structure of the Merke complex reflects the idea of the sacred organization of the world: it is centred, oriented, hierarchical, and filled with symbols. This structure can be considered as a kind of model of the universe, fixed in stone and landscape.

RESEARCH METHODOLOGY

This study employs a mixed-method approach combining quantitative and qualitative analyses. The quantitative component consisted of collecting, systematizing, and classifying archaeological data related to the mounds and stone sculptures of the Merke complex. Parameters such as location, dimensions, construction materials, and morphological features were recorded and analyzed (Table 2). The qualitative component focused on examining the burial mounds accompanied by stone sculptures, which revealed recurring structural and stylistic characteristics (Table 3). The integration of both methods allowed for the identification of typological patterns and regional specificities within the Merke complex.

The information in Table 1 shows the main characteristics of the monuments, which are the key analytical parameters throughout the study. At the same time, Table 2 presents the classification of monuments according to the characteristics indicated in Table 1. The categories are directly related to differences in shape, size, material, and orientation, which allows for a comparative analysis of different types of sacred structures.

This study focuses on the physical and spatial characteristics of the objects under study. The selected criteria: shape, size, material, and orientation are used to systematize the monuments and identify patterns in their design and placement. Analysis of shape and size helps to identify typological variations and symbolic meanings, while the study of materials provides insight into local resources and construction techniques. Orientation is considered an important indicator of cosmological beliefs and ritual practices. Since the relative positions of various elements can tell about a complex system of beliefs associated with the cult of the sun, stars, or other natural phenomena, integrating these

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characteristics into the analysis allows us to form a comprehensive understanding of the architectural logic and cultural context of the monuments.

ANALYSIS AND DISCUSSION

The Merke complex, like other sacred sites of early medieval Kazakhstan, is a unique example of the spatial implementation of the worldview model of nomadic societies. Unlike the temple complexes of sedentary civilizations, the structure of Merke is based on the principles of open landscape, integration with the natural environment, and visual-semantic orientation.

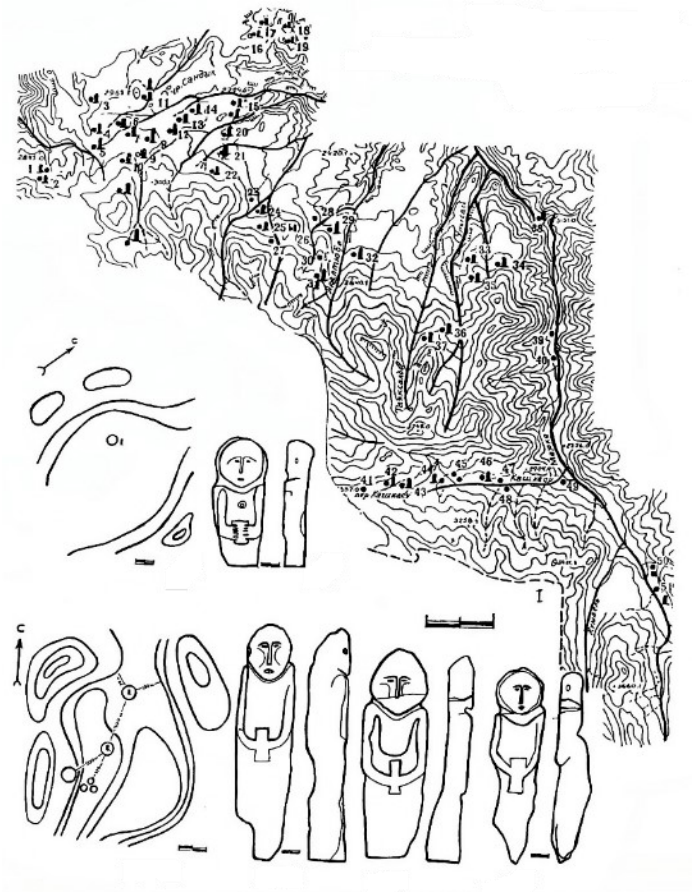


Figure 1: map of Merke
Source: from the book Merke – sacred space of the Zhetisu

The architectural logic of the complex is not subject to utilitarian, but symbolic laws: each element has not only physical, but also sacred significance.

The center of the circle, the high-rise dominant, the eastern orientation, the presence of a natural marker - all this sets the metaphysical axis that connects the earthly and heavenly levels.

Archaeological research conducted at remote memorial complexes became the basis for a preliminary chronological and cultural interpretation of ritual fences and burial mounds with stone sculptures, which were installed by nomads on the eastern side of the fence, in an extension adjacent to the embankment or center of the burial mounds from the east. (Dosymbaeva A., 2002) Among the burial mound structures of the Merke sanctuary, several ritual fences with steles and a sculpture were discovered, which were completely hidden in an extension to the fence.

Topographic features of the arrangement of ritual structures with sculptures, which are located on the ridges of the ravines, on the plateau, in the ravine itself, along the rivers, on the coastal terraces of springs, sometimes in an area separated from each other by only a few hundred meters, indicate a probable cultural kinship and chronological proximity of the monuments. For example, topographically, from the southeast to the northwest, following one after another ravine, with the names of Karalas-sazy, Togansay, Zhalanashtyn zhartysy, Sulysay, Karasay, Sholsay, Sandyk and occupying a total area of about 3 square kilometers, there are 33 stone sculptures on the mounds. In general, the territory of the localization of monuments with sculptures was a sacred space.

Based on the results of the archaeological study of the upper reaches of the Merke River, a map of the distribution of cult monuments with stone sculptures and places of accumulation of petroglyphs was compiled. In total, several dozen burial mound structures with statues were plotted on the archaeological and topographic map (Fig. 1). 64 stone sculptures were identified, including 31 female statues. Statistical analysis and data on the typology of ritual monuments made it possible to establish that the sanctuary contains only 38 complexes with statues.

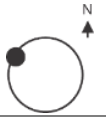
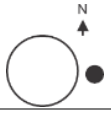
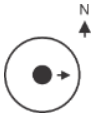
The main part of the ritual structures are stone mounds, ranging in diameter from 4-5 m to 16 m, and in height from 0.5 to 1.3 m. Some mounds are adjoined on the eastern side by rectangular extensions, also made of stone. (Dosymbaeva A., 2002) Each cult monument with a sculpture or with sculptures occupies such a position in the topography of the site that it is visible from afar. Numerous statues of women, along with men, in the materials of the Merke sanctuary help to understand some aspects of the ideological ideas of the nomads of the Middle Ages. The traditional belief of the Turks in the coexistence of the male, heavenly, and female principles has deep roots. The close interweaving of burial and commemoration rites, reflecting the desire to connect the worlds of people living with those who are no longer there, in the traditional cultures of nomads, finds its embodiment in numerous monuments of material culture, which

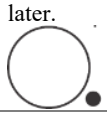
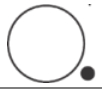
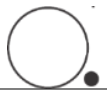
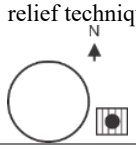
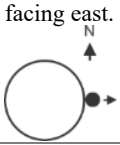
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include stone statues of the sanctuaries of the Turks. (Dosymbaeva A., 2002) The cult complexes of the Merke sanctuary, together with other sources, eloquently convince us of the long-term existence of an ideology associated with the belief in the power of stone statues depicting ancestors.

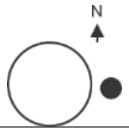
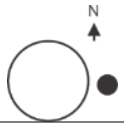
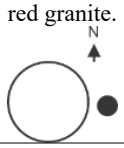
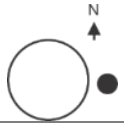
The monuments of the Merke sanctuary with stone sculptures of women, temples such as Sholsai 3, Belsaz 2 with paired sculptures, are examples of the syncretic concept of the universe described in the work, the desire of the Turks to create their own sacred territory, through the development of the spiritual experience of many previous cultures and peoples, whose historical destinies, in different periods, intersected with the nomads in the space of Central Asia.

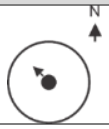
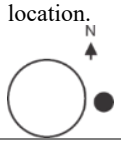
Table 2: Description of the mounds of Merke

№	Name	measurements	material	Stone sculpture location	Characteristics of the stone sculpture
1	Mound Aral-tobe 2 (surveyed and studied in 1996)	D=18 m, crater in the center of mound D= 8 m, 6 m deep. h=2 m.	large stones	was located on the northwestern edge of the embankment. 	Stele sculpture, woman, granite. The facial features are clearly visible: the eyebrow lines are curved and smoothly flow into the contour of the straight, elongated nose
2	Aktas 1 burial mound (surveyed and studied in 1996)	D= 10 m h= 0,5m	stone embankment	On the eastern side of the mound, near the embankment, there stood a stone statue. 	female, stele-like shape, bas-relief technique. The headdress and facial features are shown. The oval contours of the eyebrows and the straight line of the nose are visible. The dimensions of the sculpture: 1.1 m x 40 cm.
3	Mounds Zhalanashtyn Zhartasy 1 (surveyed and studied in 1996)	D= 11m h=1m	stone embankment	Mound 1: the sculpture is installed in the center, facing east, granite, bas-relief technique.  Mound 2: in the center, there are two sculptures - male and female, granite. 	Mound 1: Dimensions: 1.1 m x 35-45 cm x 18 cm. The head, torso, arms with a vessel at waist level are clearly detailed. Oval eyebrow contour, straight nose, cheeks, eyes and mouth are highlighted. Mound 2: The sculptures are facing each other: the male, to the southeast, the female to the northwest. Stele-like shape, bas-relief technique.

№	Name	measurements	material	Stone sculpture location	Characteristics of the stone sculpture
4	Zhalanashtyn zhartasy 2, mound (surveyed and studied in 1996)	D=11m h=1m	stone embankment	Next to the mound, there is a stone statue, placed in this place later. 	Partially destroyed. Made of granite, in bas-relief technique. The arms are clearly visible, half-bent at waist level and holding a flat-bottomed vessel.
5	Karasai 1 burial mound (surveyed and studied in 1996)	D= 9m h=1m	stone embankment	made of granite, moved from its original location, and later installed next to the mound. 	sculpture: 1.2m x 0.4m x 0.25 m. in the bas-relief technique. Has a head, separated from the body by an oval, deep groove, with hands supporting a round-bottomed pot at waist level. man: oval eyebrows, straight nose, a mustache that lowered down.
6	Karasai 2 burial mound (surveyed and studied in 1996)	D= 8m h= 1m	stone embankment	Next to the mound, there is a stone female statue, moved from its original location. 	The sculpture is stele-like, in the bas-relief technique. The face: oval contours of the eyebrows turn into straight lines of the nose, the eyes and lips are shown as almond-shaped and oval depressions.
7	Kashkasu 1 burial mound (surveyed and studied in 1994)	D=10m h=1,2m	stone saturated with an extension built on the eastern side.	The dimensions of the extension are 2.3 m x 2.7 m. In the center of the extension, there is a female sculpture, made using the bas-relief technique. 	sculpture protruding on the surface: 80 cm x 45 cm x 25 cm. The sculpture is worked out using the deep relief technique. The relief lines of the eyes and mouth of the sculpture are lowered at the edges, conveying a mournful expression on the face.
8	Sandyk 2 burial mound (surveyed and studied in 1996)	D= 9m h= 0,7m	stone embankment	On the eastern side of the mound, close to the embankment, a female stele-like sculpture is installed, facing east. 	in the bas-relief technique, the headdress, facial features are shown, and the contours of the eyebrows, turning into a straight line of the nose, are worked out. The contours of the oval cheeks are emphasized.
9	Sandyk 3 burial mound (surveyed and	D= 12m h= 0,8m	stone embankment	On the eastern side of the mound. The female, 1.1 m high.	The stele clearly depicts facial features and a kimeshek-type headdress. A round temple

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№	Name	measurements	material	Stone sculpture location	Characteristics of the stone sculpture
	studied in 1996)			The width of the stone stele is 35 cm, and the thickness is 28 cm. 	pendant is visible on the side of the headdress. The statue's ears are shown in the form of an oval relief. The sculpture is made of granite.
10	Sandyk 4 burial mound (surveyed and studied in 1996)	D=12m h= 0,5m	stone embankment the outer part is partially damaged.	The sculpture of a woman was located next to the burial mound. It was moved from its original location. 	made of granite, stele-like sculpture: 1 m x 38 cm x 29 cm. On the front part of the sculpture, a headdress and oval eyebrows are worked out, smoothly turning into the contour of a straight nose.
11	Togansay 2 burial mound (surveyed and studied in 1996)	D= 10m h=1,2m	stone embankment	The stone sculpture, broken into two parts, was located in the eastern part of the burial mound. Sculpture: 1.1 m x 40 cm x 25 cm. Made of red granite. 	Sculpture of a man, in whose half-bent arms, at waist level, a cup-shaped, flat-bottomed vessel is depicted. Technique of execution - relief knockout. Facial features are carefully worked out.
12	Tayaksaldy mound 2, (surveyed and studied in 1997)	D= 12m h= 1,3m	stone embankment	On the eastern side of the mound there is a female statue facing east. 	made of granite in the bas-relief style, stele-like. The head of the sculpture was broken off and lay in the mound. The contours of the eyebrows, straight nose, oval depressions of the mouth are clearly conveyed.
13	Mound Sulusay 5 (surveyed and studied in 1996)	D= 8 and 10 m h= 0,4m and 0,3m.	stone embankments located close to each other.	On the mound D=8 m in the center there is a female stone sculpture made of granite. The sculpture faces northwest.	protruding part of the sculpture surface: 1 m x 43 cm x 22 cm. The sculpture is made in the bas-relief technique, stele-like. The head of the sculpture and the facial features on it are clearly detailed.

№	Name	measurements	material	Stone sculpture location	Characteristics of the stone sculpture
					
14	Mound Sulusai 6 (surveyed and studied in 1998)	D= 10m h= 1,5m	stone embankment	The statue was removed from its original location and lay next to the burial mound.	Sculpture of a man with a vessel in his hand. In the bas-relief technique. The facial features are clearly conveyed.
15	Mound Sholsai 1 (surveyed and studied in 1998)	D= 9m h= 1m	stone embankment.	Not far from the mound stood a female statue, moved from its original location.	Sculpture: 0.9 m x 27 cm x 42 cm x 29 cm, made of granite, in bas-relief technique. The headdress and facial features are detailed. waist-level hands, the woman holds a flat-bottomed.
16	Mound Sholsai 2 (surveyed and studied in 1998)	D= 12m h= 1,3m	stone embankment.	female sculpture. Traces of a shallow crater can be seen on the top of the mound. stood on the eastern side of the mound. It may have been moved from its original location. 	Sculpture, 0.9m x 35-40cm x 37cm, made of red granite, in bas-relief technique. The body, head, hands with fingers holding the vessel at waist level are worked out. Facial features are Turkic.
17	Mound Sholsai 3 (surveyed and studied in 1996)	D=10m h= 0,8m	stone embankment.	A mound with two sculptures installed in the center, made of granite, bas-relief technique. Only the heads of the sculptures are visible on the surface. Facing each other, the male to the southeast, the female to the northwest 	The statues are made in the traditional style, corresponding to the canonical pictorial of the Merke sanctuary.

Source: Author's Calculation

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Table 3: Summary of the main characteristics of burial mounds and stone sculptures

Parameter	Characteristic and Range
Size of the mounds	D = from 8-18m (average 10-12m) h= 0.3-2m (average ~ 1m)
Material of the burial mounds	Stone embankment
Availability of extensions	Rare (only in Kashkasu 1: 2.3x2.7 m)
Material of the burial mounds	Granite (gray or red)
Technique of execution	Bas-relief (sometimes deep)
Gender of the sculptures	More often female, less often male
Type of figures	Stellar-like, vertical
Number of sculptures	Usually 1, sometimes 2 (paired)
Location of the mound	More often to the east of the mound
Face orientation	East, NW, face-to-face (in pairs)
Height of the sculptures	0.9-1.2 (average ~ 1.1 m)
Width of the sculptures	35-45 cm
Thickness of the sculptures	22-29 cm
Characteristic details	Vessel in hands, headdress, decorations
Symbolism and iconography	Vessel, kimeshek, pendants, pectoral ornaments

Source: Author's Calculation

Analysis of the burial mounds with stone sculptures located within the Merke complex reveals a set of consistent characteristics.

The diameter of the mounds ranges from 8 m. to 18 m., with an average height of approximately 1 meter. All mounds are constructed from stone; in some cases, looting pits are observed in the central part.

The stone sculptures are predominantly stele-like in form and executed in bas-relief technique from granite, including its reddish varieties. The average height of the sculptures is about 1 m. -1.1 m., with a width of 35-45 cm and thickness of 20-30 cm. The sculptures depict both male and female figures, often holding vessels. Facial features are frequently well-defined oval eyebrows, straight noses, lips and eyes, as well as elements of clothing such as headdresses, necklaces and pendants.

In terms of placement, the sculptures are most often located on the eastern side of the mound or in its center. In some cases, they have been displaced from their original locations. The orientation of the sculptures is predominantly eastward or northwestward, indicating, the presence of a stable ritual practice governing the spatial organization of sacred objects.

A comparative analysis highlights several underlying principles:

1. An emphasis on the center as a sacred point of energy concentration
2. The recurring motif of the circle and square as symbols of the cosmos and the earth
3. A social structure expressed through spatial zoning, from the periphery toward the center.

It is important to note that the architecture of the complex of Merke does not imply "buildings" in the classical sense. Sacredness is established through ritual, presence, and offering, not through monumentality. In this way, the space functions as a temporary vessel for sacred action, actualizing a cosmological order.

The contemporary significance of sites such as Merke goes beyond academic interest. In the context of cultural identity formation and the development of cultural tourism, it becomes an element of national consciousness and the historical positioning of Kazakhstan. In this regard, the inclusion of the complex in UNESCO programs and other international initiatives is of particular importance. Thus, interpreting the Merke complex through the lens of sacred planning and architectural symbolism allows not only for the reconstruction of the past worldview but also provides a foundation for a new approach to the preservation and representation of cultural heritage.

CONCLUSION

The conducted research has identified key features of the architectural and spatial organization of the Merke sacred complex within the context of Tengrianism cosmology. The elements comprising the complex are governed by a symbolic logic that reflects the worldview of nomadic societies regarding the structure of the universe, the relationship between the natural and the supernatural, life and death, and the duality of masculine and feminine principles.

The scientific novelty of the article lies in the systematization of the monuments according to architectural attributes (form, size, material, orientation) and in their interpretation as integral components of a sacred space. Merke emerges not merely as an archaeological ensemble, but as a coherent ritual and spatial system reflecting a sacred cosmological order.

The practical significance of the results lies in the potential application of the proposed approach to the analysis of other cultic complexes across the Eurasian steppe, as well as in the development of strategies for the preservation, promotion, and museological representation of Kazakhstan's sacred heritage. It is recommended that further comprehensive and interdisciplinary research be carried out, including the designation of the Merke complex as a priority cultural heritage site at both the national and international levels (including consideration for UNESCO listing).

Thus, sacred planning within the Tengrianism tradition proves to be an important resource for understanding architectural practices, spiritual values, and the historical identity of the peoples of the Great Steppe. While the conclusion summarizes findings, it could be strengthened by discussing future research directions (digital reconstruction, GIS mapping, interdisciplinary approaches) and policy implications for heritage preservation.

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EFFECTIVENESS OF AIRPORT FUNCTION SEPARATION IN INDONESIA: A CASE STUDY OF SOEKARNO-HATTA AND HALIM PERDANAKUSUMA AIRPORTS, WITH A PROPOSAL FOR UTILIZING KERTAJATI AIRPORT FOR PRIVATE AVIATION

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Abstract

This study analyzes the effectiveness of airport function separation in Indonesia as a strategic response to airspace congestion, operational inefficiencies, and overlapping civil-military airport usage. Focusing on Soekarno-Hatta (CGK), Halim Perdanakusuma (HLP), and Kertajati (KJT) Airports, the study adopts a qualitative-descriptive method supported by in-depth interviews with stakeholders from the Ministry of Transportation, Indonesian Air Force (TNI-AU), airport operators, airlines, and aviation experts. The findings reveal that overlapping functions at Halim generate flight delays, coordination difficulties, and safety risks, while Soekarno-Hatta faces high traffic volume with limited relief options. Meanwhile, Kertajati remains underutilized despite having modern infrastructure and a strategic location. Drawing on international best practices, such as Japan's Narita-Haneda-Chōfu model and similar systems in the US and UK, the study proposes a five-function airport classification: international commercial, domestic commercial, state/VVIP, military, and private/general aviation. It recommends formalizing a national regulation on function separation, reclassifying Halim for exclusive state and military use, and optimizing Kertajati through Public-Private Partnerships (PPPs) supported by regulatory incentives. Establishing a civil-military coordination body is also urged to enhance airspace governance. The novelty of this study lies in its integrated policy framework, which combines regulatory, institutional, and operational dimensions. Unlike previous studies that focus only on Jakarta's traffic management or civil-military coordination, this research introduces Kertajati as a national hub for private and general aviation, an approach that remains underexplored in Indonesian aviation discourse and presents a viable solution to redistribute traffic and improve national airspace efficiency.

Keywords: Airport management, civil-military coordination, airspace governance, function separation, Kertajati Airport, Indonesia aviation policy

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INTRODUCTION

Background

Airports play a vital role in national transportation by enabling regional integration, facilitating population movement, and supporting both economic activities and national defense logistics. As an archipelagic country, Indonesia relies heavily on air transportation to bridge vast geographical distances (Hayakawa et al., 2020; Prastyoutomo, 2024; Rimmer & Dick, 2018; Svetlana, 2021). Consequently, airport management is not merely a technical issue, but also one deeply connected to logistics efficiency, public service delivery, and strategic national interests.

Despite the rapid growth of air traffic, Indonesia continues to face structural challenges in airport governance, particularly the overlapping functions between civil and military operations, as well as between commercial and non-commercial aviation (Abeyratne, 2014). This issue is most prominent at Halim Perdanakusuma Airport, which has long served a dual role as both a strategic military base and a commercial airport. The lack of clear functional separation frequently leads to operational disruptions, flight delays, and elevated safety risks. Meanwhile, Soekarno-Hatta International Airport (CGK), the country's main commercial aviation hub, has expanded significantly with three terminals and three runways. However, increasing air traffic and rising demand for flight slots across various aviation sectors require functional consolidation and more efficient coordination. These pressures underscore the urgent need for a rational and strategic separation of airport functions.

The Indonesian government's decision to relocate most scheduled commercial flights from Halim to Soekarno-Hatta beginning August 1, 2025, marks a pivotal policy shift. Additionally, to accommodate private and charter flights currently dispersed across multiple airports, Kertajati International Airport (KJT) presents strong potential to serve as a national hub for private and general aviation, aligned with best practices observed in advanced aviation systems. In response to these pressing challenges, the present study evaluates how airport function separation has been implemented in Indonesia, focusing on Soekarno-Hatta and Halim Perdanakusuma Airports, while proposing the strategic utilization of Kertajati Airport as a medium-term solution for national aviation realignment.

Problem Statement

This study aims to address three core questions regarding airport function separation in Indonesia. *First*, it investigates the effectiveness of the government's policy in separating operational functions between Soekarno-Hatta and Halim Perdanakusuma Airports. *Second*, it explores the challenges and consequences that arise from such functional separation within the Jakarta

airspace, particularly with regard to flight efficiency and aviation safety. *Third*, the study examines the potential role of Kertajati International Airport as a strategic alternative for accommodating private and general aviation activities in the national airport network.

Research Objectives

This study seeks to achieve three main objectives. *First*, it analyzes the effectiveness of the airport function separation policy in the Greater Jakarta/Jabodetabek area (BPTJ, 2023). *Second,* it identifies the key barriers and dynamics involved in stakeholder coordination, particularly in separating civil-military and commercial-non-commercial airport functions. *Third*, the research assesses the feasibility and potential impact of utilizing Kertajati International Airport as a hub for private aviation, within the broader context of national airport restructuring.

Significance of the Study

This study is expected to offer threefold contributions. *Academically*, it enriches scholarly discourse in the fields of air transportation management, infrastructure policy, and national airspace governance; *practically*, it provides data-driven recommendations for policymakers and airport operators in formulating more effective airport function separation strategies; and *strategically*, the research promotes the optimal utilization of Kertajati International Airport as both a regional economic catalyst and a relief node to ease congestion at overburdened airports in Jakarta.

Scope of the Study

This study focuses on the effectiveness of functional separation between civil and military airports, as well as between commercial and non-commercial operations within the Greater Jakarta area. The primary case studies are Soekarno-Hatta and Halim Perdanakusuma Airports, complemented by an exploration of Kertajati International Airport as an alternative policy option. The analysis is confined to regulatory frameworks, flight operations, slot management, and airspace efficiency. Technical assessments of radar systems or financial analyses of airport operations fall outside the scope of this research.

THEORETICAL AND POLICY REVIEW

Concept of Airport Function Separation and Integration

In modern air transportation systems, effective airport management is largely determined by the clarity of each airport's functional role within the national airport network (Adisasmita & Caroles, 2021; Delaurentis & Fry, 2008; Gifford & Garrison, 1993; Ivannikova et al., 2021; Rocha, 2017). Broadly, two primary

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management models exist based on operational function: single-use airports and dual-use airports. A single-use airport is dedicated to a specific type of operation—such as civil-commercial, military, or VVIP, and is generally regarded as more efficient and secure, as air traffic control, security protocols, and infrastructure planning can be tailored to a single category of users (Darjono, 2025). In contrast, dual-use airports are shared between civil and military aviation, a model commonly found in developing countries like Indonesia due to limited infrastructure and legacy systems. However, such shared usage often results in overlapping operational interests, which can trigger conflicts in airspace prioritization, schedule disruptions, and increased safety risks. The function separation has become essential in increasingly complex air traffic environments, especially in high-density metropolitan regions (Graham, 2023; Schmitt & Gollnick, 2015; Zhang & Graham, 2020). The separation of airport functions must be aligned with the regional transport network by ensuring passenger accessibility, minimizing logistical costs, and enhancing connectivity with surrounding infrastructure (Darjono, 2025). This was evident in the relocation of Adisutjipto Airport to Yogyakarta International Airport (YIA), where accessibility challenges persisted despite advanced facilities (Fitrada, 2019). Moreover, effective function separation requires support from spatial planning policies that secure airport safety zones from incompatible land use. A study on Indonesia's military-civil airports found that misalignment between spatial regulations and aviation safety standards may result in operational and security risks (Septanaya et al., 2025). In advanced aviation systems, the specialization of airport functions is widely implemented to enhance efficiency, operational safety, and the overall quality of public service delivery.

International Regulations on Airport Management

The International Civil Aviation Organization (ICAO), a specialized UN agency responsible for regulating international civil aviation, has developed a set of Standards and Recommended Practices (SARPs) that member states are expected to adopt. Two key documents are particularly relevant to airport and airspace management. First, Annex 14 to the Convention on International Civil Aviation (Volume I) outlines technical and operational requirements for civil airports, including airport design standards, safety installations, and the designation of restricted areas to ensure secure and efficient operations (ICAO, 2022). Second, ICAO Doc 9971: Manual on Civil/Military Cooperation in Air Traffic Management underscores the importance of coordinated governance between civil and military aviation authorities (ICAO, 2019). This document introduces the concept of Flexible Use of Airspace (FUA), a dynamic model that allows the allocation of airspace based on real-time civil and military needs. Together, these international regulations provide a comprehensive global framework that guides

states in managing airport functions and shared airspace effectively, without compromising operational safety.

National Regulations and Policies on Airports

In Indonesia, the primary legal foundation for airport management is established by Law No. 1 of 2009 on Aviation. Article 212 allows military airports to be used for civil purposes and vice versa, provided such use does not compromise the airport's primary function (Sekneg, 2009). Article 216 permits airports to be managed by the government, state-owned enterprises (BUMN), or private entities, as long as operations remain aligned with the airport's designated status and function. Complementing this, Government Regulation No. 70 of 2001 on Airport Operations elaborates on key operational aspects and emphasizes the importance of clearly defined airport classifications to ensure safety and efficiency (Sekneg, 2001). A pivotal policy document is the Minister of Transportation Decree No. KM 166 of 2019, which presents the National Airport System Plan (RINBU), a strategic framework that classifies airports by hierarchy, function, and development priority (Kemenhub, 2019). Under RINBU, Kertajati International Airport is categorized as a primary international airport for West Java, though its utilization remains suboptimal as of 2025. The plan also promotes functional separation based on regional and strategic considerations, distinguishing among commercial, VVIP/state, military, and special-purpose airports. Furthermore, Minister of Transportation Regulation No. 40 of 2023, which revises Regulation No. 39 of 2019, reinforces that any alteration in airport status or function must be coordinated across multiple sectors, including the Ministry of Defense, Directorate General of Customs and Excise, Immigration, and quarantine agencies (Kemenhub, 2023). Such inter-agency coordination ensures that the designation of airport functions remains consistent with national security, logistical, and strategic objectives.

Issues and Challenges in Airport Function Separation in Indonesia

Examples of Dual-Use Airports in Indonesia

Several airports in Indonesia operate under dual-use arrangements, serving both military and civil aviation needs (Darjono, 2025). Notable examples include Halim Perdanakusuma Airport in Jakarta, which functions as a military airbase while also accommodating commercial, charter, and VVIP flights. Adisutjipto Airport in Yogyakarta previously operated under a similar arrangement between the Indonesian Air Force and civil aviation authorities until the opening of Yogyakarta International Airport (YIA) allowed for the relocation of most commercial traffic. Supadio Airport in Pontianak continues to serve both military and civil purposes, though with limited facilities dedicated to civilian operations.

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These cases highlight the structural legacy and operational complexity of dual-use airports in Indonesia's aviation system.

Security and Safety Challenges

The shared use of airspace and infrastructure by civil and military aviation presents several safety and security risks. These include inconsistent flight prioritization, the absence of harmonized operating procedures, and potential disruptions during military exercises or official state visits. Such conditions complicate air traffic management and heighten the risk of conflict between stakeholders. According to ICAO (2019)**,** operational incidents are statistically more likely to occur at dual-use airports due to fragmented institutional coordination and unclear lines of authority in day-to-day operations.

Impact on Operational Efficiency and Service Quality

Dual-use functionality significantly impacts the operational efficiency of civil aviation, particularly in terms of flight slot availability, airline scheduling reliability, and overall service quality for passengers. Civil operators at these airports often face logistical constraints such as limited apron space, delayed aircraft rotation, and irregular slot allocations. A 2023 report by the Transportation Policy Agency (BPTJ) found that airlines operating from Halim Perdanakusuma experienced repeated schedule disruptions and turnaround time inefficiencies, largely due to competition with military activities and inadequate ground infrastructure (BPTJ, 2023). These challenges ultimately reduce the effectiveness of civil aviation operations and hinder efforts to improve service quality.

Case Studies of Airport Function Separation

Comparative Study: Soekarno-Hatta vs. Halim Perdanakusuma

Soekarno-Hatta International Airport serves as Indonesia's primary commercial aviation hub, featuring modern infrastructure and large operational capacity. In contrast, Halim Perdanakusuma Airport, originally designed as a military airbase and VVIP entry point, has been compelled to handle scheduled domestic commercial flights. This dual-role arrangement has frequently led to operational disruptions, particularly during official state visits and military activities. The Indonesian government's decision to relocate most commercial flights from Halim to Soekarno-Hatta, effective August 2025, represents a critical policy shift toward rationalizing airport functions. This move not only addresses safety and efficiency concerns but also opens a strategic window for restructuring the broader national airport network.

Airports with Effective Function Separation

Several airports in Indonesia and abroad demonstrate effective models of functional separation. Domestically, Sultan Hasanuddin International Airport in Makassar and Hasanuddin Air Force Base operate under distinct management structures with well-coordinated airspace usage. Similarly, Lombok International Airport is geographically and administratively separated from the nearby Rembiga Air Force Base, ensuring that military operations do not interfere with commercial aviation. International examples further underscore the benefits of this approach. In Japan, Haneda and Narita Airports serve different aviation segments, domestic and international, respectively, while Chōfu Airport caters to general aviation. In the United States, Washington Dulles International Airport and Andrews Air Force Base represent a clear demarcation between civilian and military functions. These cases highlight the importance of specialization and institutional clarity in enhancing safety, service delivery, and strategic airspace utilization.

METHODS

Research Approach

This study adopts a qualitative descriptive approach (Moleong, 2017; Sugiyono, 2014), aiming to gain an in-depth understanding of the dynamics of airport function separation in Indonesia through case studies of Soekarno-Hatta Airport, Halim Perdanakusuma Airport, and the potential use of Kertajati Airport. This approach was chosen because the research focuses on interpretation, policy context, and implementation processes, rather than statistical measurement or quantification of variables. According to Creswell, a qualitative approach (Creswell & Plano Clark, 2023; Creswell & Poth, 2016) is suitable for exploring complex phenomena that are not yet fully structured theoretically, such as policy actor interactions, institutional overlap, and the social implications of decision-making.

Types and Sources of Data

This study employs a qualitative descriptive approach to explore the dynamics of airport function separation in Indonesia, focusing on case studies of Soekarno-Hatta Airport, Halim Perdanakusuma Airport, and the prospective role of Kertajati Airport. This approach is appropriate given the interpretative nature of the research, which emphasizes policy context, institutional coordination, and implementation processes over statistical measurement. As Creswell notes that qualitative inquiry is well-suited for examining complex, poorly structured phenomena (Creswell & Poth, 2016), such as inter-agency dynamics, civil-military operational overlaps, and the broader socio-political implications of transport policy.

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The study utilizes both primary and secondary data**.** Primary data were obtained through in-depth, semi-structured interviews with key stakeholders, including officials from the Ministry of Transportation (e.g., Director General of Civil Aviation, Director of Airports, and policy analysts), the Indonesian Air Force (e.g., operational commanders and national airspace regulators), airport operators such as Angkasa Pura, airline representatives (e.g., operations directors and station managers), and academics from institutions such as the Indonesian Civil Aviation Polytechnic and CSAS Indonesia. Secondary data were sourced from laws and regulations, official reports, academic publications, and international documents, including ICAO manuals and SARPs. These multiple data streams allowed for a holistic understanding of both the regulatory framework and on-the-ground realities.

Data collection methods included literature review**,** in-depth interviews**,** and document/policy analysis, all of which were analyzed through thematic analysis (Braun et al., 2023; Fryer, 2022; Kärmeniemi et al., 2022; Khoa et al., 2023; Kiger & Varpio, 2020)**.** This process involved reducing data to relevant content, categorizing it into key themes, such as institutional overlap, operational efficiency, separation strategy, and Kertajati's development potential, interpreting findings in the context of Indonesia's airport system, and conducting triangulation across data sources to ensure validity and consistency. The combined methodology enabled a nuanced understanding of the challenges and prospects for implementing more effective airport function separation in Indonesia.

Research Location and Period

This research was conducted in the Jakarta and West Java regions, focusing on three key airports that represent different functional roles within Indonesia's air transportation system: Soekarno-Hatta International Airport (CGK) as the primary commercial hub, Halim Perdanakusuma Airport (HLP) as a dual-use facility serving both military and limited commercial operations, and Kertajati International Airport (KJT) as a potential hub for private and general aviation. The study was carried out over six months from January to June 2025, encompassing all stages of the research process, including initial preparation, field data collection, analysis, and the final report writing.

Data Validity and Reliability

This research was conducted in the Jakarta and West Java regions, focusing on three major airports: Soekarno-Hatta International Airport (CGK), Halim Perdanakusuma Airport (HLP), and Kertajati International Airport (KJT). The research period spanned from January to June 2025 and included stages of preparation, data collection, analysis, and report writing. To ensure the validity

and reliability of data, the study employed triangulation strategies. Source triangulation was used by comparing inputs from government officials, military personnel, airport operators, and academic experts. Method triangulation was applied through the integration of interviews, literature reviews, and policy document analysis. Data accuracy was further enhanced by cross-checking key findings with official regulations and international references, including ICAO reports. Ethical standards were also strictly upheld throughout the research process. All informants provided informed consent**,** and their anonymity was preserved. The researcher maintained analytical neutrality**,** avoiding conflicts of interest, and presented findings with objectivity. Furthermore, transparency of sources was ensured by relying solely on credible and scientifically verifiable references.

Semi-Structured Interview Guidelines

To support the qualitative inquiry of this study, semi-structured interviews were conducted with selected key stakeholders representing the government, military, airport operators, airlines, and academic experts. These interviews aimed to explore institutional perspectives, operational experiences, and policy implications related to airport function separation in Indonesia. The questions were designed to be open-ended, allowing for flexibility while maintaining consistency across interviewees.

For the Ministry of Transportation (Directorate General of Civil Aviation)**,** the questions focused on the formulation and implementation of policies, the role of Ministerial Decree No. KM 166/2019, and inter-agency coordination in the functional separation of airports. Key inquiries also examined the strategic planning aspects of utilizing Kertajati Airport and whether a long-term roadmap exists within the Ministry's framework (Kemenhub, 2019). Interviews with the Indonesian Air Force (TNI-AU) aimed to capture the military's perspective on dual-use airport operations, the prioritization of military and VVIP flights, and the practical application of the Flexible Use of Airspace (FUA) model. Discussions addressed the challenges of civil-military coordination and assessed the preparedness of reverting Halim Airport to exclusive state/military use.

The airport operators (PT Angkasa Pura) were consulted to gain operational insights into managing dual-use airports, particularly the complexities faced at Halim and Soekarno-Hatta. Questions explored the implications of flight relocations, technical and administrative coordination, and the future potential of Kertajati as a dedicated hub for private aviation. From the airline perspective (e.g., Citilink, Batik Air), the interviews investigated how dual-use airport arrangements influence daily operations, including aircraft rotation, passenger satisfaction, punctuality, and operational costs. Additional

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questions examined airline engagement in policy-making and their views on operating from alternative airports like Kertajati.

Lastly, academic and transportation policy experts were interviewed to obtain independent analysis on regulatory implementation, comparative policy perspectives, and long-term impacts. These interviews provided critical evaluations of policy effectiveness and offered strategic recommendations to improve Indonesia's airport governance and system restructuring.

RESULT AND DISCUSSION

Ideal Framework for Airport Function Separation in Indonesia

Findings from interviews, policy documents, and international comparative studies suggest that the ideal framework for airport function separation in Indonesia must be anchored in five fundamental principles. First, clarity of institutional function is essential to prevent overlapping mandates between civil, military, and special-purpose airport authorities. The overlap of civil and military operations often creates operational inefficiencies, safety concerns, and limits the scalability of airport facilities (Aida & Meilani, 2023; Darjono, 2025; Lestari et al., 2020). Such cases emphasize the urgency of establishing clearly separated functional roles between civil and military airport operations in Indonesia. Second, aviation safety and security must remain a non-negotiable priority, particularly in dual-use environments where operational risks are elevated. Third, operational efficiency must be enhanced by ensuring proper slot allocation, infrastructure utilization, and traffic flow management. Fourth, the framework must support strategic national interests, including defense readiness, diplomatic accessibility, and national logistical resilience. Lastly, regional economic sustainability must be considered by aligning airport development and function designation with local growth potential, connectivity needs, and investment priorities. Together, these five principles provide a comprehensive basis for designing a rational and adaptive airport function separation model suited to Indonesia's geographic, institutional, and developmental context.

Based on an in-depth study of operational activities at Soekarno-Hatta Airport, aircraft movement data were obtained as follows:

Table 1. Aircraft Movements at Soekarno-Hatta Airport 2020–2024

No	Year	Acft. Movement	Remarks
1	2020	~248.000	Sharp decline due to Covid-19 pandemic
2	2021	~196.000	Slow recovery due to ongoing restrictions
3	2022	~298.000	Significant post-pandemic recovery
4	2023	~360.000	Approaching pre-pandemic levels (2019)
5	2024	~380.000	Full recovery, routine growth

Notes: (1) Aircraft movements refer to total take-offs and landings; (2) Pre-pandemic movements (2019): ~450,000 (*Source: Soekarno-Hatta Airport Operator, PT Angkasa Pura, 2024).*

The data in Table 1 show a steady recovery of aircraft movements at Soekarno-Hatta Airport between 2020 and 2024. The sharp drop in 2020 and 2021 reflects the global aviation downturn caused by the Covid-19 pandemic. From 2022 onward, the recovery trajectory indicates a return to normal operations, approaching pre-pandemic levels by 2023 and achieving full stabilization in 2024.

This upward trend suggests that capacity utilization and airside operations have largely normalized, yet the rapid rebound also introduces renewed pressure on slot allocation and turnaround processes. Congestion during peak hours, particularly at Terminals 2 and 3, continues to test the airport's efficiency, highlighting the importance of strategic function separation between Jakarta's main airports to distribute traffic more evenly.

The findings correspond with the operational efficiency dimension outlined in the theoretical model (Section 2.1), which links function specialization to system-wide throughput optimization (Schmitt & Gollnick, 2015).

Further, based on collected data, the average monthly aircraft movements at Soekarno-Hatta in 2024 are as follows:

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Table 2. Monthly Aircraft Movements at Soekarno-Hatta Airport (2024)

No	Month	Acft. Movements	Remarks
1	January	~30.000	Influenced by the year-end holiday season
2	February	~28.500	Post-holiday low season
3	Marc	~30.500	Gradual recovery
4	April	~31.000	Increased demand during the Eid Holiday
5	May	~33.000	Peak school holiday period
6	June	˜34.000	Rise in international traffic
7	July	~33.500	Hajj and school holiday
8	August	˜32.000	Post-peak stabilization
9	September	˜31.000	Normal operation
10	October	~31.500	Year-end prep
11	November	˜30.500	Steady
12	December	˜35.000	Peak Christmas / New Year holiday

Summary: (a) Total aircraft movements (2024): ~380,000; (b) Monthly average: ~31,600–32,000 movements; (c) Daily average: ~1,100 movements; peak hour movements can reach ~75 take-offs/landings
(*Source: PT Angkasa Pura, 2024)*

The monthly trend demonstrates consistent traffic growth throughout 2024, with notable peaks in May–July (holiday season) and December (year-end). These fluctuations mirror seasonal demand cycles typical of Indonesia's domestic market, dominated by religious holidays and school vacations. Despite an overall positive growth trend, the data reveal that slot utilization during peak months exceeds optimal runway capacity, causing potential delays in apron turnover and taxiway congestion. The analysis supports the view that operational strain at Soekarno-Hatta remains structurally linked to centralized traffic concentration, reinforcing the need for a multi-airport system. The consistency between these operational findings and the theoretical argument that multi-nodal airport systems enhance both capacity and resilience (Delaurentis & Fry, 2008) further validates Indonesia's ongoing policy to redistribute traffic toward Kertajati and Halim.

Meanwhile, Halim Perdanakusuma Airport (HLP) shows a unique dynamic as a multi-function airport, with an average of 4,200 to 4,600 aircraft movements per month in 2024:

Table 3. Monthly Aircraft Movements at Halim Perdanakusuma Airport (2024)

No	Month	Acft. Movements	Remarks
1	January	~4.500	Influenced by VVIP and charter flights
2	February	~4.000	Post-holiday low season
3	March	~4.300	Normal activities
4	April	~5000	Eid Travel surge
5	May	~4.800	Mix of civil and military flight activities
6	June	˜4.600	Stable: commercial &Military activities
7	July	~4.500	Hajj season, special flight
8	August	~4.400	Military exercises (Independence Day)
9	September	~4.200	Normal Operation

No	Month	Acft. Movements	Remarks
10	October	~4.300	Year-end preparation
11	November	~4.100	Relatively stable
12	December	~5000	Increase in VVIP and charter flights

(Source: PT Angkasa Pura, 2024)

The data in Table 3 shows that Halim Perdanakusuma Airport maintains a steady operational volume of approximately 4,000–5,000 aircraft movements per month. Peaks occur in April and December, corresponding to Eid travel and state/VVIP events. Unlike Soekarno Hatta, Halim's operational fluctuations are influenced more by governmental and military priorities than by commercial demand.

This confirms that Halim serves as a strategic complement to Soekarno-Hatta, absorbing state and defense-related traffic while relieving the main airport during specific operational peaks. However, the data also reveal capacity limitations: simultaneous scheduling of VVIP, military, and limited commercial flights often causes slot conflicts and ground handling delays. These operational challenges validate the necessity of function separation and specialization proposed in the national airport framework. As ICAO (2019) and Doc 9971 emphasize, civil–military coordination efficiency increases when roles and access rights are clearly defined. Hence, reverting Halim to an exclusive state and military role while shifting private and general aviation to Kertajati aligns with international best practice and strengthens Indonesia's overall airspace efficiency.

Furthermore, the operational strain observed at multi-function airports also reflects inadequate facility-management competencies, a challenge similarly identified in other Southeast Asian contexts (Said & Hayani, 2025). In addition, studies on passenger facility preferences at dual-use airports demonstrate that mismatches between facility supply and user expectations can exacerbate operational bottlenecks (Muldiyanto & Handajani, 2025). The illustration is as follows:

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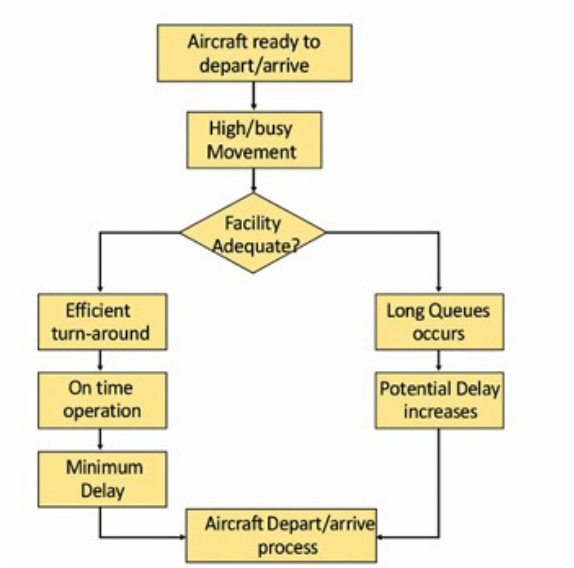


Figure 1: Turnaround Process Flow vs Facility Readiness
(Source: Processed from Interviews/Research documentation 2025)

The flowchart illustrates the direct relationship between airport facility readiness and turnaround efficiency. When aircraft movements increase, sufficient ground handling and apron capacity become critical for maintaining on-time performance. Adequate facilities enable efficient turnaround, faster gate clearance, and reduced taxi-in/out times, which collectively minimize overall delay.

Conversely, when infrastructure is inadequate, operational bottlenecks emerge. Aircraft may queue for parking stands, turnaround durations extend, and the cumulative delay risk increases. This condition was repeatedly emphasized by operational managers during interviews at Soekarno-Hatta and Halim Perdanakusuma, who noted that facility readiness and slot coordination remain two major determinants of airport performance. This observation directly supports the efficiency dimension of the theoretical model outlined in Section 2.1, confirming that physical capacity and process discipline must evolve together to achieve true functional separation in busy airport environments.

Drawing from multiple variables and references, a national airport function separation framework is proposed as follows:

Table 4. Framework for Airport Function Separation

No	Function	Main Airports (examples)	Remarks
1	International Commercials	Soekarno-Hatta; Ngurah Rai; Juanda; Kualanamu; Sultan Hasanuddin	Serves scheduled domestic and international passengers & cargo
2	Domestic Commercial	Ahmad Yani; Sepinggan; Lombok Praya; Patimura; Haluoleo; dll.	Focus on domestic connectivity.
3	State / VVIP	Halim Perdanakusuma; Adi Soemarmo	For state duties, VIP guests, and Air Force Operations
4	Military	Major Air Bases	Prohibited from civilian flight, except in an emergency
5	Private/general Aviation	Kertajati; Pondok Cabe	For executive jets, charters, and flight training

(Source: Research documentation 2025)

Table 4 proposes a structured national framework for airport function separation. It assigns operational roles based on specialization and strategic purpose: commercial, domestic, state/VVIP, military, and private/general aviation. This categorization directly addresses long-standing inefficiencies arising from overlapping operations, particularly at Halim Perdanakusuma, while offering a pathway to balance civil, defense, and private aviation needs.

The model builds on lessons from both international references and local realities. By aligning airport function with airspace capacity, infrastructure availability, and institutional responsibility, Indonesia can achieve a more coherent, safe, and efficient multi-airport system. This structure also facilitates regulatory clarity, as each airport type can operate under distinct safety oversight mechanisms (e.g., DGCA for civil, TNI-AU for military, and joint coordination for state/VVIP).

Moreover, it supports broader national goals: a) Economic efficiency through reduced delays and better slot distribution; b) National security through controlled airspace segmentation; and c) Investment optimization through targeted infrastructure planning.

The integrated framework, therefore, positions Soekarno-Hatta as Indonesia's principal international gateway, Halim for state and limited domestic duties, Kertajati for private and general aviation, and military bases exclusively for defense operations. This separation mirrors international best practices while remaining adaptive to Indonesia's archipelagic geography and dual-use heritage.

Lessons from International Airport Function Separation Models

The proposed framework draws inspiration from several international systems that have successfully implemented functional separation without overlap. Each provides practical insight into how Indonesia can adapt these models within its regulatory and infrastructural realities.

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In Japan, the Narita–Haneda–Chōfu model demonstrates the effectiveness of tri-functional specialization. Narita handles international operations, Haneda serves domestic flights, and Chōfu manages general aviation. This structure prevents congestion and enhances service differentiation across the Tokyo metropolitan area. The model resonates with Indonesia's plan to designate Kertajati for private and general aviation, complementing Soetta and Halim. However, Japan's success depends heavily on ground transport integration (rail and highway links), suggesting that Indonesia must improve intermodal access to Kertajati to achieve similar results.

In the United States, the Dulles–Andrews–Manassas system exemplifies clear separation between civilian, military, and private operations. Each airport functions under independent authority, yet operates within a unified airspace system managed by the Federal Aviation Administration (FAA). For Indonesia, this model underlines the importance of establishing a joint civil–military coordination body, as recommended in ICAO Doc 9971, to enhance situational awareness and harmonize airspace usage between DGCA and the Indonesian Air Force.

The United Kingdom follows a comparable structure (commercial), Northolt (state/military), and Biggin Hill (private aviation) through Heathrow. This separation reduces congestion while supporting London's complex airspace system and maintaining high safety standards. It also reinforces economic specialization, as each airport caters to distinct market segments under consistent regulatory oversight.

Applying these lessons, Indonesia can progressively develop a multi-node system for the Greater Jakarta region: a) Soekarno-Hatta as the main commercial hub; b) Halim Perdanakusuma reserved for state and defense purposes; and c) Kertajati as the private/general aviation hub. Such an approach aligns with international best practices and supports the principle that functional specialization enhances safety, efficiency, and governance. It also creates the regulatory foundation for sustainable airspace management as outlined in Section 2.3 of this research.

Implications for State-Owned and Private Airport Management

The implementation of systematic airport function separation has significant implications for both state-owned enterprises (SOEs), such as Angkasa Pura I and II, and private sector stakeholders. For SOEs, the policy encourages operational restructuring, allowing for more efficient allocation of human resources, flight slots, and airport facilities. It also enables core business strengthening, as seen in the potential for Angkasa Pura to focus its international commercial services at Soekarno-Hatta without the operational burden of managing dual-use functions at Halim. Additionally, the emergence of specialized airports like Kertajati

creates partnership opportunities, particularly through Public-Private Partnerships (PPPs), to support private and general aviation development (Hudalah et al., 2022; Naipospos et al., 2020; Niederberger, 2025). This collaborative approach aligns with the Triple Helix framework of synergizing government, industry, and academia to enhance innovation in the aviation sector (Zainol et al., 2022).

From the private sector's perspective, delineated airport functions enhance business certainty, offering a stable regulatory and operational environment for long-term investment planning. The policy also opens pathways for service specialization, enabling private operators to concentrate on niche markets such as charter services, executive jets, or Maintenance, Repair, and Overhaul (MRO) facilities. Furthermore, airport function separation encourages the growth of integrated connectivity ecosystems, including hospitality, cargo handling, and regional logistics, through better space utilization and streamlined management practices. Collectively, these changes can improve the efficiency, attractiveness, and competitiveness of Indonesia's broader aviation sector.

Challenges to Implementation

Despite its strategic rationale, the implementation of airport function separation in Indonesia faces several structural and institutional challenges. *Overlapping Authority and Institutional Culture*

The first major issue concerns overlapping authority among key stakeholders, particularly the Indonesian Air Force (TNI-AU), the Ministry of Transportation (DGCA), and state-owned airport operators. Each institution operates under distinct mandates, procedures, and organizational cultures (Frederickson & LaPorte, 2002; Lockhart et al., 2021; Salter, 2007; Starkie, 2002). This fragmentation often results in unclear lines of coordination and slow decision-making, particularly during airspace conflict management or dual-use scheduling. Several informants from both the DGCA and Angkasa Pura described coordination as "episodic rather than systemic," depending heavily on personal networks rather than institutionalized mechanisms. This supports previous research highlighting that institutional overlap rather than resource shortage is the primary cause of inefficiency in Indonesia's civil–military airport operations (Darjono, 2025). To address this, a joint coordination body should be established under a shared legal framework between DGCA and TNI-AU, aligned with ICAO Doc 9971's concept of Flexible Use of Airspace (FUA). Such a structure would formalize communication protocols, enhance real-time coordination, and minimize jurisdictional ambiguity.

Infrastructure Gaps and Underutilized Facilities

A second challenge lies in the limited availability of alternative infrastructure capable of supporting function separation. While policy directives

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encourage decentralization, many regions still lack fully equipped substitute airports to absorb diverted traffic. The case of Kertajati International Airport illustrates this problem vividly. Despite having modern facilities and strategic proximity to Jakarta's eastern corridor, it remains underutilized due to limited flight demand, poor ground connectivity, and insufficient supporting services. Interview data from operators indicate that airlines hesitate to shift operations to Kertajati because of passenger access constraints and logistical inefficiencies. This underlines the importance of synchronized infrastructure development, not only expanding airport capacity but also improving road, rail, and cargo linkages. The experience parallels Japan's early challenge in integrating Narita with Tokyo's urban transport network, which was later resolved through high-speed rail expansion. For Indonesia, achieving similar integration is essential to realize the full potential of multi-airport systems.

Policy Politics, and Regional Resistance

Another obstacle stems from policy politics and regional resistance. Local governments and political actors often oppose changes in airport function that could reduce local accessibility or economic activity. Several stakeholders noted that proposals to reassign airport roles sometimes meet with political hesitation or public misperception, particularly when local airports are perceived as being "downgraded." These political sensitivities highlight the need for policy socialization and stakeholder engagement. Transparent communication on the long-term benefits, such as safety enhancement, traffic balance, and regional growth potential, can build broader support for implementation. Moreover, decentralization policies should include local compensation mechanisms, ensuring that regional economies continue to benefit from redefined airport functions through new roles in logistics, training, or maintenance activities.

Lack of Integrated Roadmap and Cross-Sectoral Coordination

The absence of a clear, integrated roadmap further complicates the execution of functional separation. Currently, there is no consolidated policy document specifying implementation phases, responsibility allocation, or monitoring mechanisms. This regulatory vacuum creates uncertainty for both state and private stakeholders. Developing a National Functional Separation Master Plan, jointly endorsed by the Ministry of Transportation, TNI-AU, and the National Development Planning Agency (Bappenas), would address this gap. Such a plan should outline milestones, performance indicators, and coordination protocols, mirroring the integrated planning frameworks adopted in Singapore's Changi system and the United States' National Airspace System (NAS) modernization programs. By formalizing inter-agency collaboration, Indonesia can transition from ad hoc coordination to a sustainable governance model, ensuring that functional separation delivers both operational efficiency and strategic resilience.

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Potential of Kertajati Airport for Private and General Aviation Use

Kertajati International Airport (KJT), equipped with a 3,000-meter runway and a modern terminal facility, remains significantly underutilized despite its strategic infrastructure. Based on interviews with airport operators, airline representatives, and transportation policy analysts, Kertajati presents strong potential as a dedicated hub for private and general aviation (GA) in Indonesia (Darmawan et al., 2018; Hudalah et al., 2022; Luanlaka et al., 2021; Mahfudz et al., 2021; Olii, 2024; Ricardianto et al., 2021; Sari et al., 2018; Syafarudin & Mulyana, 2019). Its development could serve multiple strategic purposes, including reducing slot congestion at Soekarno-Hatta, providing a base for charter, training, and private jet operations in eastern West Java, and supporting industrial and logistics zones emerging in the Majalengka region.

The realization of this potential, however, is contingent upon several enabling factors. *First*, improved ground accessibility, such as seamless integration with toll road networks and the prospective Jakarta–Bandung high-speed rail, is critical to increase airport reach and attractiveness. *Second*, the government and airport authorities must consider offering regulatory incentives to attract GA operators, including competitive pricing structures, prioritized slot allocation, and dedicated facilities for small aircraft operations. *Finally*, the success of Kertajati's transformation relies on legal certainty and long-term policy consistency to assure investors and operators of the airport's viability and strategic support within the national aviation framework.

Legal and Regulatory Gaps in Function Separation Implementation

Although the rationale for airport function separation is widely accepted in both policy and practice, this study identifies a number of legal and regulatory gap**s** that hinder its effective implementation in Indonesia. Most critically, there is an absence of a specific national regulation that mandates the functional separation of airports based on categories such as civil, military, VVIP, and private aviation. Without such a formal legal foundation, enforcement remains inconsistent and largely dependent on ad hoc administrative decisions.

In addition, the lack of a national roadmap outlining the strategic phases, timelines, and institutional responsibilities for function separation further exacerbates the issue. The absence of a systematic, measurable plan introduces the risk of unintended socio-economic consequences, including disruptions in regional accessibility and uncertainty among investors. A particularly pressing case is the unclear functional status of Halim Perdanakusuma Airport, which continues to operate under a mixed-use model, serving military, VVIP, and commercial flights simultaneously. This creates friction in coordination, undermines efficiency, and blurs institutional accountability.

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Another notable gap lies in the underutilization of Kertajati Airport, which, despite its infrastructure readiness, has yet to be fully positioned as a hub for general aviation or aviation training. One of the major obstacles to the effective use of Kertajati Airport lies in its limited connectivity to urban centers and the lack of supporting infrastructure, such as high-speed rail or dedicated airport expressways. Despite the advanced facilities at Kertajati Airport, its underutilization reflects a broader issue of insufficient multimodal connectivity, mirroring the experience of Yogyakarta International Airport during its early operational phase (Arti et al., 2023; Carnis & Yuliawati, 2013; Fitrada, 2019). This suggests that infrastructural readiness alone is not sufficient; strategic alignment with transportation planning and passenger behavior is also crucial. Likewise, civil-military coordination in airspace management remains fragmented and sectoral. This weak coordination complicates slot allocation, reduces national airspace efficiency, and increases the risk of operational conflicts. Without addressing these regulatory deficiencies, the long-term goals of Indonesia's airport restructuring strategy may remain unrealized.

Policy Recommendations for the Government

Based on the study's findings, several policy measures are proposed to strengthen airport function separation in Indonesia. First, the Ministry of Transportation should enact a dedicated regulation to formally govern airport function separation nationwide, aligning with the Aviation Law and providing clear guidance for all stakeholders. Second, a national roadmap should be developed to outline timelines, responsible agencies, implementation phases, and socio-economic outcomes, ensuring coherent long-term restructuring.

Halim Perdanakusuma Airport should be reclassified for exclusive state, VVIP, and military use, redirecting commercial flights to Soekarno-Hatta or other suitable airports. Kertajati Airport should be optimized as a hub for general aviation, charter services, and pilot training, facilitated through Public-Private Partnerships (PPPs) and policy incentives.

Finally, an inter-ministerial coordination task force, including the Ministry of Transportation, Ministry of Defense, Indonesian Air Force, and PT Angkasa Pura, is essential to integrate civil and military operations. This ensures efficient joint airspace management, safety, and strategic alignment. Implementing these recommendations will create a legally grounded, operationally efficient, and strategically coherent airport system that maximizes infrastructure utilization while enhancing aviation safety and national priorities.

CONCLUSION

This study shows that function separation at Indonesian airports not only achieves operational efficiency but also supports national priorities in aviation safety,

security, and competitiveness. Case studies of Soekarno-Hatta, Halim Perdanakusuma, and Kertajati International Airport reveal that overlapping functions between military and civil operations or VVIP and commercial flights compromise safety, punctuality, and service quality. An ideal model of function separation should prioritize institutional clarity, operational efficiency, aviation security, national strategic interest, and regional economic sustainability. Properly defined roles also enable state-owned enterprises like PT Angkasa Pura and private partners to design targeted business models, form alliances, and enhance the resilience of Indonesia's air transportation system.

The study introduces Kertajati as a potential national hub for private and general aviation, complementing Jakarta's airspace and addressing underutilized infrastructure. However, challenges such as institutional overlap, insufficient alternative facilities, local resistance, and weak inter-agency coordination remain. Addressing these requires an integrated, legally grounded, and transparently communicated roadmap, backed by political commitment and cross-sectoral collaboration.

Strategic policy recommendations include enacting a dedicated regulatory framework to clearly delineate commercial, military, VVIP, and private airport functions. A national roadmap should involve key stakeholders, the Ministry of Transportation, Indonesian Air Force, PT Angkasa Pura, and others, with phased implementation, regional priorities, and socio-economic considerations. In the short to medium term, Halim should be designated for exclusive state and military use, while Kertajati should serve private, charter, and training aviation through PPP schemes supported by accessibility improvements and regulatory incentives. Civil-military coordination must be institutionalized via a dedicated task force, and transparency and stakeholder engagement should be ensured throughout. By combining coordinated governance, empirical policy design, and inclusive engagement, Indonesia can establish a resilient, strategically coherent airport network that optimizes infrastructure, reduces conflicts, and enhances overall aviation performance.

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DISCLOSURE STATEMENT/ETHICAL STATEMENT

The authors declare that no conflict of interest is related to this research. The authors also affirm that this research is original, plagiarism-free, and has not been submitted for publication elsewhere.

AUTHORS' CONTRIBUTIONS

All authors have read and agreed to the published version of the manuscript. They drafted and participated in contributing to the text and the manuscripts together, discussed all parts of this paper, edited and revised the earlier version, and approved the final version of the paper to be published

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CONTENT ANALYSIS USING USER AND GRATIFICATION THEORY: UNDERSTANDING THE INFLUENCE OF TIKTOK SOCIAL MEDIA PLATFORM ON TRAVEL BEHAVIOUR AMONG GEN Z IN MALAYSIA

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Abstract

This study investigates how TikTok influences travel behaviour among Generation Z in Malaysia through the perspective of the Uses and Gratifications Theory. The research addresses the problem of limited scholarly understanding of TikTok's role in fulfilling multidimensional user needs that shape travel decision-making. The objective is to explore goal-oriented uses of TikTok that influence travel preferences and behaviours in this demographic. A qualitative content analysis was conducted on 30 highly engaged TikTok travel videos, with 300 top comments selected and examined, adhering to ethical standards by utilising only publicly available data. Thematic coding identified cognitive, affective, personal integration, social, and tension release needs. Findings reveal that TikTok operates as more than an entertainment platform, functioning as a dynamic space for information seeking, emotional connection, self-identity validation, peer interaction, and leisure inspiration. These needs influence destination choice, trip planning, and travel experiences by aligning content with personal goals, values, and social aspirations. The platform's immediacy, visual appeal, and peer-generated recommendations strengthen its role in reducing uncertainty and enhancing travel confidence. The study concludes that TikTok is a critical digital influence channel that shapes both practical and affective dimensions of travel among Generation Z. The implications suggest that tourism marketers, destination managers, and policymakers can optimise TikTok's potential by designing targeted, identity-relevant content and promoting sustainable tourism narratives that resonate with younger audiences, thereby enhancing destination competitiveness and fostering loyalty.

Keywords: Generation Z; TikTok; Tourism Marketing; Travel Behaviour; Uses and Gratifications Theory

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INTRODUCTION

The rapid proliferation of short-form video platforms has reshaped the tourism communication landscape, with TikTok emerging as a dominant channel influencing Generation Z's travel awareness, motivation, and decision-making (Borges, 2023; Liu et al., 2024). Unlike earlier social media channels that relied on static imagery or long-form narratives, TikTok's algorithmically curated feed delivers highly personalised content that aligns with individual viewing patterns and interaction histories (Boeker & Urman, 2022). This algorithmic personalisation, combined with immersive audiovisual storytelling, enables the platform to satisfy a range of cognitive, affective, and social needs as conceptualised in the Uses and Gratifications (U&G) framework (Katz et al., 1973; Child & Haridakis, 2017). However, while U&G theory has been widely applied to study information search, entertainment, and social interaction gratifications in tourism contexts (Du et al., 2023; Wei et al., 2023), the integration of platform-specific affordances such as real-time trend amplification remains underexplored. While prior research has explored TikTok's role in destination marketing and user engagement, few have integrated the Uses and Gratifications framework to examine how algorithmic affordances and participatory culture reshape travel motivation among Generation Z. This study advances U&G theory by contextualising gratification patterns within the dynamic, trend-based architecture of TikTok and by empirically grounding the analysis in Malaysian Gen Z travel discourse. Through this, it offers both theoretical refinement and contextual depth to the understanding of social media driven travel behaviour.

RESEARCH BACKGROUND

In Malaysia, Generation Z constitutes a significant emerging travel segment, characterised by a high degree of social media dependency for destination discovery (Asri et al., 2024; Tan & Halim, 2021). TikTok's viral travel videos often present curated visual narratives of destinations, blending informational cues with affective appeal. Engagement metrics such as likes, comments, and shares are frequently used in research to identify high-impact content (Campbell et al., 2020). However, this selection strategy may bias samples toward entertainment-oriented content at the expense of informational depth, which could influence the prominence of certain gratification categories in thematic analysis. Furthermore, interpreting user comments as indicators of travel intent requires methodological caution. Expressed intention in social media discourse does not necessarily translate into behavioural outcomes (Fong et al., 2024; Liu et al., 2024). Triangulation techniques such as cross-referencing comment

sentiment with creator follow-up content or external visitation data can improve validity (Abbadia, 2023; Vivek et al., 2023).

PROBLEM STATEMENT

Existing studies on TikTok's role in tourism often focus on destination marketing or influencer strategies but provide limited theoretical integration between U&G constructs and platform-specific affordances (Wei et al., 2023; Zhou et al., 2023). Moreover, few studies address the temporal fragility of findings in an environment where algorithmic parameters change rapidly, potentially altering which gratifications are most salient. This creates uncertainty about whether observed patterns reflect enduring motivational drivers or temporary artefacts of a particular content-distribution model.

RESEARCH OBJECTIVE

This study aims to apply U&G theory to examine how TikTok travel content gratifies cognitive, affective, and social needs among Malaysian Generation Z, while explicitly addressing three methodological imperatives: distinguishing expressed travel intent from actual behavioural outcomes through triangulation, justifying the use of engagement-based sampling over alternative stratification strategies, and evaluating the resilience of findings in light of potential platform algorithm changes. Through this approach, the study seeks to refine the theoretical fit of U&G in a short-form video context and provide more durable insights into the intersection of social media affordances and tourism behaviour.

LITERATURE REVIEW

The Uses and Gratifications (U&G) framework has been extensively applied in media and communication research to explain why audiences actively choose specific media channels to satisfy various needs (Katz et al., 1973; Ruggiero, 2000). Within tourism studies, U&G has been adopted to examine how travellers engage with online content for informational search, entertainment, and social interaction (Wei et al., 2023; Du et al., 2023). The cognitive dimension encompasses the pursuit of information and knowledge about destinations, activities, and logistics (Child & Haridakis, 2017), whereas affective gratifications refer to the pursuit of pleasurable, aesthetically pleasing, and emotionally stimulating content. Social gratifications capture the desire for interaction, self-presentation, and community belonging through content creation and engagement. The adaptability of U&G makes it a suitable theoretical lens for analysing short-form video platforms such as TikTok, which combine informational cues with strong affective appeal.

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TikTok in tourism communication

TikTok's meteoric growth has introduced a new layer to tourism communication, distinguished by algorithmic personalisation, interactive audiovisual formats, and participatory culture (Boeker & Urman, 2022; Borges, 2023). Unlike traditional social media, TikTok's "*For You*" feed prioritises content relevance over network ties, allowing travel-related videos to reach users without prior connection to the creator. This algorithmic structure amplifies the visibility of emerging travel trends and destinations, which can influence tourist perceptions and intentions (Asri et al., 2024). Research has shown that TikTok facilitates both direct and indirect destination promotion, with viral travel content shaping destination image, curiosity, and perceived social endorsement (Pitanatri et al., 2024; Fuad et al., 2023).

Generation Z travel behaviour

Generation Z represents a digital-native cohort characterised by a high degree of media multitasking, a preference for visual communication, and reliance on peer-generated content for decision-making (Tan & Halim, 2021). In tourism, this group demonstrates a tendency toward experiential consumption and spontaneous travel decisions, often triggered by short, visually appealing content encountered on mobile devices (Liu et al., 2024). TikTok aligns well with these behavioural traits by delivering highly curated content in brief, engaging bursts, meeting both the entertainment needs and informational expectations of this demographic (Campbell et al., 2020). However, scholars have cautioned against equating engagement metrics with actual behavioural outcomes, as the performative nature of online commenting may inflate stated travel intentions (Fong et al., 2024).

Platform affordances and gratification patterns

According to the official TikTok Business Insights report (2023), the platform surpassed one billion monthly active users. This statistic provides contextual relevance rather than theoretical grounding. Studies on social media platforms in tourism contexts indicate that the platform satisfies overlapping gratifications. Cognitive gratifications arise from informative destination overviews, travel tips, and logistical insights embedded in video captions or voiceovers (Du et al., 2023). Affective gratifications emerge from cinematic storytelling, music synchronisation, and aesthetic framing, which create an emotional resonance with viewers (Wei et al., 2023). Social gratifications stem from features enabling comments, duets, and stitches, fostering parasocial interaction and community co-creation (Boeker & Urman, 2022). While these align with the classic U&G dimensions, platform-specific elements such as trend cycles, audio memetics, and

the algorithm's dynamic content curation may alter the relative prominence of each gratification over time (Zhou et al., 2023).

Research gaps

Although previous studies have examined TikTok's role in destination marketing, few integrate U&G theory with a critical analysis of platform affordances in the Malaysian tourism context. Furthermore, limited attention has been given to the methodological challenge of distinguishing between expressed intent in online discourse and actual travel behaviour. Existing works often rely on cross-sectional content analysis without triangulating findings through interviews, follow-up studies, or observational data (Abbadia, 2023). Another gap lies in understanding the resilience of gratification patterns when algorithmic distribution mechanisms evolve, which has implications for both theoretical refinement and practical application in tourism marketing.

RESEARCH METHODOLOGY

Research design

This study employed a qualitative content analysis approach to investigate how TikTok travel videos meet the cognitive, affective, and social needs of Malaysian Generation Z viewers. Content analysis was selected for its capacity to systematically interpret media messages and uncover latent themes that align with the Uses and Gratifications (U&G) framework (Graneheim & Lundman, 2003). The approach was designed to capture both manifest content, such as explicit informational cues, and latent content, such as underlying emotional or social appeals. The analysis incorporated triangulation to enhance validity, integrating video content, user engagement metrics, and audience comments to cross-check thematic interpretations (Abbadia, 2023; Vivek et al., 2023).

Sampling strategy

A purposive sampling method was used to identify videos that were likely to yield rich, relevant data for the research objectives (Campbell et al., 2020). Videos were selected from the "travel" category on TikTok's "For You" feed and filtered by Malaysian geotags to ensure contextual relevance. Engagement-based thresholds (minimum 50,000 views, 1,000 likes, and 50 comments) were applied to focus on content with demonstrated audience reach and interaction. This approach follows prior qualitative tourism research that prioritises high-visibility media for content analysis while recognising the need to critically interpret engagement signals (Asri et al., 2024; Arfan et al., 2023). A total of 30 videos were included, ensuring thematic saturation without overwhelming the coding process (Lacy et al., 2001).

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Data collection

Each selected video was downloaded along with its associated metadata, including the upload date, creator profile type, number of likes, shares, and comments. Comments were exported using an online scraping tool, with care taken to preserve original text for contextual accuracy. To reduce bias introduced by TikTok's algorithmic personalisation, video searches were conducted using a cleared browser cache and a newly created account without prior watch history, following recommendations for mitigating platform bias in social media research (Boeker & Urman, 2022).

Data analysis procedure

The analysis was conducted using ATLAS.ti software, which supports the systematic organisation, coding, and retrieval of qualitative data (Adelowotan, 2021; Soratto et al., 2020). An initial deductive coding frame was developed based on the core U&G categories, cognitive, affective, and social gratifications (Katz et al., 1973), with inductive codes added to capture emergent themes unique to TikTok's affordances. Coding proceeded in three cycles: open coding to identify relevant text and visual elements, axial coding to link patterns across cases, and selective coding to refine categories and integrate them into the theoretical framework (Bazén et al., 2021).

Ethical considerations

Ethical protocols for research using publicly available social media data were followed, in line with established guidance (Bhatia-Lin et al., 2019). No personally identifiable information was disclosed, and comments were anonymised in reporting. Given that TikTok users may not anticipate their content being used in academic research, interpretive sensitivity was applied to avoid misrepresentation of creators' intent.

FINDING

In this research, 30 TikTok videos related to travel were selected based on their high levels of likes, comments, and shares, ensuring the relevance and generalizability of travel industry trends. A total of 300 best comments were retained for analysis, with 10 comments analysed per video. The content analysed was specific to a Generation Z audience in Malaysia, based on activity on their TikTok accounts and other available information, while adhering to ethical research practices by using only publicly available data.

RESEARCH OBJECTIVE

To explore goal-oriented uses in social media, focusing on TikTok, that influence travel behaviour among Generation Z in Malaysia.

1. Cognitive Needs

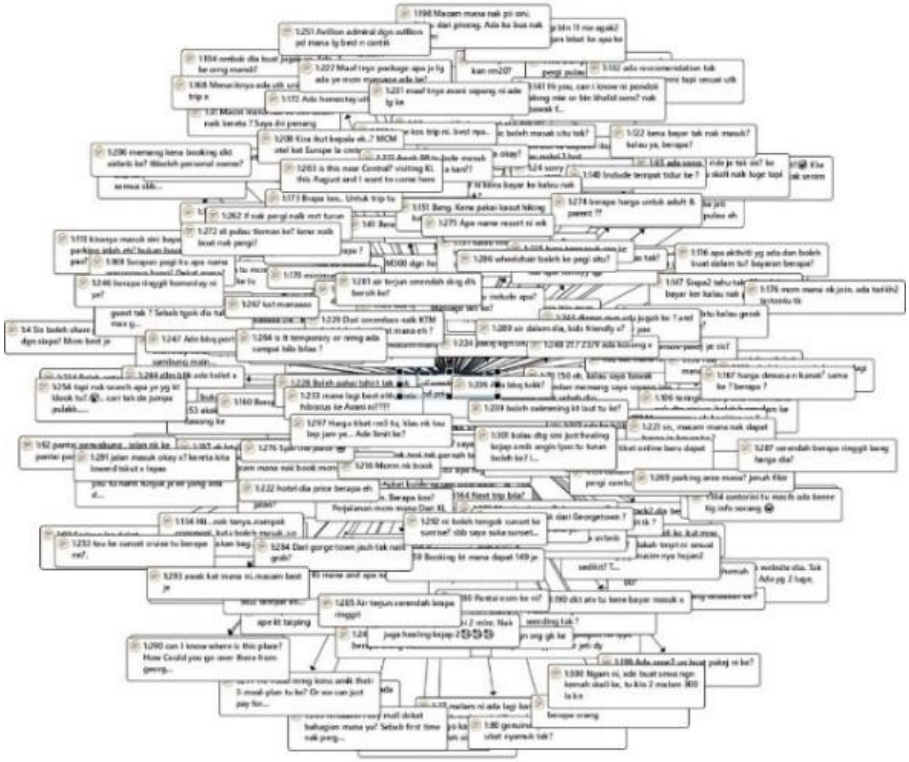


Figure 1: Comments on Cognitive Needs

Self-interest activities, such as knowledge acquisition, learning, and understanding, that are affiliated with cognitive components substantially affect the travel behaviour of Malaysian Generation Z. These demands are highly influenced by social networks, especially TikTok. Many people turn to TikTok for recommendations on various aspects of their travel plans, as well as tips and reviews of specific locations. These questions include: *"Macam mana nak pi sini dari Penang" (How do one get here from Penang?)* and *"boleh tengok sunset kt mana" (Where can we watch the sunset?)*. These interactions shed light on TikTok's relevance to users' informational needs and, consequently, to their trip

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planning and choices (Xiang & Gretzel, 2010). The interaction with TikTok, which also contains pictures and texts, can be considered to meet the cognitive needs of Generation Z users; For instance, comments such as *"Hotel dia ada swimming tak?" Does the hotel have swimming facilities?* and *"How much is the price for adults and children?"*. The most noticeable example is the following questions: *(Where should we eat?) and (What is the price for adults and children?)* These questions demonstrate the users' interest in specific and practical information regarding meals and expenses during a trip.

This pertains to the Uses and Gratification (U&G) theory, which posits that individuals use media to fulfil certain wants, including the pursuit of knowledge (Dewi Yanti et al., 2023; Katz et al., 1973). TikTok helps address the cognitive needs of its users, as it not only provides the information they seek but also nurtures the educational aspect through cultural, historical, and experiential content related to travel destinations. This educational dimension is most apparent in narrative descriptions and user-generated contributions that provide a holistic picture of the experience one can have in a given place. For example, debates such as *"berbaloi tak masuk ke sini" (is it worth entering here)* and *"berapa lama nak drive ke sini?" (how long is it going to take to drive here)*. Examples of specific questions asked by such users include (*is it worth entering here*, and *How long does it take to drive here?)* as described by the users before making travel plans.

From the thematic coding, three sub-themes emerged within cognitive needs: (i) Informational research, where users sought details on destinations, lodging, and attractions to support itinerary design; (ii) Decision-making support, where peer advice reduced uncertainty and enhanced confidence in travel choices, consistent with Shao and Lee's (2020) observations on digital travel communities; and (iii) journey planning, involving discussions on transportation costs, parking availability, and public transit options, consistent with evidence that social media platforms provide both inspiration and logistical support in trip planning (Hamid et al., 2016). Users make informational inquiries online to learn about travel destinations, lodging options, and attractions. The majority of their comments discuss recommended sites to visit, along with essential experiences to have. Building on the classic U&G paradigm proposed by Katz et al. (1973), users rely on TikTok for personal travel recommendations due to their need for informational understanding. The exploratory learning process receives support from TikTok, as the platform showcases immediate user-generated content, enabling informed decisions about travel destinations (Shao, 2009).

TikTok enhances decision-making processes and provides tools to explore travel logistics, demonstrating its ability to satisfy cognitive needs. Users discuss travel options while seeking confirmation and recommendations; thus, the platform helps reduce decision uncertainty regarding travel choices (Shao &

Lee, 2020). These sub-themes demonstrate that TikTok has a vital role in meeting cognitive needs through its interactive, real-time travel resources, which affect user travel behaviours and engagement.

2. Affective Needs

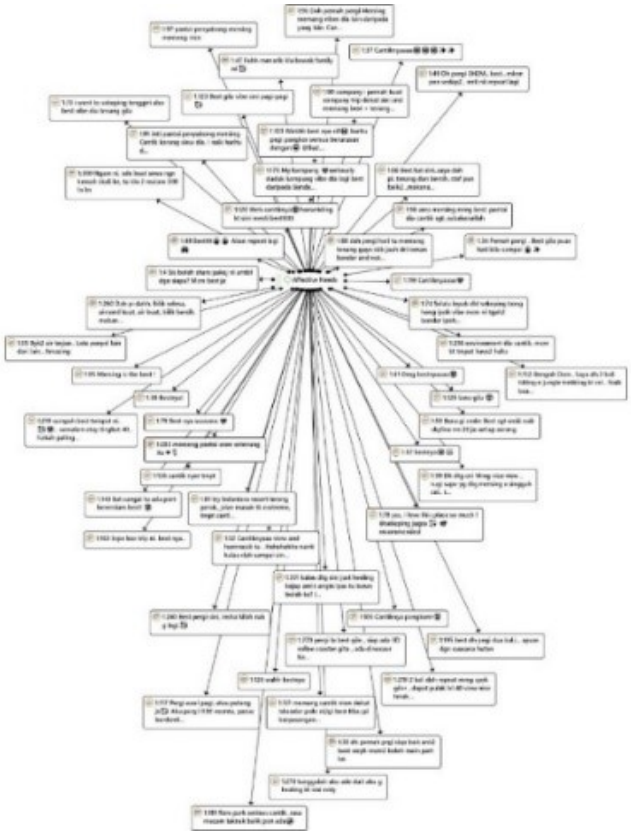


Figure 2: Comments on Affective Needs

An understanding of the affective needs depicted in Figure 2 reveals that they play a central role in shaping the travel behaviour of Gen Z in Malaysia, particularly through the adoption of the TikTok social media application. Affective needs relate to self-actualisation needs, which include fun, fascination, and pleasure, as conceived by users when consuming travel-related information (Dewi Yanti et al., 2023). Comments related to affective needs involve qualities that stimulate users' senses and emotions regarding the travel destination. Such

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utterances as *"cantiknya view" (beautiful view), 'best sangat' (so amazing), 'sumpah best tempat ni' (this place is truly amazing)* are clear indications that positive feelings elicited by what the travel bloggers find aesthetically interesting or which they find engaging, form part of users' motivational pull toward travelling.

The feelings reported in comments as "*akan repeat lagi*" (will visit again) and "*rugi siapa yang tak singgah sini*" (a pity for those who do not drop in) show that affective motives are intertwined with utilitarian purposes. Positive emotional experiences serve more than the direct self-need gratification, and lead users to have more specific travel-related goals, such as returning to the place or recommending it to colleagues. Figure 2 illustrates three sub-categories of affective needs, including emotional expression, experience sharing, and sentimental attachment, as observed in TikTok user responses. Users share their travel emotions by giving descriptive feedback that includes terms like *"bestnya"* and *"cantiknya"* as well as *"wahh best."* These words reflect their elevated feelings of admiration, along with their enthusiasm and deep happiness. Social media operates as an emotion-sharing platform, which confirms the emotional need principles documented by Shao (2009). People utilise social media to meet emotional needs by obtaining psychological satisfaction when they share upbeat content (Quan-Haase & Young, 2010). People use media actively for emotional satisfaction through enjoyment, along with escapism and self-expression, according to the Uses and Gratifications Theory. This demonstrates why TikTok users are enthusiastic about sharing their experiences (Katz et al., 1973).

3. Personal Integration Needs

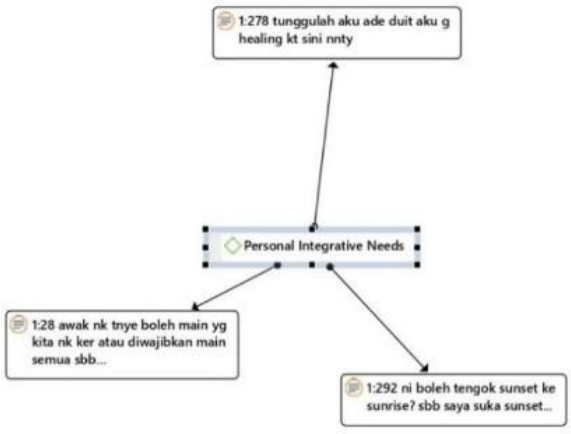


Figure 3: Comments on Personal Integration Needs

Figure 3, assessing personal integrative needs, again reveals how TikTok content helps Generation Z users in Malaysia achieve their desired travel goals, complemented by self-actualisation and acceptance through social recognition. Isolation-related needs are defined as the need for identity, self-esteem, recognition, and personal development, and are met through interaction with the intervening variables of social media platforms. In the context of the research question, TikTok serves as a means for users to set goals related to travel and learning, and, in turn, influences their travel identity.

Comments like "*tunggulah aku ada duit aku g healing kt sini nnty*" ("wait until I have money, I will heal there") show how TikTok stimulates users to set travel goals that fit their desires and healing needs. Likewise, *"Ni boleh tengok sunset ke sunrise? Sbb saya suka sunset" (Can you see the sunset or sunrise here? I like sunsets)* shows how audience goals revolve around the experiences that personally matter to them, and thus TikTok enables and encourages goal setting on objectives that are appealing to the user. Another comment *"awak nk tnya boleh main yg kita nk ker atau diwajibkan main semua sbb sbb kitonyo gayat part tinggi ii tu😂🤣😅." (I just want to know am i allowed to choose what to play or do I have to play them because I have a fear of heights😂🤣😅).* The following interaction demonstrates how users utilise TikTok to align their intended activities with their comfort levels.

These examples illustrate TikTok's pivotal role in facilitating self-directed travel planning. Users display their personal integrative requirements in Figure 3, which represent their goals for self-improvement, decision-making, and personal confidence when using TikTok travel content. Users choose to acquire knowledge which matches their personal preferences through three examples of questions: *"Can one observe the sunset or sunrise?" "Saya menyukai matahari terbenam…" and "Adakah anda ingin bertanya jika kita boleh memilih permainan yang kita inginkan atau diwajibkan untuk bermain semua kerana...".*

The findings indicate that vacation planning necessitates both self-assurance statements and decisions informed by personal preferences. According to the Uses and Gratifications Theory, people use media to validate their values and identities (Katz et al., 1973). Through digital interactions on platforms such as TikTok, users can determine whether their travel preferences align with their lifestyle and personality, thereby strengthening their sense of self (Sundar & Limperos, 2013). Travel offers consumers more than recreational enjoyment because they view it as an essential marker of personal development and social validation, as demonstrated by the statement "*wait until I have money for healing at this place that I need."* Self-improvement functions through social media, according to Whiting and Williams (2013), influencing future user behaviour.

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4. Social Needs

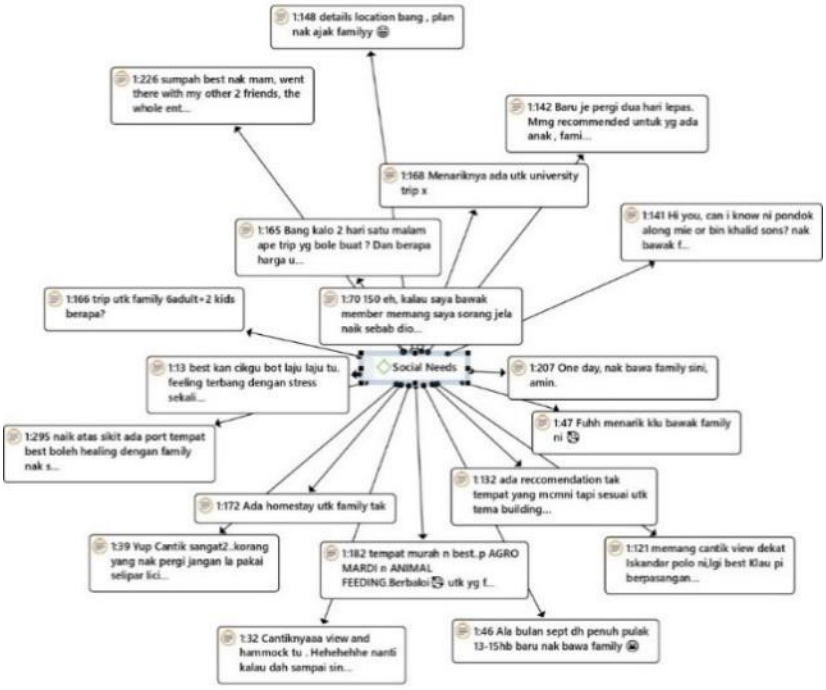


Figure 4: Comments on Social Needs

This study reveals that social needs are critical antecedents to the travel behaviour of Malaysian Gen-Z, mediated by social media. This is a native digital generation, and they tend to use social media platforms to satisfy social needs, such as family time and meet-ups with friends, which in turn significantly influences their travel choices. For instance, remarks like *"details location bang, plan nak ajak family" (concerning reception referencing intentions to invite family)* and *"Fuhh menarik klu bawak family ni" (it is fun if the family is to be invited)*. Chung and Koo (2015) acknowledge that the generation places a strong emphasis on family values.

Peer pressure is an important factor whereby one notices comments like this, *"best kan cikgu bot laju laju tu…feeling terbang dengan stress sekali (fast boat is fun; it helps forget stress),* and *"Baru je pergi dua hari lepas…Mmng recommended untuk yg ada anak, family" (went there two days ago; recommended for children and family).* These remarks provide insight into how social influences, including peer endorsement and endorsements, impact travel

decisions. This finding aligns with several research studies that highlight how social norms significantly influence the consumer decisions of Generation Z (Sheldon & Bryant, 2016). The goal-oriented use of social media for gathering specific information and sharing experiences is revealed in questions such as *"Bang kalo 2 hari satu malam ape trip yg bole buat?" (What activities can one do in two days and one night?)* and *"Ada homestay utk family tak"* which can be translated to mean *(Is there any home rental for familie?)* These interactions demonstrate how Generation Z utilises social media to make informed travel decisions that cater to the social needs of travellers. This behaviour aligns with the research findings, as social media is vital to travel planning among young people (Priyagus et al., 2024). The platform allows passengers to share information while participating in planning activities, thus demonstrating how social connections influence their travel decisions, according to Sundar and Limperos (2013). TikTok serves as a social platform for connecting with individuals and identifying with groups, while also enabling community participation during travel experiences.

5. Tension Release Needs

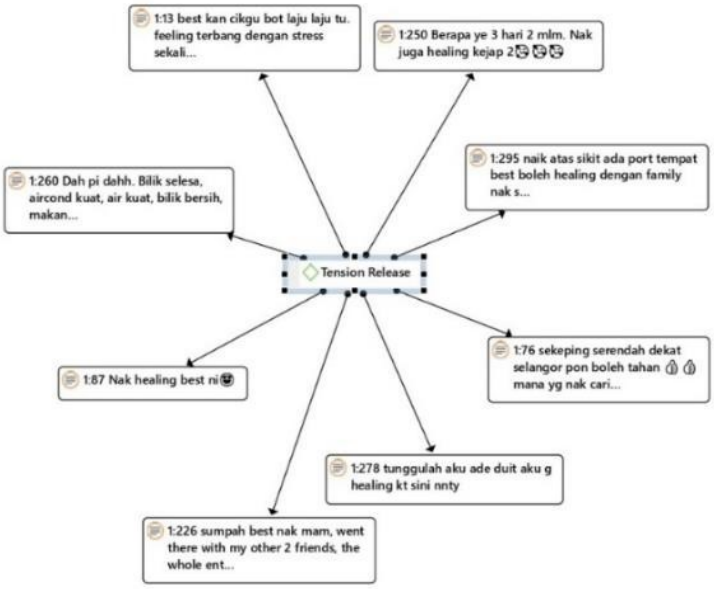


Figure 5: Comments on Tension Release Needs

The desire to find relief from tension, or in other words, to have recreation and leisure, can also be considered one of the goal-oriented factors

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influencing the travel behaviour of Gen Zs in Malaysia, where, for instance, they pursue specific goals on social media, such as TikTok. As we see on social media platforms, users post that they need to "fix" or "relax" through travelling. Phrases like *"Nak healing best ni", (I'd like to have a nice healing)* and *"naik atas sikit ada port tempat best boleh healing dengan family", (literally – there is a nice place a little higher where you can relax with your family),* show that stress relief is one of the factors that influences their choice of travel. The above examples illustrate that destinations offering peaceful and relaxing services cater to the needs of this age group, as they satisfy their desire for stress reduction. Furthermore, peer experiences are present in phrases such as *"sumpah best nak mam, went there with my other 2 friends, the whole entire exp mmg very relaxing, mula2 ingtkan cam x syok, no no no, pergi k* 💔*"* , (swear, this is really fun, *went there with my other 2 friends, the whole entire experience very relaxing, first thought, this is not fun but you need to go okay),* and *"tunggulah aku ade duit aku g healing kt sini nnty" (wait till I have money, I'll go heal here later)*. The above statements illustrate how install-pals waste time and stir up a desire for having a peaceful time away from work, as witnessed by the happy faces of other travellers who are ones one must emulate. This is true according to U&G theory, whereby people consume media to fulfil some needs they require, such as leisure and escape from stress (Whiting & Williams, 2013).

Three distinct categories form the sub-themes of tension release patterns in the data**,** including healing, stress relief, comfort, relaxation, and socially reinforced relaxation. Travel users express a connection between healing and stress management through phrases like "*Nak healing best ni*" and "*Tunggulah aku ade duit aku g healing kt sini nnty,"* viewing brief vacations as outlets for stress relief. Research indicates that people engage in recreational activities to fulfil their emotional and mental needs (Katz et al., 1973), in line with the Uses and Gratifications Theory. The mention of short getaways, such as *"Berapalah ye 3 hari 2 malam.* The ability to travel for brief periods to heal becomes a central aspect of stress management, according to these statements. Because people need both comfortable environments and clean spaces to relax properly.

DISCUSSION

The integration of thematic findings across the five gratification dimensions reveals a cyclical relationship between TikTok's affordances and Gen Z travel behaviour. Algorithmic curation enhances informational accessibility (cognitive need), audiovisual aesthetics stimulate emotional engagement (affective need), and interactive functions facilitate identity performance and peer connection (personal and social needs). These gratifications collectively influence travel

decisions, validating the Uses and Gratifications framework while extending it to account for algorithmic mediation. Figure 6 visualises this dynamic process, proposing a model that links platform affordances, user gratifications, and behavioural outcomes within an iterative feedback system.

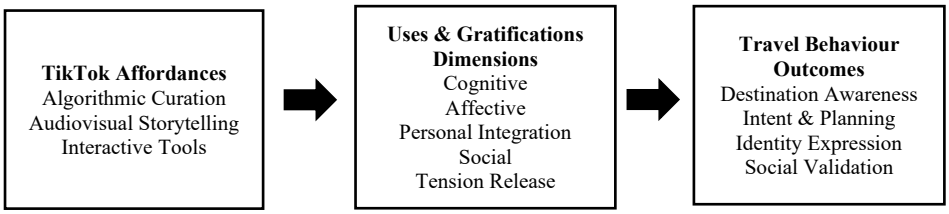


Figure 6: Conceptual Framework

Figure 6 illustrates the model integrates the Uses and Gratifications framework with TikTok's platform-specific affordances to explain how short-form video engagement influences travel behaviour. Algorithmic curation and audiovisual storytelling stimulate cognitive and affective gratifications by providing personalised, emotionally resonant content. Interactive affordances such as comments, duets, and stitches fulfil personal and social integration needs, reinforcing identity expression and peer belonging. The collective satisfaction of these needs contributes to travel-related decision-making and experiential validation, which subsequently feed back into content creation and sharing. The model conceptualises this as a cyclical process of algorithmic exposure → gratification fulfilment → behavioural enactment → social reinforcement.

CONCLUSION

This study contributes to tourism communication theory by extending the Uses and Gratifications framework to capture how TikTok's algorithmic and participatory affordances shape travel behaviour. The integration of platform-specific features such as trend amplification, audiovisual storytelling, and comment-based validation reframes gratification from a static typology into a dynamic, co-constructed process. Empirically, it provides Malaysia-specific insights into how Gen Z travellers negotiate identity, emotion, and social belonging through short-form video culture, thereby enriching both urban and global (U&G) and digital tourism scholarship.

Despite revealing meaningful links between gratification needs and travel discourse, this study recognises the limitation of inferring actual travel behaviour from digital expressions. Future research should triangulate content analysis with behavioural evidence. Surveys or in-depth interviews with TikTok users who have viewed or engaged with travel content could validate whether the

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motivations articulated online translate into concrete visitation choices. Integrating behavioural data such as geotagged posts or digital footprint analytics would enable a more precise understanding of how gratification fulfilment predicts tourism mobility among Generation Z

Recommendation for future studies

Building upon this study's qualitative findings, future work should integrate multi-method validation to bridge the gap between perceived intent and actual travel behaviour. Quantitative surveys could measure the extent to which TikTok engagement correlates with trip planning and visitation frequency, while semi-structured interviews could capture deeper insights into emotional and social gratifications. Such studies would not only validate the Uses and Gratifications framework within algorithmic media but also advance theoretical precision in linking digital interaction to tangible tourism outcomes.

Implications

The insights from this study have significant implications for tourism marketers, destination managers, and policymakers. Tourism marketers can leverage TikTok's interactive and visually engaging format to design content that addresses both the informational and emotional dimensions of travel decision-making. Destination managers may utilise the platform to highlight experiences that resonate with Generation Z's identity and social values, thus enhancing destination competitiveness. Policymakers can consider the role of social media in promoting sustainable and inclusive tourism narratives tailored to the preferences of young travellers. Understanding the interplay between user needs and digital engagement enables more strategic, data-driven approaches to marketing and tourism development in the social media era.

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CONTRACTORS' READINESS FOR ENERGY AWARENESS IN GOVERNMENT BUILDINGS: EVIDENCE FROM MALAYSIA

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Abstract

The Malaysian government has implemented Energy Management (EnM) within its Facilities Management (FM) practices to support Energy Efficiency and Conservation (EEC), aligning with national sustainable development goals. In government buildings across Putrajaya, energy awareness initiatives central to EnM are driven by Facilities Management and Maintenance (FMM) contractors under the supervision of Jabatan Kerja Raya Wilayah Persekutuan Putrajaya (JKR-WPP). Despite these efforts, energy-wasting behaviours persist, highlighting gaps in current awareness programmes. This study evaluates the readiness of FMM contractors to effectively implement energy awareness initiatives. Using an exploratory sequential design, the research began with qualitative phase using interviews to uncover readiness dimensions, followed by a quantitative phase to assess the extent to which these dimensions are present across contractors in Putrajaya This study identified six key readiness factors: personnel, competency, processes, tools, monitoring mechanisms, and management support. The findings indicate that contractors demonstrate moderately above-average readiness but lack structured and standardised methodologies for planning, implementing, and evaluating awareness initiatives. The study highlights the need for comprehensive procedural guidelines to ensure consistent execution and sustained behavioural change among building occupants. Enhancing contractor capability is crucial to achieving broader EEC and sustainability objectives in government facilities. These improvements are crucial for supporting Malaysia's long-term sustainable development agenda.

Keywords: Facilities Management, Energy Management, Energy Awareness, Government Buildings

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INTRODUCTION

Malaysia has long treated Energy Efficiency and Conservation (EEC) as a national priority, supported by policies such as the National Energy Policy (1979), National Green Technology Policy (2009), and the National Energy Efficiency Action Plan (2015). These frameworks shape EEC efforts in the built environment (Kementerian Tenaga Teknologi Hijau dan Air Malaysia (Ministry of Energy Green Technology and Water Malaysia) [KeTTHA], 2015, 2017; Shaikh et al., 2017). To put these policies into action, the Government Lead by Example (GLBE) initiative introduced practical measures in government buildings, including energy audits, electricity cost reduction, temperature guidelines, and daily energy-saving practices (Ministry of Finance Malaysia (MoF), 2014).

Yet, energy-wasting behaviours continue to surface, showing that policy direction does not always translate into everyday practice. Current efforts still rely heavily on awareness campaigns, with limited integration of technology and structured energy management processes (C. W. Wai, Mohammed, & Ting, 2009). Studies consistently highlight that lasting change requires a formal Energy Management System (EnMS) to support proper monitoring, evaluation, and continuous improvement (Fiedler & Mircea, 2012; Introna, Cesarotti, Benedetti, Biagiotti, & Rotunno, 2014).

In Putrajaya, FMM contractors are responsible for carrying out awareness activities under performance-based FM contracts. However, there is little evidence on whether they have the right people, skills, processes, tools, and management support to do this effectively. This gap matters, as contractor capability directly shapes behavioural outcomes in government buildings and influences the success of national EEC goals. This study therefore explores how ready FMM contractors are to deliver energy awareness programmes in Putrajaya, aiming to identify strengths, uncover gaps, and help bridge the distance between policy and real-world implementation.

LITERATURE REVIEW

Energy Management as Driver of EEC

Energy management can be described as a collection of initiatives which are planned and implemented systematically with the aim of minimizing energy consumption within an organisation (Fiedler & Mircea, 2012). Thus, in relation with energy efficiency and conservation drive, energy management can be regarded as its driver. Energy management can be established either on its own, in which it is its own anchor practice, or embedded as part of FM scope. It is in this respect, energy management, as driver for dissemination of energy efficient practices in building operation, has been found to be a highly befitting scope to be inserted into FM (Min, Morgenstern, & Marjanovic-Halburd, 2016).

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Another impetus for incorporation of energy management within FM practice is the on-going adoption of energy efficiency measures through legislative instruments, especially those that legally mandate adoption of those measures (Roberts, Bobrova, & Marjanovic-halburd, 2017). Nevertheless, even in jurisdictions in which the legislative efforts are still in contemplation stage, with yet-to-be-established take-off date, numerous organisations are taking the proactive step of incorporating energy management into their building operation, deeming it as worthy pursuits, with or without imposing legislation (International Facility Management Association [IFMA], 2011; Roberts et al., 2017).

It has also been asserted that a purely technological approach, without accompanying behavioral approach, to embrace energy efficiency, will gradually render the gains from technological approach to peter out in the long run in the absence of sustained efforts to manage the energy usage that, left unmanaged, will eventually upstage the earlier gains from technological approach (Lo, Peters, & Kok, 2012). Hence, this observation also serves as another spur towards adopting energy management in FM as driver for behavioral approach in energy efficiency and conservation.

Energy Awareness as Component of Energy Management

In carrying out energy awareness initiatives, FMM contractors are bound by contractual obligations that follow a performance-based rather than a prescriptive approach. The contract makes only a brief reference to the requirement for conducting energy awareness activities and does not explain how these initiatives should be implemented (JKR, 2018b). This is consistent with JKR's overall FM practice, which relies on a performance-based system guided by Key Performance Indicators with Ascertained Performance Deduction (KPI-APD) to set expectations for contractors (JKR, 2018a).

Although the contract allows flexibility, it does not prevent contractors from meeting their responsibilities. Yet energy-wasting habits still appear in government buildings, even with reminders like posters and stickers. This suggests contractors may not be fully ready to deliver these efforts with the needed consistency. Similar gaps in readiness have been noted in facilities management contexts (Vengadesan et al., 2025), and low stakeholder awareness has also been shown to weaken energy-efficiency initiatives (Kamarazaly et al., 2024).

Needless to say, such behavioural change will only occur subject to some precursor. That precursor has been identified in a number of literatures as existence of awareness on the importance of energy savings (C. W. Wai, 2009; Yen & Wai, 2010). In the model for energy awareness development process expounded by Wai, Mohammed, & Alias (2006), raising awareness is regarded as the foremost external stimulus needed to commence the chain of thought

process and behavioural conduct, followed by facilitation, as in enabling conditions, and solidification, as in motivational factors, that will lead to sustained energy-saving behaviour. These insights show that energy awareness initiatives are not simple or one-off activities. For results to last, they must be delivered systematically rather than in an ad-hoc or trend-driven manner. In practice, this means energy awareness must be closely tied to broader energy management efforts to create consistent and lasting behavioural change.

In the International Organization for Standardization [ISO] standard for energy management, ISO 50001:2011 "Energy management systems - Requirements with guidance for use", there are a number of elements that constitute a systematic energy management (ISO, 2011). Figure1 below shows the main elements in the model of the standard.

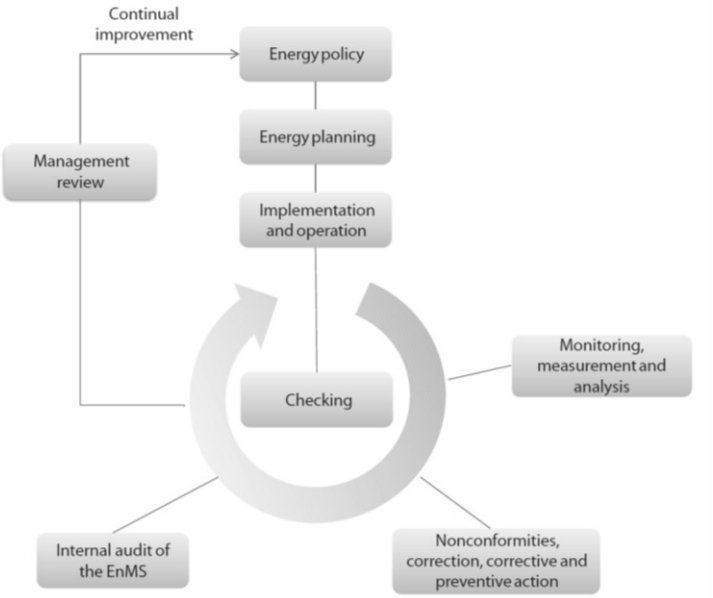


Figure 1: Energy Management System Model for ISO 50001:2011
Source: ISO (2011)

Under the element "Implementation and operation", there is a requirement for "Competence, training and awareness". The requirement specifies that organisation shall ensure its personnel have awareness on, among others, advantages of improving energy performance and impact on energy consumption brought about by their behaviour. Based on this ISO 50001:2011 requirement, initiatives related to raising awareness on energy efficiency indeed have been made to form part and parcel of energy management. In generic term, awareness can be described as the state of knowing about something in any

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context complimented with the acknowledgement on what that something may entail. In this instance, the awareness can be specifically referred to as energy-saving awareness or simply energy awareness (Yen & Wai, 2010). In simple terms, energy awareness means understanding the benefits of saving energy and recognising the drawbacks of not doing so. In buildings, this responsibility naturally falls on those who manage and operate them daily, FM practitioners, who play a key role in helping occupants become more aware and adopt energy-saving behaviours.

Strategies for Conducting Energy Awareness Initiative

There exist numerous literatures on various strategies that can be deployed to effect behavioural change towards energy-saving behaviour through energy awareness initiative (European Energy Agency [EEA], 2013; ISO, 2011; Lee et al., 2013; Mastura; Low Sheau-Ting, 2015; Mulville et al., 2016; Ting et al., 2011; C. W. Wai et al., 2009; Zierler et al., 2017). They involve a mix of approaches revolving in a cycle that, at the basic, start with appraisal of current situation, then crafting most suitable awareness slant to be driven through the targeted audience from a menu of available communication channels, tracking the message deployment and measuring the outcomes, making necessary adjustment to suit the evolving progress and to further improve upon it, and finally performing overall review whereby the cycle will recur continually (Carbon Trust, 2011; Natural Resources Canada, 2011; United States Department of Energy [DoE], 2007). The standard for energy management system ISO 50001:2011 succinctly describe this process as "Plan – Do – Check – Act (PDCA) continual improvement framework" – a framework of taking "actions to continually improve energy performance" (ISO, 2011, p. *v*). All these elements in conducting energy awareness initiative point to incontrovertibility of the need to possess, or at least having access to, the necessary wherewithal to embark on energy awareness initiative on the part of entity designated to drive it. C. Wai et al., (2006), in their conceptual framework of "Energy Awareness Development Process", designate such entity as "transferor", that is the side that create and transfer message for raising awareness, as opposed to the "receiver", that is the targeted audience for whom awareness is to be raised.

Awareness raising message can be conveyed through various forms of media to generate the commencing stimuli that affect senses such as visual, audio, taste, smell and feel. However, for energy-saving awareness only visual and audio are considered appropriate as the conveying inlet points for the message (C. Wai et al., 2006). Some of the channels to roll-out awareness message is verbal / face-to-face conveyancing through presentation, workshop, meeting, training, walk-about and targeted meet; written communication by way of fliers, periodicals and write-ups posted on notice boards; visual messaging such as posters and stickers;

audio messaging such as through public announcement; and active involvement of users by invitation for ideas. (JKR, 2017; Lee, Choong, Mohammed, & Abdullah, 2013; Mastura; Low Sheau-Ting, 2015).

The multitude of channels that can be utilised may confound the awareness drivers on which channel, or channels, should be used. It is suggested that instead of looking at each channel in isolation, they should be blended to produce the most optimal combination to roll-out energy awareness message, taking into account the context in which the message will be conveyed (Mastura; Low Sheau-Ting, 2015).

Approach for Energy Management and Awareness in FM

JKR has taken the approach of incorporating energy management within its FM practice, instead of EnM being its own anchor practice, as demonstrated by the inclusion of provision for such within its standard form of contract for FM. Some of the obligations on the FMM contractors that due to the provision are providing continuous support service for monitoring and managing energy usage as part of client's energy management system; conducting initiative to raise energy awareness amongst building occupants; and appointing suitably qualified personnel as energy manager / officer who will be a member of contractors' on-site team as the main point person for the running of energy management and conducting energy awareness initiative (JKR, 2018b).

RESEARCH METHODOLOGY

The study involves two respondent groups: one key JKR energy management officer and 31 FMM contractors' energy managers, with sampling designed to reflect meaningful variation in energy performance across buildings. Given the single JKR personnel, a qualitative key-informant interview is conducted, while purposive maximal variation sampling is applied to select FMM respondents who best capture representativeness and comparability. As referred to Creary et. al, (2015) and Kallio et. al (2016), semi-structured interviews guided by themes related to energy awareness, management practices, performance differences and organisational constraints are carried out, with data analysed through systematic coding (open, axial, and thematic) using qualitative software. Ethical clearance, informed consent, confidentiality and secure data handling are observed throughout. Limitations include the small sample size, qualitative scope and the localised context, which constrain broader generalisability but offer rich contextual insight. For the data analysis, both deductive and inductive approaches will be utilised to produce a more holistic outlook from the analysis. In this research, theme can be described as topical grouping of issues at hand under which the issues will be categorised and assigned to themes perceived as most suitable accordingly. A review on the resultant themes, relationships among the

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themes and the newly conceptualised framework will be performed. Through the review, researcher will attempt to form opinions on the resulting outcomes. It is also intended to validate literature-derived findings and uncover additional insights. Specifically, it aims to confirm the relevance of the influencing factors affecting FMM contractors' readiness to implement energy awareness initiatives and to assess, as far as practicable, whether these factors are present or absent within the interviewees' organisational contexts.

ANALYSIS AND DISCUSSION

Interviewee Selection

Figure 3 below shows the ranking of FMM Contracts According to Average Year-to-Year Building Energy Intensity (BEI) Reduction Performance. Having ranked the FMM contracts in a way that is more reflective of the thrust of energy management, selection of interviewees can be duly made in accordance with prescribed sampling technique. The sampling selection is illustrated graphically in Figure 2.

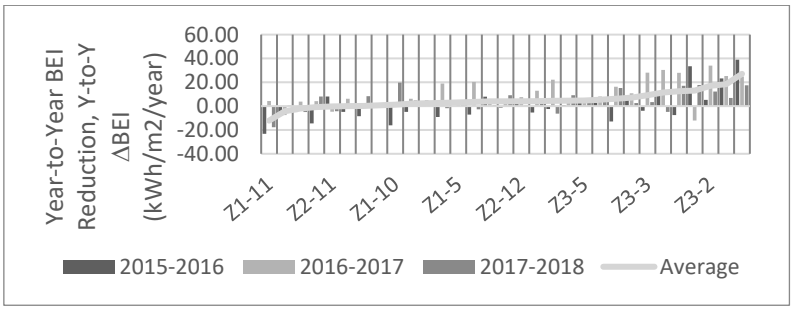


Figure 2: Ranking of FMM Contracts According to Average Year-to-Year BEI Reduction Performance

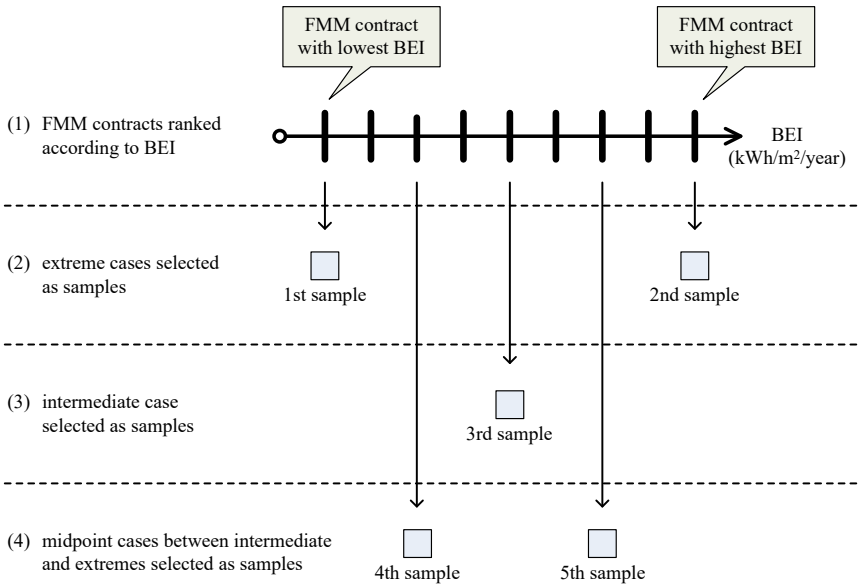


Figure 3: Selection of Interviewees through Purposive Sampling Technique by Performance Ranking for Representativeness and Comparability

The finalised interview list is as follows.

Table 1: List of Interviewees

No.	Position	Organisation	Sample's Ranking by Y-to-Y ΔBEI Performance	Tag
1	Energy Management Coordinating Officer	JKR-WPP	–	JC-1
2	Visiting Energy Manager	FMM contractor	Rank 1	Z3-1
3	Energy Manager	FMM contractor	Rank 2	Z1-3
4	Energy Manager	FMM contractor	Rank 3	Z2-2
5	Energy Manager	FMM contractor	Rank 4	Z1-10
6	Energy Manager	FMM contractor	Rank 5	Z1-11

Interview responses reveal a consistent view that contractors are trying to deliver energy awareness activities, but their efforts are often limited by structural and operational challenges. Several key factors shape how effectively these initiatives are carried out. Success relies heavily on strong client commitment, close cooperation between the client, JKR, and contractors, adequate manpower, and a basic level of energy awareness within FMM teams. While contractors generally meet basic competency requirements, many still

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depend on informal knowledge sharing, borrowed staff, and occasional visits from energy managers, with dedicated personnel remaining a common gap. Awareness activities follow GP SPT JKR guidelines but tend to be reactive and inconsistent, with no standard feedback mechanisms or clear behavioural measurement. Communication tools such as posters, stickers, and email reminders are widely used, yet messaging is not standardised and often developed on the spot. Monitoring mainly draws on utility bills and sub-meters, but indicators like BEI or carbon index are applied unevenly. Management support appears through recognition programmes and some centralised units, although budget limits and unclear job scopes remain persistent barriers. Overall, contractors show moderately strong readiness, rated around 4.5/5, but improvements are needed in staffing, tools, structured processes, and consistent monitoring to strengthen the overall impact of awareness initiatives.

Influencing Factors

Table 3 shows the thematic issues touched on by interviewees during interview sessions, it is observed most of the influencing factors identified earlier in the literature review are in-sync as among issues distinguished by the interviewees to occupy their top-most concerns in the running of energy management, generally and conducting energy awareness initiative, specifically.

It is also found that two (2) influencing factors are not mentioned by any of the interviewees as significant thematic issues that merit to be accorded a remark:

(1) having full-time energy manager at site; and
(2) conducting energy awareness survey before and after initiative.

The absence of remark on this two (2) influencing factors as thematic issues during interviews may indicate several possibilities. For full-time energy manager at site, the nil mention may be due to the ubiquitous presence of the factors that they no longer strike interviewees' mind as issue of concern. For conducting energy awareness survey before and after initiative, this may indicate the same phenomenon of ubiquity leading to nil register in interviewees' mind, or it may indicate unawareness amongst interviewees on the essentiality of establishing baseline when embarking on any energy management programme, as espoused earlier by numerous literatures during literature review. Thus, these findings call for further examination in quantitative phase of this research.

Table 2: Validation of Influencing Factors

Influencing Factors		LR	Qualitative Interview					
			JC-1	Z3-1	Z1-3	Z2-2	Z1-10	Z1-11
Personnel	Dedicated energy manager	√	√				√	√
	Full-time energy manager	√						

Influencing Factors		LR	Qualitative Interview JC-1	Z3-1	Z1-3	Z2-2	Z1-10	Z1-11
	Adequate supporting staff	√	√	√	√		√	√
Competency	Adequate competency	√	√					√
	In-house reference	√	√	√	√		√	
	External reference	√						√
Process	Established procedure	√	√	√	√		√	√
	Standard or guidelines	√	√	√		√		√
	Awareness survey before & after	√						
Tools	Access to communication channels	√	√	√	√	√	√	
	Suitable & adequate technologies	√	√		√	√	√	
Checking	Method to measure initiative effectiveness	√	√	√	√		√	√
	Data access for initiative checking	√	√	√	√		√	
	Regular tracking to monitor initiative	√	√	√		√	√	
Management support	Regular reporting to management	√		√	√	√	√	
	Regular budget allocation	√			√	√		√
	Organisation-wide EnM coordinator	√			√			
	Centralised EnM division/unit	√	√					√

Observable Emerging Themes

Throughout the course of interviews, two (2) themes were observed to have emerged in a number of sessions that apparently were not unearthed earlier during literature review. The tabulation of the themes' occurrence is provided in Table 3 below.

Table 3: Observation on Emerging Themes

Emerging Theme	Literature review	Qualitative Interview JC-1	Z3-1	Z1-3	Z2-2	Z1-10	Z1-11
Collaboration within FMM team	Nil		√	√	√		
Client agencies' commitment & participation	Nil	√	√		√	√	

The emergence of these themes may be due to several possible reasons. For collaboration within FMM team, this may be due to most literatures on FM and energy management are not overly concerned with the matters of team

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dynamics and cohesion of team members, since such subject are mostly the forte of other related fields such as organisational behaviour, for which the literatures on the fields, for example, by McShane and Glinow (2018), would have covered in abundance. Nonetheless, the fact of its mention by several interviewees indicates the seriousness placed by some of them on the issue, as understandably, the collaboration, or rather the lack of it, among FMM team members can be reasonably induced as one of important factors in influencing the contractors' readiness to embark on any enterprise, energy management and energy awareness initiative included. The other emerging theme, commitment and participation by client agencies, as occupants of government office building, the absence of which, in literatures on FM and energy management, may be due to unique situation for government office buildings in Putrajaya, whereby the building utilisation involves three (3) separate entities – client agencies who, as building occupants, are the assets owners, JKR-WPP, as responsible agency for building maintenance, is the assets manager, and the appointed FMM contractors as assets handlers (JPM, 2003, 2009, 2012).

As reviewed earlier, the current literatures available thus far on modes for acquiring FM services by client encompass either unipartite arrangement, through in-house setup with occasional out tasking (delegating specific tasks to outsider on temporary basis without surrendering any control), or bipartite arrangement, of which the prominence model will be outsourcing, varying in degrees from single outsourced service, partially-outsourced services to wholly-outsourced services, for which the client still retain the tasks of integrating various FM services, or a total FM procurement, for which even the integration is performed by the external party. Even if there is third-party in the bipartite arrangement, it will be in the form of sub-provider, such as sub-contractor, who only deal with the main services provider, that is the party contracted by the client, and does not directly with the client in the absence of the main service provider (Ikediashi et al., 2012; Jensen, 2017; Jensen et al., 2013; Jeynes, 2014; Kamarazaly, 2007; Kurdi et al., 2011; Pickard, 2011, 2012; Pitt et al., 2016; Stanley, 2009; Usher, 2004). This differs drastically in the case study, whereby the FMM contractors, as entities working on behalf of JKR-WPP, are vested with certain qualified mandate by the contracting party, that is JKR-WPP, to deal directly with clients in delivering their services as per contractual provisions (JKR, 2016b, 2018b). This renders the arrangement for FM services delivery for government buildings in Putrajaya, practically, a tripartite arrangement. As current coverage on tripartite arrangement for FM services acquisition in literatures is practically nil, this can explain why the issue of clients' commitment is not discernible during literature review yet it manifests itself during qualitative interview.

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Revision of Theoretical Framework

The qualitative findings offer fresh insight that helps refine the original theoretical framework developed from the literature. While the initial model reflected key readiness dimensions from FM and energy management studies, the interviews revealed additional factors specific to Putrajaya's government buildings. As a result, the two emerging themes make it necessary to adjust the framework rather than rely solely on the literature-based version. The revision will be carried out through realignment between the existing framework and the emerging themes. To do that, a check is carried out to spot any interrelatedness between the emerging themes and the framework, as it is currently framed. It is resolved that the emerging themes can be readily slotted into the existing major themes, *collaboration within FMM team* into *personnel*, and *client agencies' commitment and participation* into *management support*. Hence, the revised breakdown of influencing factors that constitute the theoretical framework appears as in Table 4 below.

Table 4: Revised Breakdown of Influencing Factors

Influencing Factors						
Major factors	**Personnel**	**Competency**	**Process**	**Tools**	**Checking**	**Management Support**
Sub factors	1. Dedicated energy manager 2. Full-time energy manager 3. Adequate supporting staff 4. Collaboration within FMM team*	1. Adequate competency 2. In-house reference 3. External reference	1. Established procedure 2. Standard or guidelines 3. Awareness survey before & after	1. Access to communication channels 2. Suitable & adequate technologies	1. Method to measure initiative effectiveness 2. Data access for initiative checking 3. Regular tracking to monitor initiative	1. Regular reporting to management 2. Regular budget allocation 3. Organisation-wide EnM coordinator 3. Centralised EnM division/unit 4. Clients' agencies' commitment & participation*

***. Emerging theme.**

CONCLUSION

This study assessed how ready Facilities Management and Maintenance (FMM) contractors are to implement energy awareness initiatives in government buildings throughout Putrajaya. The findings indicate that while contractors show commitment and possess basic technical capability, many initiatives are still delivered on an ad-hoc basis. Without structured planning, delivery, and evaluation, it becomes difficult to create consistent practices or encourage long-term behavioural change among occupants.

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The results point to the need for a more organised and unified framework to guide awareness efforts. Clear procedures such as setting baselines, engaging stakeholders, tailoring communication, and tracking outcomes would strengthen implementation and ensure continuity. Embedding these elements within a broader Energy Management System (EnMS) would further support measurable and sustained improvements. Achieving this will also require stronger backing from contractors and client agencies, especially in terms of dedicated personnel, adequate resources, and coordinated oversight.

By identifying the operational challenges faced by FMM contractors, this study helps clarify how behavioural-based energy initiatives can be better embedded within public-sector facilities management. The findings highlight the importance of aligning organisational commitment, management structures, and day-to-day practices to enhance the impact of national EEC goals. Future research may expand on this work by comparing readiness across different regions or building types, evaluating the cost–benefit of more structured awareness frameworks, and exploring how behavioural measures interact with technological solutions over time.

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KEY CAUSES AND DRIVERS OF ENERGY PERFORMANCE GAPS IN MALAYSIAN NON-RESIDENTIAL GREEN BUILDINGS

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Abstract

The Building Energy Performance Gap (BEPG) describes the difference between predicted and actual energy consumption, a mismatch that ultimately weakens the credibility and effectiveness of green buildings. Despite various technological and regulatory efforts, many Malaysian non-residential green buildings continue to consume more energy than anticipated. This study addresses a critical research gap, namely the absence of a comprehensive framework that integrates the root causes and driving factors of BEPG specific to the Malaysian context. The root causes are categorised as design-related, construction or commissioning-related, and operational-related. To examine these relationships, 21 hypotheses were tested through a survey of 278 Malaysian energy management and green building experts. The findings reveal that operational-related causes are the most prevalent, with the highest Relative Importance Index (RII), and exert the greatest influence on the energy performance gap. Key contributing factors include organisational, leadership, and behavioural aspects. The novelty of this study lies in its integrative approach to identifying and categorising BEPG root causes, as well as its contextual focus on Malaysia. The findings not only highlight high-priority intervention areas but also offer practical strategies for stakeholders to improve energy performance outcomes. The study contributes actionable insights for improving energy efficiency practices and supporting the long-term success of green building initiatives in Malaysia.

Keywords: Energy performance gap; Energy efficiency; Office building; Sustainability; Green Buildings; Malaysia.

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INTRODUCTION

The Building Energy Performance Gap (BEPG) refers to the discrepancy between predicted and actual energy use in buildings, or between designed and actual energy performance. Addressing this gap requires an understanding of its magnitude, patterns, and underlying causes to formulate effective interventions (Li et al., 2023; Shi et al., 2019). The discrepancy between simulated building energy performance and actual measured outcomes significantly hampers progress towards achieving sustainability goals (Igugu et al., 2025). Contributing factors include building type, location, ownership, occupancy rate, and usage patterns (Liang & Qiu, 2019; Zheng et al., 2024). Broadly, BEPG causes can be categorised into design, construction, and operational issues (Wilde & Jones, 2013; Zou et al., 2018; Zheng et al., 2024). Many existing buildings were not originally designed for energy efficiency (Ramli et al., 2023), and some fail to perform as intended due to design and technological shortcomings during early development stages (Zheng et al., 2024). In certain cases, actual energy consumption can be up to 2.5 times higher than anticipated, significantly undermining energy-saving goals. Bridging this gap requires identifying the factors that prevent buildings from achieving optimal performance. These factors span the building lifecycle stages of design, construction, and operation, each stage contributing to the emergence or mitigation of BEPG (Li et al., 2023; Zheng et al., 2024). Non-residential buildings are affected by a combination of socio-technical factors, including technological, organisational, and behavioural factors (Liang & Qiu, 2019; Zheng et al., 2024). Other influential elements include leadership (Li et al., 2023; Staddon et al., 2016; Zou et al., 2018), knowledge and skills (Shrubsole et al., 2019; Ramli et al., 2023), access to information (Li et al., 2017; Mineeva, 2016; Zheng et al., 2024), and external influences (Cattaneo, 2018; Shi et al., 2019). These have been categorised into seven key driving factors: organisational leadership, technological attributes, behavioural patterns, skills and knowledge, informational resources, and external influences, each shaping how green buildings perform in practice (Zheng et al., 2024).

However, current research has not yet comprehensively categorised, managed, or addressed the root causes of BEPG (Zou et al., 2018; Zheng et al., 2024), highlighting the need for deeper investigation into the complex relationships between BEPG causes and their drivers (Li et al., 2023; Shi et al., 2019). In response, this paper offers new empirical insights into these causes and influencing factors while emphasising the importance of strategies that reduce the energy performance gap effectively in Malaysian non-residential green buildings.

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LITERATURE REVIEW

Green Buildings and Energy Demand in Malaysia

Energy is a critical resource in Malaysia's built environment, with national energy demand reaching 4.11 exajoules in 2020. The highest energy-consuming sectors were industry (40%), transport (38%), commercial and residential (13%), non-energy use (8%), and agriculture (1%) (Suruhanjaya, 2020). More than 80% of national electricity use occurred in the industrial, residential, and commercial sectors, underscoring buildings as major contributors to greenhouse gas emissions. It was largely proven that the economic growth and energy consumption are linked to the emission of carbon dioxides, which negatively degrade the environment (Ahmat et al., 2025). The projection of Malaysian population is expected to surge to 40 million by 2050, with anticipated urbanisation increase from 75 % in 2020 to 85 % by 2040, Malaysia is poised for heightened energy demands in every sector (Fernandez et al., 2025).

In Peninsula Malaysia, energy demand is projected to rise from 19,480 MW in 2024 to 20,049 MW by 2030 (Yiau, 2024), driven by economic growth, industrialisation, and the expansion of data centres.

Malaysia has introduced several initiatives to promote sustainable construction and energy efficiency. There is an increasing effort from the government in the energy sector, particularly in energy security, sustainability, efficiency, and affordability (Ahmad et al., 2024). The Green Building Index (GBI), established in 2009, assesses buildings across six areas, including energy efficiency, indoor environmental quality, and water conservation (GBI, 2009). The national agendas and strategic plans, including:

a) National Green Technology Policy (NGTP, 2009): *Aims to position green technology as a driver of economic growth and sustainable development.*
b) Renewable Energy Act (2011): *Seeks to increase electricity generation from renewable energy sources.*
c) National Energy Efficient Action Plan (NEEAP, 2016-2025): *Targets reduced electricity demand growth through efficiency measures.*
d) Green Technology Master Plan (GTMP, 2017-2030): *Outlines strategies to support sustainable growth in the energy sector.*
e) National Energy Policy (DTN, 2022-2040): *Defines energy transition as a structural shift towards a more sustainable energy system.*

While Malaysia has made notable progress in promoting green technology, energy efficiency, and green building development, both green and conventional buildings frequently fall short of achieving expected reductions in energy use and greenhouse gas emissions (Cross et al., 2017). Green buildings continue to face challenges that hinder their widespread adoption and effective

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performance (Zakaria et al, 2024). For example, Zaid & Kiani (2016) observed that buildings certified under the GBI exhibited a higher Building Energy Index (BEI) at 111 kWh/m²/year compared to non-certified buildings, which recorded 69 kWh/m²/year. Despite a rising number of GBI applications, fewer than 18% of buildings achieve final certification through the Completion & Verification Assessment (CVA), largely due to poor operational performance (Coleman & Robinson, 2018; Liang & Qiu, 2019; Zaid & Kiani, 2016).

Building Energy Performance Gap Factors

Many buildings, including those equipped with advanced energy efficiency technologies, have been reported to fall short of their projected energy savings targets (Zou et al., 2018). Actual energy consumption can exceed intended levels by as much as 2.5 times, significantly undermining efforts to achieve energy efficiency goals. Maintaining optimal energy performance is crucial to upholding the credibility of green building certifications (Shaardan et al., 2024). The causes of BEPG are commonly categorised into three broad groups: design-related, construction or commissioning-related, and operation-related causes, which are also defined by Zheng et al. (2024).

In the global context, researchers have identified seven key driving factors that influence BEPG mitigation efforts: organisational structure, leadership, technological systems, behavioural practices, knowledge and skills, access to information, and external conditions.

(i) *Organisational*

Organisational or institutional factors contribute significantly to the energy performance gap in non-residential buildings (Liang & Qiu, 2019). Organisational drivers encompass governance structures, accountability systems, and internal policies that determine energy management responsibilities (Liang & Qiu, 2019; Lane et al., 2024). Strong organisational commitment forms the backbone of continuous energy performance improvement, as weak coordination will fragment the landlord–tenant roles.

(ii) *Leadership*

Strategic leadership is crucial for sustaining long-term energy efficiency and balancing social, environmental, and economic objectives. While facilities managers oversee broad operational functions beyond energy management (Myeda et al., 2014; Liang & Qiu, 2019), appointing dedicated energy managers is vital to maintain focus on performance goals (Staddon et al., 2016). Leadership thus shapes both the underlying causes and solutions to energy performance gaps throughout the building lifecycle.

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(iii) Technological

Technological shortcomings remain a key contributor to the energy performance gap. Technological drivers concern system design, specification, commissioning, and compatibility between modelling assumptions and real-world operation (Zheng et al., 2024; Tanaka et al., 2022). The energy gap often arises when actual equipment efficiency, control strategies, or occupancy conditions differ from those simulated.

(iv) Behavioural

Occupant behaviour significantly affects building performance during the operational stage (Zou et al., 2018). Multiple factors influence behaviour, impacting both comfort and satisfaction. Behavioural change remains complex, influenced by contextual and informational variables (Liang & Qiu, 2019). Behavioural interventions are vital for closing the performance gap in the operational phase.

(v) Skill and knowledge

Skill and knowledge drivers relate to the technical competencies of professionals throughout the building lifecycle, from designers and contractors to FM personnel (Lane et al., 2024; Hair et al., 2017). Insufficient expertise in simulation, commissioning, or energy management can lead to inaccurate design assumptions and inefficient operation. Growing environmental concerns underscore the importance of facilities management (FM) involvement from the design stage (Jawdeh, 2013). However, FM is often overlooked during design, resulting in costly post-construction modifications (Zou et al., 2018). Addressing knowledge gaps among stakeholders across a building's lifecycle is critical to narrowing the energy performance gap.

(vi) Informational

Information is crucial for effective energy management, yet challenges persist across the building lifecycle. The lack of reliable data hinders continuous calibration of models and performance tracking (Zou et al., 2018; Gupta & Gregg, 2016). Ensuring reliable data and developing interpretive competencies are essential for precise energy forecasting (Wilde, 2014). The "human-in-the-loop" concept has emerged as a solution, integrating occupant data via pre- and post-occupancy evaluations with digital modelling tools (Zou et al., 2018). Integrating post-occupancy evaluation (POE) data and real-time monitoring enhances feedback between operational outcomes and future designs.

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(vii) External

External drivers encompass climatic conditions, market incentives, energy tariffs, and regulatory enforcement that influence building energy use (Zheng et al., 2024). Weather-related uncertainty can lead to annual performance deviations of up to around 6–7 % (Van Dronkelaar, 2016; Wang et al., 2012). Although these factors are largely beyond organisational control, they shape energy priorities and investment decisions. Yet, energy-related policies, including subsidies and tax incentives, may reduce investment risk and promote efficiency (Cattaneo, 2018). Therefore, inclusive and accessible measures are essential to realising broad societal benefits.

RESEARCH METHODOLOGY

A survey was conducted across three Malaysian states using cluster sampling to collect responses from professionals involved in green building initiatives. Of the 795 individuals invited via email, 278 responded, yielding a response rate of 33.9%. According to Tan et al. (2005), a minimum of 20 respondents per subgroup is required to justify cluster analysis. Therefore, the sample size of 278 provides sufficient statistical power (Dalmaijer et al., 2020). Cluster sampling was appropriate as the target population was geographically concentrated, enabling the efficient grouping of relevant respondents and enhancing data collection effectiveness. The research population included 105 active Green Building Index (GBI) facilitators and 1,302 Registered Electrical Energy Managers (REEM) within the Klang Valley area of Malaysia. Respondents were categorised into three groups: Group A – experts not involved in the green building industry (89 respondents), Group B – experts in the green building industry but not GBI facilitators (130 respondents), and Group C – experts actively involved as GBI facilitators (59 respondents). All groups met the minimum requirement of 20 respondents per subgroup, ensuring statistical adequacy. The survey comprised three sections: demographics (Section A); root causes of the energy performance gap (EPG), categorised into design-related, construction/installation and commissioning-related, and operation-related causes (Section B); and driving factors to bridge the EPG, encompassing organisational, leadership, technological, behavioural, skill and knowledge, informational, and external factors (Section C). A five-point Likert scale was used to rate items. The measured constructs in the survey were extracted from the literature review. The data were analysed using SPSS and PLS-SEM to explore relationships among latent variables.

Method of Analysis

Respondent feedback was analysed using SPSS and PLS-SEM, incorporating descriptive analysis, Relative Importance Index (RII) analysis, and PLS-SEM

modelling. RII analysis was used to rank the critical root causes of the BEPG and the key mitigation factors, based on expert perceptions. RII values were computed according to Equation (2), adapted from Fagbenle (2011):

$$\text{Relative Importance Index (RII)} = \frac{\Sigma W}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N} \quad \textbf{(1)}$$

$(0 \leq \text{RII} \leq 1)$

Where W is the weight assigned by respondents on a five-point Likert scale (1–5), A is the highest possible weight, N is the sample size, and n is the total responses for each scale. Akadiri (2011) states that RII values range from 0 to 1 and can be divided into five levels of importance: high (H) for values between 0.8 and 1.0, high–medium (H–M) for 0.6 to 0.8, medium (M) for 0.4 to 0.6, medium–low (M–L) for 0.2 to 0.4, and low (L) for 0 to 0.2.

PLS-SEM was employed to examine the relationships between exogenous constructs (root causes) and endogenous constructs (driving factors) within the structural model using Smart-PLS Version 3.2. Following Hair et al. (2014), the model was evaluated using five key criteria: collinearity, path coefficients (β), effect size (f^2), predictive relevance (Q^2), and coefficient of determination (R^2).

ANALYSIS AND DISCUSSION

Background of Respondents

Of the 278 responses received, engineers represented the largest proportion of respondents (27.3%), followed closely by executives (27%), senior managers (22.3%), directors (15.8%), and lecturers (7.6%). Within the green building sector, 47% were actively involved as green facilitators, 32% were involved but not in a facilitator role, while 21% reported no involvement. In terms of professional experience, 30.6% had 6 to 10 years of industry experience, and 33.5% had less than 5 years of experience specifically in green building. A smaller proportion of respondents (10.4% and 1.4%) reported 16 to 20 years of experience in the industry and the green building sector, respectively, indicating a wide range of professional backgrounds and levels of expertise among participants.

Relative Importance Index (RII) Analysis

(a) Root Causes to BEPG Analysis

Table 2 presents the RII values and corresponding rankings of the root causes contributing to the BEPG. Operational causes emerged as the most critical category with the highest RII value of 0.753, followed by construction and

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commissioning-related causes (0.743) and design-related causes (0.729). Among operational causes, the most significant factors identified with High Level Important were lack of occupant awareness (ORC1), inadequate financial resources and incentives (ORC11), insufficient skills and knowledge (ORC14), and poor occupant interaction with building systems (ORC2). The lowest-ranked operational factor was the failure of energy-efficient equipment to meet specifications (ORC17), with an RII of 0.649. Within construction and commissioning-related causes, poor workmanship and improper techniques (CRC3) ranked highest, with an RII of 0.773. As for design-related issues, inefficient or oversized systems (DRC7) recorded the highest RII in this category and ranked twelfth overall with a score of 0.760. A comprehensive list of the RII rankings is provided in Table 2.

Table 2: High and high-medium importance ranking of root causes to BEPG

Rank	Codes	Codes	Mean RII	Level
1	ORC1	Lack of occupant awareness	0.829	H
2	ORC11	Insufficient funds and incentives	0.809	H
3	ORC14	Lack of skills and knowledge	0.807	H
4	ORC2	Poor occupants' interactions	0.801	H
5	ORC19	Lack of documentation	0.789	H-M
6	ORC12	Decision-makers are less attentive	0.788	H-M
7	ORC15	Lack of sub-metering	0.785	H-M
8	ORC16	Lack of fine-tuning	0.785	H-M
9	CRC3	Poor workmanship and improper techniques	0.773	H-M
10	ORC5	Lack of top management support	0.772	H-M
11	ORC4	Lack of information	0.768	H-M
12	DRC2	Incorporation of inefficient or oversized systems	0.760	H-M
13	DRC7	Change orders during the design stage	0.756	H-M
14	ORC13	Bypassing of the energy control system	0.756	H-M
15	CRC2	Contractors occasionally engage in dishonest practices	0.756	H-M
16	CRC1	Contractors with limited experience	0.754	H-M
17	DRC5	Lack of attention to buildability and maintainability	0.750	H-M
18	ORC3	Negative interactions and influences among occupants	0.746	H-M
19	DRC4	Lack of attention to end users' needs and convenience	0.745	H-M
20	ORC7	Poor communication between management and occupants	0.744	H-M
21	CRC5	Failure to uncover hidden problems	0.741	H-M
22	CRC7	Change orders during the construction stage	0.736	H-M
23	DRC6	Lack of communication between the designer and the owner	0.734	H-M
24	ORC6	Lack of authority for FM	0.729	H-M
25	CRC6	Lack of information on design details	0.728	H-M
26	ORC10	Excessive use of additional appliances	0.722	H-M

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27	CRC4	Full performance testing is not conducted	0.714	H-M
28	DRC1	Overestimation of the actual performance technology	0.705	H-M
29	DRC3	Inappropriate parameters used in modelling	0.695	H-M
30	DRC8	Regulatory compliance does not account for all building energy uses	0.686	H-M
31	ORC8	Increase the level of occupancy	0.685	H-M
32	ORC9	Extension of operating hours	0.683	H-M
33	ORC18	Suppliers fail to meet the specifications for replacements	0.657	H-M
34	ORC17	Energy-efficiency equipment does not meet specifications	0.649	H-M

(b) Driving Factors to Bridge BEPG

The RII analysis of the driving factors confirms the significance of all seven categories in addressing the BEPG. Ranked by RII values, the most influential factors were organisational (0.849), leadership (0.847), behavioural (0.817), external (0.816), informational (0.815), technological (0.812), and knowledge and skill (0.803). The top four factors highlight the critical role of organisational commitment, particularly the involvement of top management (ODF2), a culture of energy efficiency (ODF8), a compulsory comprehensive energy management plan (ODF3), and a clear, concise energy policy, particularly during the operational phase. Effective energy management practices and active engagement from key stakeholders, especially top management and building occupants, are essential to overcoming organisational challenges that contribute to the BEPG.

Table 3: High and high-medium importance ranking of driving factors to BEPG

Rank	Codes	Constructs	Mean RII	Level
1	ODF2	Top management commitment to continuous improvement	0.829	H
2	ODF8	Energy efficiency and energy conservation become the culture in an organisation	0.809	H
3	ODF3	A compulsory comprehensive energy management plan	0.807	H
4	ODF4	Energy policy should be short and comprehensive	0.801	H
5	LDF4	Energy managers should have the capabilities to produce complete and comprehensive evaluations	0.789	H
6	ODF7	Clear and defined roles of the energy management committee	0.788	H
7	TDF3	Well-scheduled and informed maintenance of equipment and building sub-systems	0.785	H
8	TDF4	Establishment of operational criteria and a checklist for energy efficiency	0.785	H
9	ODF5	Energy policy should be reviewed, and recommendations should be made accordingly	0.773	H
10	LDF3	Employment of an on-site energy manager	0.772	H

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11	LDF1	Good relationship between stakeholders (e.g. Management team and building occupants)	0.768	H
12	BDF4	Create the feel of ownership among building occupants for energy management	0.760	H
13	ODF1	Active involvement of top management in energy management	0.756	H
14	EDF1	The government should produce a more comprehensive policy or a guiding principle	0.756	H
15	KDF2	Good competency level of the energy manager	0.756	H
16	BDF2	Promote energy management practices and awareness among building occupants	0.754	H
17	IDF3	Energy conservation opportunities to prioritise based on its resources, budget and profitability	0.750	H
18	LDF2	The energy manager should be positioned high enough in the organisational structure.	0.746	H
19	IDF1	Continuously promoting the energy target for the upcoming years	0.745	H
20	IDF2	Conduct pre-occupancy data collection and post-occupancy data collection	0.744	H
21	BDF3	Action plans should be grouped into design, construction and commissioning and operation	0.741	H
22	TDF2	Clearly defined and documented purchasing, supply or delivery of energy services and products needs to be energy efficient	0.736	H
23	TDF5	More seminars/workshops for building practitioners	0.734	H
24	EDF3	To have an open discussion between industry, government and academia	0.729	H
25	EDF2	Energy reduction has been reduced and continuously improved every year	0.728	H
26	KDF1	Detailed information about the different initiatives in different stages	0.722	H
27	KDF4	Full understanding of the climate and energy system by both the designer and end user.	0.714	H
28	KDF5	Assignment of a sustainability champion who is a willing and knowledgeable person	0.705	H
29	BDF5	Giving rewards/recognition to occupants creates more involvement in energy saving	0.695	H
30	BDF1	Get more feedback from building occupants on how they can help more in energy saving	0.686	H
31	KDF3	Technical training for the Energy Management Committee at least once a year	0.685	H
32	KDF6	Different forms of education training should be conducted	0.683	H
33	TDF1	Simplicity in building equipment technology for an energy management system	0.657	H
34	TDF6	An energy committee should be formed; the members should be rotated once a year	0.649	H
35	ODF6	Energy audit every year	0.829	H-M

Because RII only measures importance but not causal direction, the next section uses PLS-SEM to test whether the highly ranked causes significantly affect the driving factors.

Partial Least Squares Structural Equation Modelling (PLS-SEM) Analysis

Structural Model

The PLS-SEM analysis includes both measurement and structural model evaluation, that essential for hypothesis testing and to ensure the validity and reliability of the constructs measured. The measurement models were assessed for construct validity, encompassing both convergent and discriminant validity. All exogenous and endogenous constructs demonstrated strong correlations within their respective measurement models, and in total, there were 21 relationships to be assessed as illustrated in Figure 1. The structural model was assessed based on five criteria present in the validated path model. Table 5 summarises the findings of the structural model analysis.

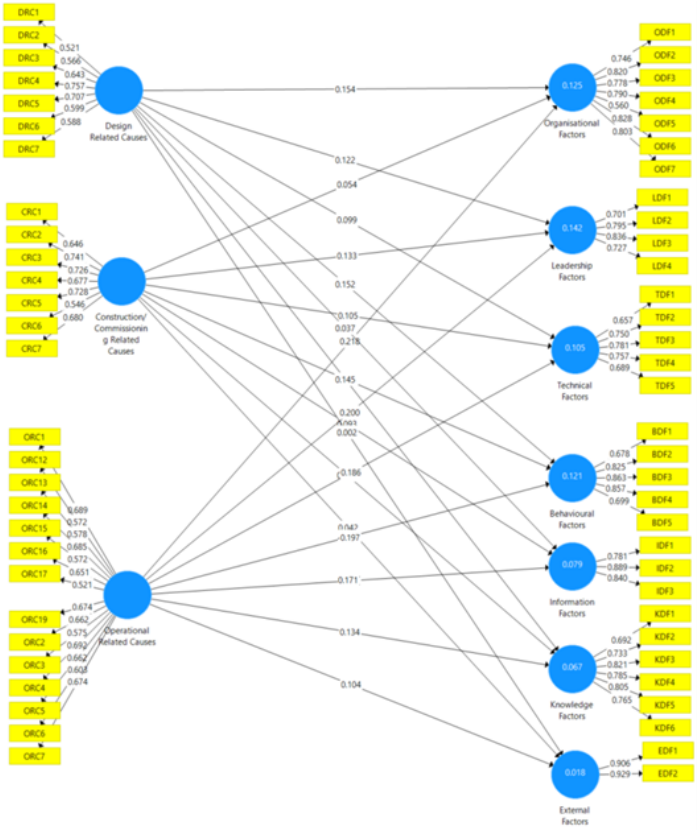


Figure 1: Validated PLS-SEM Structural Model

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Step 1: Collinearity Assessment

In this study, all constructs exhibited VIF values below 5 as indicated in Table 4, confirming the absence of collinearity issues. This result demonstrates acceptable quality and robustness in the examined correlations.

Table 4: VIF among exogenous constructs

	DRC	***CRC***	***ORC***	***ODF***	***LDF***	***TDF***	***BDF***	***IDF***	***KDF***	***EDF***
DRC		1	1.551	1.603	1.603	1.603	1.603	1.603	1.603	1.603
CRC	1		1.551	1.891	1.891	1.891	1.891	1.891	1.891	1.891
ORC	1.551	1.551		1.484	1.484	1.484	1.484	1.484	1.484	1.484

Step 2: Relevance of significant relationships assessment

After considering the path coefficients *(β)* and using *t-values* as well as *p-values*, from the twenty-one predetermined hypotheses, only six were supported: ORC → ODF, ORC → LDF, ORC → TDF, ORC → BDF, ORC → IDF, and ORC → KDF (Refer to Table 6). This indicates that operational issues outweigh design and construction causes in impacting the driving factors.

Step 3: Coefficient of Determination

This study uses a predictive accuracy, R^2 threshold of 0.10. As shown in Figure 1 (blue circle values in Figure 1 and refer to Table 5), the EDF records the lowest R^2 value of 0.01, indicating very weak explanatory power. In contrast, LDF shows the strongest prediction with R^2 of 0.13, followed by ODF (0.12) and BDF (0.11).

Step 4: Effect size f^2

The f^2 values for the ORC → KDF and ORC → EDF relationships are below 0.02, indicating negligible effect sizes (Refer to Table 6).

Step 5: Predictive relevance Q^2 and relative impact Q2

All Q^2 values are above zero as determined in Table 6, but from the last criterion, *Q2* values of only three hypotheses, namely ORC -> ODF, ORC -> LDF and ORC -> IDF, are ascertained with the relative impact of 0.02 (small impact) as in Table 6.

Table 5: The predictive accuracy (R^2) and predictive relevance (Q^2).

Code	Endogenous constructs	R^2	Q^2 (=1-SSE/SSO)
ODF	Organisational driving factors	**0.12**	0.07
LDF	Leadership driving factors	**0.13**	0.07
BDF	Behavioural driving factors	0.11	0.06
TDF	Technologies driving factors	0.10	0.05
IDF	Information driving factors	0.07	0.05
KDF	Knowledge driving factors	0.06	0.03
EDF	External driving factors	0.01	0.01

Table 6: Structural model path coefficients and hypothesis testing

Hypothesis	*β-value*	*T-values*	*P -values*	*95% CILL*	*95% CIUL*	*Support*	f^2	q^2
DRC -> ODF	0.16	1.84	0.07	0.02	0.30	Not supported	0.02	0.01
DRC -> LDF	0.13	1.61	0.11	0.01	0.25	Not supported	0.01	0.00
DRC -> TDF	0.11	1.29	0.20	-0.01	0.24	Not supported	0.01	0.00
DRC -> BDF	0.15	1.90	0.06	0.03	0.29	Not supported	0.02	0.01
DRC -> IDF	0.04	0.50	0.62	-0.08	0.17	Not supported	0.00	-0.01
DRC -> KDF	0.15	1.68	0.09	0.02	0.29	Not supported	0.01	0.01
DRC -> EDF	0.01	0.02	0.98	-0.15	0.16	Not supported	0.00	0.00
CRC -> ODF	0.06	0.68	0.50	-0.08	0.18	Not supported	0.00	0.00
CRC -> LDF	0.14	1.68	0.09	0.00	0.26	Not supported	0.01	0.00
CRC -> TDF	0.11	1.31	0.19	-0.03	0.24	Not supported	0.01	0.00
CRC -> BDF	0.10	1.14	0.25	-0.06	0.25	Not supported	0.01	0.00
CRC -> IDF	0.09	1.08	0.28	-0.05	0.24	Not supported	0.00	0.00
CRC -> KDF	0.04	0.38	0.71	-0.12	0.19	Not supported	0.00	0.00
CRC -> EDF	0.04	0.46	0.64	-0.12	0.19	Not supported	0.00	0.00
ORC -> ODF	**0.23**	**3.21**	**0.00**	**0.13**	**0.34**	**Supported**	**0.04**	**0.02**
ORC -> LDF	**0.21**	**3.02**	**0.00**	**0.10**	**0.32**	**Supported**	**0.03**	**0.02**
ORC -> TDF	**0.20**	**2.87**	**0.00**	**0.09**	**0.30**	**Supported**	**0.02**	**0.01**
ORC -> BDF	**0.21**	**2.72**	**0.01**	**0.08**	**0.33**	**Supported**	**0.03**	**0.02**
ORC -> IDF	**0.18**	**2.29**	**0.02**	**0.06**	**0.30**	**Supported**	**0.02**	**0.01**
ORC -> KDF	**0.14**	**1.99**	**0.05**	**0.04**	**0.25**	**Supported**	**0.01**	**0.01**
ORC -> EDF	0.11	1.27	0.21	-0.03	0.25	Not supported	0.01	0.01

DRC = Design related causes; CRC = Construction/commissioning related causes; ORC = Operational related causes; ODF = Organisational driving factors; LDF = Leadership driving factors; Technologies driving factors = TDF; BDF = Behavioural driving factors; Information driving factors = IDF; KDF = Knowledge driving factors; EDF = External driving factors
The five key criteria by Hair et al. (2014) as follows:

Step 1: The variance inflation factor (VIF) according to Hair, Hult, & Ringle (2017); Henseler et al. (2009), the value should be greater than 1 but lower than 5 indicate no presence of collinearity issue.
Step 2: The path coefficients (β) according to Hair et al. (2014); Kline (1998) can determine three levels of effect: 0.10-0.20 (small effect), 0.30-0.40 (medium effect) and more than 0.50 (large effect).
Step 3: The R^2 values of endogenous according to Cohen & Cohen (1983); Falk & Miller (1992); Roldán & Sánchez-Franco (2014) the construct predictive accuracy should be at least 0.10.
Step 4: The effect sizes f^2 according to Cohen (1980) are 0.35 (large), 0.15 (medium), 0.02 (small)
Step 5: The predictive relevance Q^2 according to Henseler (2009) are 0.35 (large), 0.15 (medium), 0.02 (small)

Structural model revealed that operational-related causes demonstrate the strongest and most consistent influence across the driving factors, especially organisational (ODF), leadership (LDF) and behavioural factors (BDF) after considering the last two steps f^2 & Q^2, confirming that BEPG issues predominantly arise during the operational phase.

CONCLUSION

Multiple factors contribute to the BEPG, encompassing both technological and non-technological (managerial) measures. This study identifies the primary causes of the BEPG and explores the relationship among factors that influence its mitigation. Operational-related causes recorded the highest RII values, marking them as the foremost contributors to the BEPG, followed by construction/commissioning and design-related causes. The analysis reveals a strong association between operational-related causes and three key driving factors—organisational (ODF), leadership (LDF), and behavioural (BDF)—all of which are human-centred issues that shape real energy outcomes more strongly than technical considerations alone. The structural model further validates these patterns, although overall R^2 values remain modest due to the complex socio-technical nature of BEPG. This study contributes to the BEPG discourse by providing empirical evidence from a developing country and highlighting the need for stronger operational governance, better commissioning, and improved facility management. The findings show that achieving intended energy

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performance requires organisational commitment, leadership support, behavioural engagement, and data-driven operations. Although the study's scope is limited, it points to future research on longitudinal post-occupancy evaluation, cross-country comparisons, and socio-technical interactions to further address energy performance gaps in green buildings.

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EVALUATING THE AGE-FRIENDLINESS OF PUBLIC SPACE IN CHINESE URBAN VILLAGES USING THE EFUSQ FRAMEWORK

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Abstract

This study presents a systematic evaluation of age-friendly public spaces in Chinese urban villages, focusing on an empirical investigation of Xin'er Village in Chengdu. Using the Elderly-Friendly Urban Space Questionnaire (EFUSQ), data were collected from a purposive random sample of 104 elderly residents. The results indicate that street spaces exhibit relatively higher age-friendliness (accessibility, $\beta = 0.054$, $p < 0.05$), whereas significant deficiencies persist in public activity areas and green spaces, largely due to inadequate planning and design. Key influencing factors such as barrier-free design ($\beta = 0.054$, $p < 0.05$), nighttime lighting ($\beta = 0.04$, $p < 0.05$), and spatial cleanliness ($\beta = 0.059$, $p < 0.05$) were identified, providing empirical evidence for targeted urban regeneration strategies. These findings underscore the urgent need for comprehensive improvements in the planning and upgrading of urban village environments to enhance safety, accessibility, comfort, and diversity, particularly for vulnerable elderly populations. The study's main contribution lies in establishing an evidence-based framework and validating the application of the EFUSQ within the unique context of Chinese urban villages, a typical informal urban setting. It offers both theoretical insights for environmental gerontology and concrete policy recommendations for improving elderly well-being through spatial interventions.

Keywords: Age-Friendly, Elderly, Evaluation, Public Space, Urban Village

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INTRODUCTION

China has the world's largest and fastest-growing aging population. Advances in medical technology and improved living standards have significantly increased life expectancy from 68 years in 1990 to 77.6 years in 2019 (Yang et al.,2023). However, this demographic shift has placed mounting pressure on the economy, healthcare system, and elderly care services. Establishing a sustainable support system for older adults is therefore essential not only to enhance their health and quality of life but also to ensure broader social stability. Within this context, addressing the physical decline, shifting social roles, and psychological adjustments associated with aging has become an urgent societal concern.

Existing studies highlight the importance of age-appropriate community environments in promoting the well-being of older adults (Sun, 2024). In response, China has introduced the concept of "adaptive space for the elderly", which emphasises optimising living environments, enhancing social participation, and delivering adaptive services to meet the diverse needs of the ageing population (Sun, 2024; Wang et al., 2023). Simultaneously, policy efforts have promoted a care model based on home, neighbourhood, and institutional support (Krings et al., 2022; Wang et al., 2023), marking a shift from traditional family-based care towards community-centred approaches.

Nevertheless, most research to date has focused on urban centres or well-planned communities, with limited attention paid to transitional spaces such as urban villages. These villages, shaped by China's rapid urbanisation, straddle urban and rural characteristics. Due to historical and institutional factors, they often suffer from inadequate infrastructure, limited public services, and weak social support systems (Krings et al., 2022; Tian et al., 2021). Elderly residents in these areas frequently face deteriorating housing, scarce healthcare resources, and a lack of age-friendly amenities. Despite these challenges, urban villages remain under-explored in ageing-related research, constraining our understanding and impeding the formulation of effective, targeted policies.

This study addresses this gap by assessing the age-friendliness of public spaces in urban villages. Using the Elderly-Friendly Urban Space Questionnaire (EFUSQ), it investigates the perceptions of older residents regarding their community environments and identifies key factors influencing their adaptability. The findings aim to offer empirical evidence to guide the age-friendly transformation of urban villages and inform broader urban renewal and ageing policy in China, contributing to more inclusive social and supportive urban development.

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LITERATURE REVIEW

Urban Village

The Chinese term for urban villages is *Cheng-Zhong-Cun*, meaning "village in the city." This term reflects the distinctive spatial and socio-economic features that characterise these areas (Wang, 2013). Unlike the lifestyle neighbourhoods typical of American suburbs, China's urban villages emerged as unintended consequences of rapid urban expansion (Wang, 2021). During the urbanisation process, agricultural land was frequently expropriated for development, while rural settlements were often preserved to reduce relocation costs and avoid prolonged compensation negotiations with local villagers (Xie et al., 2021). Urban villages represent a unique neighbourhood from within China's urbanisation process, marked by spatial characteristics that differ significantly from conventional urban neighbourhoods. Elderly residents in these areas also tend to have distinct socioeconomic and demographic profiles (Kochan, 2015). The formation and evolution of urban villages are closely tied to the complexities of urban development, including land scarcity, rural-to-urban migration, and planning constraints. Initially established as rural hamlets, these areas have been gradually integrated into the expanding urban fabric, giving rise to the modern urban village — a hybrid of urban and rural elements. This transformation reflects demographic shifts as well as socio-economic and spatial reconfigurations associated with rapid urbanisation. Urban villages are typically informal settlements characterised by substandard housing, inadequate infrastructure, and the absence of formal urban planning. They are often situated on the urban fringe or embedded within city boundaries (Peng et al., 2023; Al, 2019). This phenomenon has blurred the traditional urban-rural divide, creating a transitional spatial and social category that houses large populations of migrant workers.

The development of urban villages in China generally follows three stages: expansion, densification, and intensification, each driven by urban sprawl and the pursuit of employment opportunities (Hao, 2013). A key concern regarding these spaces is their limited age-friendliness, particularly poor spatial accessibility and environmental quality, which affect the elderly disproportionately.

Table 1: Comparison of rural villages, urban villages, and urban neighbourhoods

	Rural village	Urban village	Urban neighbourhood
Existing landowner	Collectively owned	Collectively owned	State owned
Industry	Agriculture	Rental	Secondary, tertiary
Economic organisation	Collective economy	Collective economy	Corporate
Society administration	Village committee	Village committee	Neighbourhood committee
Public costs	Collective economy	Collective economy	Government funds

Source:(Shen & Sun, 2023; Willits et al., 2019; Cottam, 2023).

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Furthermore, public facilities in urban villages are often poorly adapted to meet the needs of elderly individuals, with limited opportunities for social engagement and support for mental well-being. These challenges are compounded by intersecting pressures of urbanisation, population ageing, and insufficient provision of community space. Infrastructure deficits, environmental degradation, and underdeveloped social services exacerbate the vulnerabilities of elderly residents (Samsurijan et al., 2017; Wang, 2021). In response, the Chinese government has initiated a series of urban village transformation programmes. These efforts focus on upgrading dilapidated housing, improving infrastructure and sanitation, and reclaiming land for more effective spatial planning, all aimed at enhancing living conditions and promoting integrated urban development (Wang, 2021).

Elderly Friendly Environment

The conceptual foundation for age-friendly environments was established by the World Health Organization's (WHO) 2007 Age-Friendly Cities framework, which outlines core domains for supporting active ageing. This global initiative has spurred research worldwide, with studies in countries like Malaysia reinforcing the universal importance of factors such as safe walkability, accessible amenities, and social inclusion for older adults (Khalid et al., 2020; Rashid et al., 2021). This global body of work, however, predominantly focuses on formal urban settings. A recent bibliometric review by Zhao et al. (2023) corroborates this, highlighting a distinct knowledge gap regarding informal settlements like urban villages. This gap is particularly critical given the unique spatial, social, and policy challenges these areas present, and it is within this global yet under-explored niche that our study positions itself.

In China's urban villages, the translation of WHO principles and internationally recognized needs into practice faces substantial barriers. Inadequate physical infrastructure directly contradicts the emphasis on accessible outdoor spaces and buildings prevalent in the literature. Uneven walkways, limited green spaces, and insufficient seating inhibit mobility and social interaction among the elderly (Wang et al., 2023), while the lack of community support services exacerbates loneliness and mental health concerns (Sun, 2024), undermining the social participation domain central to the age-friendly canon. The frequent oversight of older adults' needs during urban village transformation (Zhao et al., 2023) further widens the gap between global policy intentions and local lived reality.

This misalignment creates an urgent need for context-specific assessment tools. Studying age-friendliness in urban villages is therefore critical not only for addressing immediate livability concerns but also for testing and adapting global age-friendly frameworks in underrepresented contexts. Such

research can inform renovations through scientifically grounded assessment of elderly needs and satisfaction (Li et al., 2022), ultimately contributing to more equitable urban development that leaves no older resident behind.

RESEARCH METHODOLOGY

Research Approach

This study adopts a quantitative research methodology with a cross-sectional design to investigate older adults' perceptions of the age-friendliness of public spaces in urban villages and the factors influencing these perceptions. Data were collected using structured questionnaires, and statistical analysis was employed to examine the relationships between key variables. A cross-sectional design is particularly suited for capturing the experiences and needs of older adults at a specific point in time, providing timely insights for policy and urban planning. The strength of the quantitative approach lies in its objectivity and capacity for systematic analysis, enabling the identification of patterns and challenges faced by the elderly, thereby enhancing the reliability and validity of the findings.

Data Collection

Data collection was conducted in three stages: instrument preparation, participant recruitment, and fieldwork. The primary measurement tool was the Elderly Friendly Urban Spaces Questionnaire (EFUSQ) (Lak et al., 2019), which has been validated in international studies on age-friendly cities. The EFUSQ assesses seven key dimensions: safety, convenience, comfort, accessibility, aesthetics, sense of belonging, and social interaction.

To tailor the EFUSQ to the cognitive and cultural context of older adults in urban villages, several modifications were made: language was simplified, using colloquial expressions and avoiding technical jargon; locally contextual examples were added, such as replacing abstract questions on accessibility with items like, "Is it convenient to take a break in a small square in the village?"; a 5-point Likert scale (1 = very inconvenient to 5 = very convenient) was adopted to improve ease of response and reduce cognitive burden.

During participant recruitment, a purposive random sampling strategy was employed. Eligibility criteria included individuals aged 60 years or above who had lived in the urban village for an extended period, regularly used public spaces, and possessed basic communication skills. From this screened pool, a random sample was drawn. This approach ensures the sample reflects typical usage patterns and needs among elderly urban village residents, avoiding biases that purely random sampling might introduce, such as overrepresenting healthy and active individuals. While this limits the generalizability of the findings, the study's objective is exploratory, prioritizing depth over breadth. The final sample size was N=104, sufficient to support basic statistical analyses.

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Fieldwork was conducted in four rounds (6th, 10th, 15th, and 23rd March 2024) using a face-to-face interview format. Researchers assisted participants in completing the questionnaire. For respondents with visual or literacy challenges, questions were read aloud and clarified as needed to ensure responses accurately reflected personal experiences. Each interview took approximately 15-20 minutes, and all responses were anonymised.

Data analysis

This study adopts a systematic and structured approach to analysing the questionnaire data. The analysis begins with an examination of the respondents' demographic characteristics, including age, marital status, education level, and length of residence in the urban village. This provides essential context for a better understanding of the sample composition. Next, the reliability of the survey instrument is assessed using Cronbach's alpha coefficient, while validity is evaluated through the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's sphericity test. These tests determine the suitability of the data for further statistical analysis and ensure the robustness of the instrument used. Upon establishing the reliability and validity of the instrument, multiple linear regression analysis is conducted to identify the factors influencing the age-friendliness of public spaces for older adults. To assess the integrity of the regression model, multicollinearity diagnostics, including variance inflation factor (VIF) tests, are performed. These steps ensure the internal consistency, rigour, and reliability of the findings.

Study Area

This study focuses on Xin'er Village, situated in the Jinniu District of Chengdu, China. With a population of approximately 10,430, about 22.76% of whom are elderly, Xin'er Village represents a typical urban village currently in the early stages of redevelopment. Like many rapidly urbanizing Chinese cities, Chengdu faces significant challenges in upgrading such informal settlements. The area is characterized by narrow, congested streets, poorly maintained sidewalks, various safety hazards, and unsanitary alleyways, all of which collectively diminish residents' quality of life. Public spaces are limited and often fail to meet the demands of daily activities, a shortcoming that disproportionately affects older residents. Despite these physical constraints, many elderly individuals maintain active engagement in community life, underscoring the critical need for age-sensitive urban design. This research evaluates the age-friendliness of three principal public space typologies within Xin'er Village: streets, alleys, and communal gathering spaces. These typologies reflect the common spatial configuration found in Chinese urban villages and provide a foundational basis for assessing the suitability of public spaces for an ageing population.

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Figure1： Satellite Image of Xiner Village
Source: Baidu map (2025)

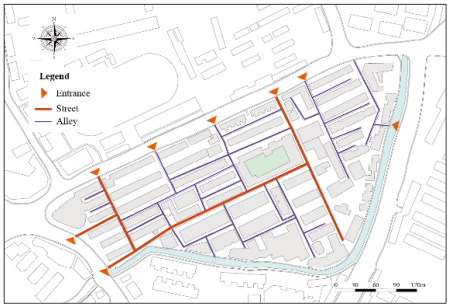


Figure 2: Distribution of streets and alleys
Source: Author's own work (2024)

ANALYSIS AND FINDINGS

Socio-Demographic Profile of the Respondents

This study surveyed 104 elderly residents of Xiner Village in Chengdu. Detailed respondent characteristics are presented in Table 2. The average age of participants was 72.1 years, with 60.6% reporting being married. Educational attainment was generally low, with only 4.8% having completed high school or higher education. Most respondents (94.2%) were retirees, highlighting a key demographic trait of the sample. In terms of financial capacity, only 7.7% reported a monthly expenditure below $500. Regarding residential location, 36.5% of the participants lived within Xiner Village itself, while a further 20.2% resided in nearby areas, indicating a strong connection to the locality.

Table 2: Respondents Profile

Total Respondent:	**104**	
	Frequency	Percentage (%)
Age		
65-74	70	67.30%
75-84	30	28.80%
85 or above	4	3.80%
Marital status		
Single	3	2.90%
Widow	38	36.50%
Married	63	60.60%
Education		
Lower than primary school	16	15.4%
Primary school-high school	83	79.8%
Higher than high school	5	4.8%
Monthly expenses（CNY）		
Lower than 500	8	7.7%
500-1000	73	70.2%
Above 1000	23	22.1%
Occupation		

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Total Respondent:	**104**	
Employed	1	1%
Housewife	5	4.80%
Retired	98	94.20%
Length of residence		
In one year	6	5.8%
1-5 years	17	16.3%
Above 5 years	81	77.9%
Place of residence		
Inside Urban Village	38	36.5%
Close to Urban village	21	20.2%
Outside Urban Village	45	43.3%
Reason for residence		
Low prices and convenient living	55	52.9%
With parents	19	18.3%
With children	30	28.8%

Source: author's work

Affordability and convenience were the primary reasons cited for residing in the area, accounting for 59.2% of responses. A small proportion of participants (5.8%) had lived in the area for less than one year, indicating a relatively stable residential population. Notably, six individuals were excluded from the analysis due to difficulties in comprehending the survey questions, which may have introduced minor limitations to the data's accuracy. The findings suggest that perceptions of age-friendliness among older residents were influenced by a range of socio-demographic factors, including age, educational background, occupation, marital status, place of residence, and monthly expenditure.

Reliability and Validity Test

The reliability of the survey data was assessed using Cronbach's alpha coefficient, which measures internal consistency. All alpha values for the respective dimensions exceeded 0.5, indicating an acceptable level of reliability. Furthermore, the α coefficient remained above 0.6 even when the individual items were removed, confirming the robustness of the evaluation index system and its suitability for further analyses.

To assess the suitability of the data for factor analysis, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity were employed. The KMO value was 0.737, surpassing the minimum threshold of 0.7, while Bartlett's test yielded a statistically significant result ($\chi^2 = 2228.883$, df = 820, $p < 0.001$). These outcomes indicate strong inter-item correlations and affirm the structural validity of the questionnaire, thereby supporting its use in subsequent statistical procedures.

Table 3: KMO and Bartlett-based validity test.

Kaiser-Meyer-Olkin metrics		0.737
Bartlett spherical test	approximate chi-square	2228.883
	df	820
	Sig.	0.000

Source: Author's work

Factors Influencing User Perception

The study identified significant differences in elderly residents' evaluation of the adaptability of urban village environments, which were shaped by various socio-demographic factors, including age, occupational background, marital status, length of residency, educational attainment, and monthly expenditure. These differences were particularly evident across several dimensions of public use. Notably, perceptions of the suitability of different types of public space exhibited a clear hierarchy. Street spaces received the highest ratings, attributed to their well-developed commercial amenities such as farmers' markets and retail shops, and the presence of organically formed social interaction venues. The spatial ambience dimension was ranked second, benefiting from the stable social networks formed by long-term residency (77.9% of respondents had lived in the area for more than five years). In contrast, formal public activity spaces and green areas received the lowest evaluations, reflecting deficiencies in landscape design and dedicated recreational infrastructure within urban villages. A summary of key influencing factors and their corresponding survey findings is presented in Table 4 below:

Table 4: Analysis of results in different factors

Factor	Key Findings	Data
Age	Seniors aged 85 and above prioritised infrastructure utility and accessibility, while younger seniors (65-74) focused more on environmental comfort and recreational attributes. This reflects a shift from leisure to protection with increasing age.	Street space rating of 40.500 (85+); Green space score of 24.586 (65–74); 75-84 age group displayed transitional preferences.
Marital status	Single seniors exhibited high spatial autonomy and environmental sensitivity. The married group demonstrated the most stable assessments, while the widowed showed the greatest variability.	Street space score for single group was 41.000; Married group rating range 35-37; Standard deviation (widowed) of 4.2
Education	A positive correlation was observed between educational level and spatial evaluation. Highly educated individuals were more critical, whereas those with lower educational levels showed greater inclusivity.	Average score: Primary school group 37.688; High school group 29.600; University group presented the highest expectations.

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Factor	Key Findings	Data
Monthly expenses (CNY)	Income level influenced expectations: low-income respondents prioritised basic functionality; higher-income groups desired multifunctional spaces; middle-income groups offered the most representative evaluations.	<$500 group street rating is 40.000; >$1000 group green space score 24.217; 70% of sample earned $500-$1000 monthly.
Occupation	Retirees gave consistently positive and stable evaluations; working seniors faced time constraints; housewives prioritised spaces for children's activities. Occupational differences influenced patterns of space usage.	Retiree average rating was 36.367; Working group scores were 15-20% lower; Child-related concerns prominent among housewives.
Length of residence	A typical 'adaptation curve' was observed: residents of 1–5-year provided the most favourable evaluations; long-term residents identified more deficiencies; newcomers experienced a 'honeymoon effect'.	Peak ratings among 1–5-year residents; 5-8% decline among the 5+ year group; Notable variability among those with <1 year residency.
Place of residence	Residents in core village areas rated their environment more favourably due to more frequent space use. Peripheral residents were more reliant on public amenities, reflecting spatial and functional disparities.	Climate rating of 29.156 (core village); Peripheral group scored 10-12% lower; transitional area residents had intermediate ratings.
Reason for residence	Family structure significantly shaped perceptions. Those living in multi-generational households gave the highest ratings. Elderly individuals living alone or as empty nesters displayed heightened reliance on public space.	Co-resident group average of 39.033; Living alone group scored 8-10% lower; Empty nesters reported pronounced social needs.
Activity characteristic	Daily activity types influenced spatial priorities. Socially active seniors emphasised ambience, while function-oriented seniors prioritised convenience. Activity radius also impacted spatial evaluations.	+12% for social atmosphere; +15% for functional convenience; Mixed activity types yielded the most balanced ratings.

Source: Author's work

Regression model analysis

This study investigates the factors influencing elderly residents' perceptions of the age-friendliness of public spaces in urban villages. A multiple linear regression model was developed to analyze the survey data. In this model, the various dimensions of public space friendliness served as dependent variables (Y), while individual survey items were used as independent variables (X). Prior to regression analysis, multicollinearity diagnostics were conducted using the Variance Inflation Factor (VIF) and tolerance statistics. The results indicated that all tolerance values were well above the common threshold of 0.1 (ranging from 0.743 to 4.351), and all VIF values were substantially below the conservative cutoff of 5 (ranging from 0.230 to 1.346). These results confirm the absence of

multicollinearity among the predictor variables, thereby ensuring the reliability and interpretability of the regression outcomes. The regression models for all four dimensions demonstrated statistical significance ($p < 0.001$) and exhibited acceptable explanatory power, with R^2 values ranging from 0.637 to 0.724, indicating that the independent variables explain 63.7% to 72.4% of the variance in the age-friendliness evaluations.

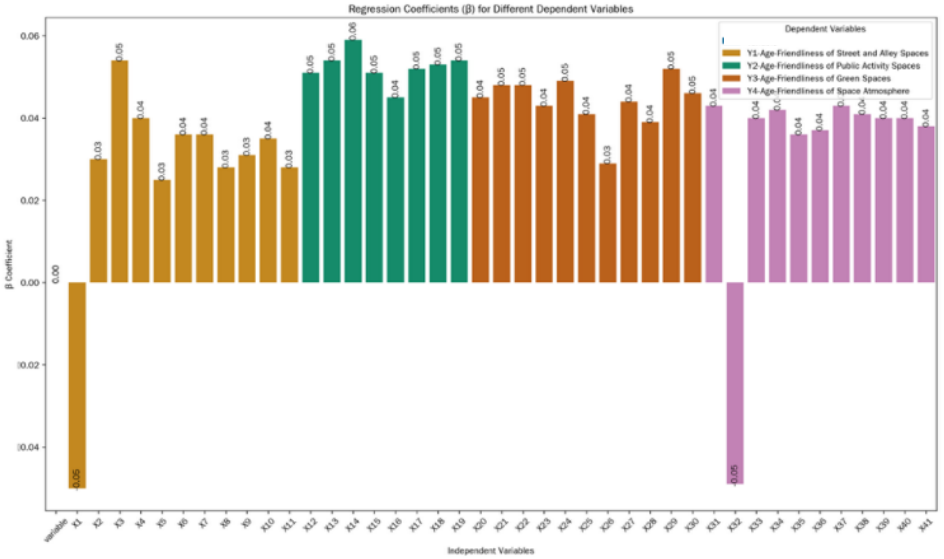


Figure 3: Results of multiple covariance tests for the independent variables and regression analyses

Street and Alleyway Space (Y1)

Regression analysis indicates that the age-friendliness of street and alleyway spaces is most significantly influenced by barrier-free design (X3, β = 0.054) and nighttime lighting (X4, β = 0.04). The model for street and alley spaces (Y1) yielded an R^2 of 0.692, explaining 69.2% of the variance. Key improvements to enhance accessibility include minimising differences in floor levels, increasing the availability of rest areas, and improving lighting conditions after dark. Additionally, pavement smoothness (X1, β = -0.05) and the presence of guide signs (X6, β = 0.036) were found to significantly affect older adults' experience in these spaces. These findings underscore the need for urban village street renewal initiatives to prioritise fundamental safety measures while enhancing pedestrian comfort.

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Public activity space suitability for the elderly (Y2)

For public activity spaces, the most influential factors are cleanliness (X14, β = 0.059) and privacy-oriented design (X19, β = 0.054). The regression model for public activity spaces (Y2) achieved an R^2 of 0.724, indicating strong explanatory power. Elderly participants showed a preference for clearly demarcated, well-maintained areas and expressed support for gender-segregated facilities. The results also highlight the importance of seating comfort (X17, β = 0.052) and adequate shading (X21). These insights suggest that facility managers should focus not merely on the quantity of amenities but also on maintenance quality and user-centred design to better address the specific needs of older users.

Green space suitability for the elderly (Y3)

The perceived suitability of green spaces is largely determined by functional diversity (X29, β = 0.052) and spatial zoning (X32, β = -0.049). The model for green spaces (Y3) produced an R^2 of 0.637, accounting for 63.7% of the variance. Elderly respondents expected green spaces to offer both opportunities for social interaction and leisurely enjoyment. However, noise disturbance from children's play areas significantly diminished satisfaction levels. Effective zoning — separating quiet zones from active zones and managing usage by age group— emerged as a key recommendation. Furthermore, the selection of vegetation types (X24, β = 0.049) and the design of walking paths (X30, β = 0.046, $p < 0.01$) were also important considerations for fostering a more enjoyable and accessible outdoor environment.

Spatial Atmosphere Age-Friendliness (Y4)

The age-friendliness of the spatial atmosphere is primarily shaped by architectural aesthetics (X37, β = 0.043) and air quality (X38, β = 0.041). The regression model for spatial atmosphere (Y4) resulted in an R^2 of 0.658, explaining 65.8% of the variance. Participants favoured building facades that reflected local cultural elements and well-ventilated environments. Conversely, high-rise buildings were associated with a sense of oppression (X36) and negatively influenced perceptions. Incorporating community memory (e.g., traditional motifs) and establishing social interaction nodes were also found to enhance residents' sense of belonging. Renovation efforts should aim to balance new developments with the preservation of existing landscapes and soften rigid environments through the integration of public art and cultural expression.

DISCUSSION

The findings of this study on the elderly-adaptability of public spaces in urban villages offer valuable policy implications. Older residents of Xiner Village rated the street space most favourably, attributing their positive evaluations to the

multifunctional nature of these spaces, which organically integrate commercial, social, and leisure functions. This spontaneously formed, mixed-use spatial pattern effectively operates as a neighbourhood life hub and serves as a meaningful reference for the age-friendly transformation of similar urban villages environments. In contrast, public activity spaces and green spaces received lower evaluations in terms of elderly-adaptability, pointing to deficiencies in their design and planning. Based on the regression analysis, the study proposes the following interventions: first, prioritise improvements to accessibility infrastructure and night-time lighting in street environments; second, enhance the functional configuration of existing public activity areas through targeted 'micro-renewal'; and third, establish a collaborative public space maintenance mechanism involving government agencies, community organisations, and residents. These findings present a useful comparative perspective alongside the study by Tao et al., (2021) on five age-friendly neighbourhoods in Singapore. In terms of spatial accessibility, both Singapore's formalised 'barrier-free walking network' and the informally developed pedestrian system in urban villages effectively promote daily mobility among older adults. This affirms the importance of a continuous, safe, and accessible walking environment as a fundamental component of age-friendly urban design. Moreover, regarding the social support dimension, both contexts demonstrated how spatial design facilitates social connections. In Singapore, intergenerational communication spaces are intentionally incorporated into the neighbourhood plan, whereas in urban villages, similar outcomes emerge through organically formed commercial and social nodes. These findings collectively underscore the pivotal role of the social function of public space in promoting the well-being of older people.

Nevertheless, the study also highlights culturally rooted differences in implementation. Singapore's approach to creating age-friendly environments is largely government-led and characterised by standardised retrofitting of infrastructure. In contrast, urban villages tend to evolve through resident-led, adaptive spatial practices. This divergence suggests that while elderly-adaptability should adhere to universal principles such as safety, accessibility, and social connectivity, it must also respond sensitively to local spatial characteristics and socio-cultural contexts.

CONCLUSION

This study provides a systematic evaluation of age-friendly public spaces in the informal setting of Chinese urban villages, revealing that street spaces exhibit higher age-friendliness while significant deficiencies exist in public activity and green areas. Key influencing factors such as barrier-free design, nighttime lighting, and spatial cleanliness were empirically identified. The primary theoretical contribution of this research lies in the successful adaptation and

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validation of the EFUSQ framework within an informal urban context, thereby extending its applicability beyond formally planned environments and offering a replicable methodological tool for studying age-friendliness in similar informal settlements globally.

To enhance age-friendliness, urban village upgrades must integrate physical improvements with tailored social support, addressing the diverse needs of elderly residents. Although limited by its cross-sectional design and single-case focus, this study establishes a crucial evidence-based foundation for future urban renewal policies and provides a validated framework for creating inclusive, supportive environments for ageing populations in rapidly urbanizing contexts.

ACKNOWLEDGEMENT

The study was conducted in strict adherence to academic ethical standards. Research permission was duly obtained, and all participants provided informed consent prior to data collection. To ensure confidentiality, all data were anonymised and securely stored on a password-protected server, accessible only to authorised members of the research team. The study received no external funding and was free from any conflicts of interest. All data were used solely for academic purposes.

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ANALYZING THE ELDERLY POPULATION IN MALAYSIA FROM THE PERSPECTIVES OF QUALITY OF LIFE, ASSISTIVE TECHNOLOGY, AND AN AGE-FRIENDLY ENVIRONMENT

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Abstract

This paper contributes to the concept of aging in place among older adults in Malaysia by exploring the interconnected roles of assistive technology, quality of life, and age-friendly environments in facilitating this lifestyle. The methodology employed in this study includes quantitative methods and snowball sampling technique. Drawing on survey data collected from 499 participants aged 60 to 75, this research examines the impact of assistive technology on various aspects of older adults' lives, including physical health, psychological well-being, and social engagement. The findings reveal substantial improvements in overall quality of life. Furthermore, age-friendly environments play a crucial role in enhancing autonomy by eliminating environmental obstacles. However, the effectiveness of assistive technology is hindered by several challenges, such as financial constraints and limited technological proficiency among some seniors. This paper underscores the importance of adopting a comprehensive approach that integrates both technological and human support. By providing valuable insights for policymakers, this research offers practical recommendations for developing interventions that uphold the autonomy and dignity of older adults in Malaysia.

***Keywords**:* Assistive Technology, Quality of Life, Age-friendly Environment, Aging in Place, Elderly Studies

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INTRODUCTION

Malaysia is undergoing a notable demographic transformation, with its aging population anticipated to increase swiftly. The Department of Statistics Malaysia (2023) projects that those aged 65 and above will represent 15.3% of the national population by 2030, signifying the nation's transition into an aging society. This trend mirrors extensive global patterns of population aging, primarily influenced by heightened life expectancy, enhanced healthcare, and decreasing birth rates. As Malaysia nears this demographic milestone, there is an imperative requirement for comprehensive initiatives to assist older adults in preserving independence, well-being, and social integration.

A primary policy response to population aging is the advocacy for "aging in place," which underscores the capacity of older adults to reside in their homes and communities securely, autonomously, and comfortably. To attain this objective, three interconnected elements are essential: quality of life, assistive technology, and an age-friendly environment. Collectively, these dimensions influence how older adults manage daily activities, obtain assistance, and engage in societal participation. Notwithstanding the growing acknowledgment of these elements, research in the Malaysian context is still constrained, especially on the impact of socio-demographic features on the utilization of assistive devices and perceptions of age-friendly surroundings. Bridging this gap is essential for guiding policies and initiatives that are culturally and contextually relevant.

This study seeks to investigate the correlation between quality of life, assistive technology, and age-friendly environments within the demography of older adults in Malaysia. It aims to (1) furnish a comprehensive profile of the respondents' sociodemographic attributes, and (2) analyze the strength of the correlations among the researched variables. The results are anticipated to aid in the formulation of cohesive strategies that promote independent living and improve the quality of life for older adults in Malaysia.

LITERATURE REVIEW

Asia is undergoing a significant demographic change, with increasing life expectancy and lower fertility rates contributing to rapid rise in the elder population (Leung & Chen, 2019; Wong et al., 2018). This transformation necessitates a reconsideration of healthcare, urban development, and social welfare systems to accommodate an older population. Japan, sometimes referred to as a "super-aged" society, exemplifies the importance of adopting sustainable policies as the proportion of people aged 80 and up rises (Elokla & Hirai, 2015). In Malaysia, comparable demographic shifts are evident, with forecasts predicting that 24% of the population would be 65 or older by 2050, qualifying the country as an "aged society" (Ng et al., 2020b). The 1995 National Policy for the Elderly sought to improve the well-being and dignity of Malaysia's elderly

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(Ambigga et al., 2011). While demographic development represents higher living conditions, it also requires integrated methods that incorporate social, health, and technology initiatives to maintain older individuals' autonomy and quality of life (Chew et al., 2021).

Malaysia's aging trend has resulted in complicated socioeconomic and health consequences that affect national productivity, family dynamics, and healthcare systems. While the growing older population may boost demand for age-related services, it also creates financial and policy issues that necessitate investment in healthcare and social protection (Taasim, 2020; Tey et al., 2015). Health status, income stability, and family support all influence the quality of life for older Malaysians across ethnic and socioeconomic categories (Lai & Tey, 2021). Urbanization and shifting cultural norms have damaged traditional caregiver systems, increasing dependency on official care services (Makhtar et al., 2023). Furthermore, chronic health issues such as cardiovascular disease and diabetes remain common, exacerbated by lifestyle choices and polypharmacy (Lim et al., 2017). Although these research focus on the social and biological difficulties of aging, few have investigated how environmental and technological treatments can work together to increase older individuals' well-being and independence.

In response to these demographic and health issues, experts emphasize the need of age-friendly environments that promote active aging and social participation (Lai et al., 2016; Shi Ying et al., 2021). Research in Malaysian cities such as Taiping and Ipoh has identified important aspects of age-friendly settings: safe public spaces, accessible transportation, and accessibility to healthcare, as critical to improving older individuals' inclusion and mobility (Rashid et al., 2021; Rashid et al., 2022). However, many existing housing and urban infrastructures do not follow universal design principles that address the physical and psychological demands of older persons (Ismail et al., 2021). The growing concept of retirement villages in Malaysia represents a hopeful future, combining community living with healthcare and recreational services (Lim et al., 2019; Ng et al., 2020a). However, generations have different preferences for location, design, and social activities (Ismail et al., 2023). Despite this development, insufficient study has integrated the physical environment with digital and assistive technology, leaving a vacuum in understanding how spatial and technical elements work together to support aging in place.

The importance of assistive technology in Malaysia's aging policy has received increased attention due to their potential to improve independence, safety, and well-being. Initiatives like smart towns and home-based monitoring systems demonstrate the government's commitment to incorporating digital innovation into aged care (Huang et al., 2024). Medical warning devices, fall detectors, and medication management systems are examples of products

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developed to help people live safely and autonomously. Assistive aids have also been used in educational settings to promote inclusion for people with special needs (Istiyati et al., 2023), and safety features such as smoke and heat monitors safeguard older adults who live independently (Azmi et al., 2021). Despite these advances, Malaysian older individuals' adoption of assistive technologies remains limited, owing to compatibility concerns, smartphone fear, and enabling conditions (Mshali et al., 2018).

Addressing these psychological and social aspects is critical for promoting universal acceptance. As a result, this study creates an integrated framework that connects assistive technology, age-friendly environments, and aging in place, adding to a more comprehensive understanding of how environmental design and digital readiness can work together to improve the quality of life for older Malaysians.

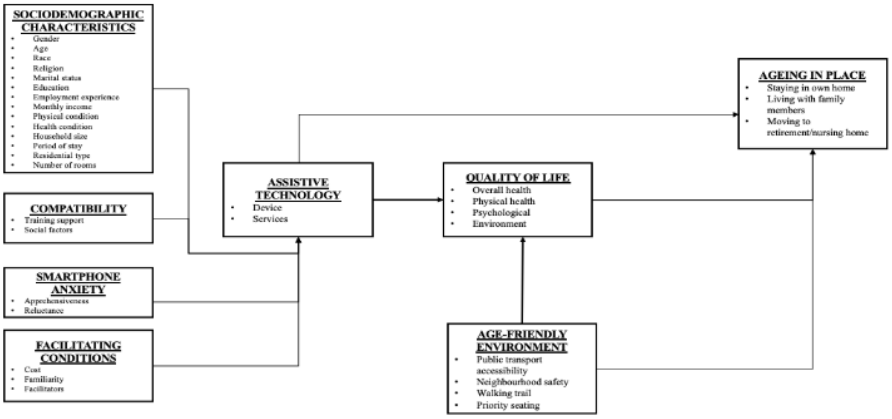


Figure 1: Conceptual framework for Aging in Place

RESEARCH METHODOLOGY

This study utilized a quantitative cross-sectional design, employing structured questionnaires to gather measurable data from older adults. The methodology allowed the researcher to collect data at a singular moment, which is appropriate for examining contemporary actions, perspectives, and circumstances. The questionnaire utilized numerical scales, including the Likert Scale, to evaluate subjective factors such as perceptions and attitudes, while multiple-choice questions were employed to gather demographic and factual data. The study employed a standardized questionnaire to ensure consistency in data collection, facilitating statistical analysis of the correlations among variables pertinent to

assistive technology utilization, quality of life, age-friendly environments, and aging in place among older adults in Malaysia.

The questionnaire comprised five principal sections, each aligned with a distinct study purpose. The items were modified from previously validated instruments outlined in pilot test, guaranteeing both relevance and reliability. Moreover, content authenticity was preserved via meticulous item selection, translation into the local language, and contextual modifications to align with the Malaysian environment. Section 1 concentrated on sociodemographic data, consisting of 15 items derived from sources like Dikken et al. (2020); Elokla and Hirai (2015); Liao et al. (2018); Ma et al. (2015); Musa and Sim (2010). This part gathered information on gender, age, race, religion, marital status, educational attainment, employment status, work experience, income, physical and health problems, residential location, household size, and duration of residence. Section 2 examined the utilization of assistive technology via 20 items derived from the CTAILS Survey by Petrovčič et al. (2019) and the QUEST 2.0 instrument. This section measured constructs such as compatibility, smartphone anxiety, enabling situations, and device usage frequency.

Section 3 examined quality of life with 26 measures derived from the WHOQOL-BREF framework (World Health Organization, 1999), supported by research conducted by Hasanah et al. (2003); Iqbal et al. (2020); Khan and Tahir (2014). The four assessed domains encompassed physical health, psychological well-being, social interactions, and environmental factors. Section 4 evaluated perceptions of the age-friendly environment using six questions derived from the Gibney et al. (2020); Hau (2017); Shiau and Huang (2014); the World Health Organization (2010); World Health Organization (2007). This part highlighted the accessibility of public transit, neighborhood safety, walkability, and the provision of priority seats for senior citizens. Ultimately, Section 5 assessed attitudes regarding aging in situ with three measures modified from Robinson-Lane et al. (2022). This discussion centered on issues of self-empowerment and autonomy about the preservation of one's residence and community during the aging process.

The researcher utilized a non-probability snowball sampling technique, which was particularly suitable due to the sensitivity of the topic and the challenges in reaching older adults. Snowball sampling is advocated for research involving hard-to-reach or marginalized populations, as it facilitates participant recruitment via referrals from current subjects (Cohen & Arieli, 2011; Gierczyk et al., 2024). This approach fosters engagement by establishing trust, particularly when respondents are suggested by others within their own social networks (Noy, 2008). The researcher employed snowball sampling for numerous justifications. Initially, it facilitated access to older adults who may be socially isolated or inadequately represented in conventional sample techniques (O'Quin et al., 2015;

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Sadler et al., 2010). Secondly, the peer-referral method fostered a sense of trust and comfort among participants, which is crucial when addressing sensitive topics such as personal health and technology utilization. Ultimately, the method proved to be economical and feasible for data collection over an extensive geographical region, especially considering the scarcity of centralized databases for the older adults (Kubiciel - Lodzińska, 2021).

Participants were chosen according to two criteria. The primary criterion was age, stipulating that eligible participants must be 60 years or older, as delineated by the World Health Organization and other research (Deorari et al., 2017; Tiraphat et al., 2021; Tiraphat et al., 2017). The second condition required individuals to have utilized a smartphone at least once in the preceding year (Takahashi et al., 2011). Initial participants were discovered via the researcher's personal network, comprising relatives and friends, who were subsequently requested to suggest other older adults meeting the inclusion criteria. The recruitment process persisted until the requisite sample size was attained.

The data gathering occurred during a five-month duration, spanning from January to May 2023. The researcher employed self-administered, paper-based questionnaires that were physically disseminated among individuals. Before participating, each respondent received a permission form detailing the study's purpose and their rights as participants. Participants were allotted one day to complete the questionnaire at their own pace and leisure. To guarantee precision and integrity, the researcher carefully collected all completed questionnaires. This individualized collection method mitigated the danger of data loss or incompleteness and ensured the confidentiality of responses. A total of 499 valid responses were obtained, surpassing the minimum sample size required for this investigation. The substantial sample size enhanced the reliability and generalizability of the results.

The research was executed in compliance with ethical guidelines pertinent to studies involving human participants. Participation was wholly voluntary, and informed consent was secured from all participants prior to the commencement of the survey. All participants were explicitly apprised of the study's objectives, their right to refuse participation, and their liberty to withdraw at any moment without repercussions. No personally identifiable information was collected to ensure confidentiality. All replies were anonymized, and data were managed with rigorous confidentiality to safeguard privacy. The paper-based questionnaires were securely maintained and viewed solely by the researcher. Ethical protections were particularly essential due to the potentially sensitive nature of inquiries concerning aging, health state, and personal technology utilization.

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Consistent with current literature, snowball sampling within older demographics necessitates ethical diligence and a respectful methodology for participant involvement (Noy, 2008; Sadler et al., 2010). By following the ethical principles established in research by Gierczyk et al. (2024) and Cohen and Arieli (2011), the researcher guaranteed that participants were treated with dignity and respect during the data gathering process. The study adhered to institutional and academic standards for ethical research and responsibly advanced scholarly knowledge on aging in Malaysia.

ANALYSIS AND DISCUSSION

After a comprehensive analysis, the table below presents a detailed breakdown of critical sociodemographic variables for the 499 respondents. These factors encompass essential demographics such as gender distribution, age range, racial and ethnic composition, religious affiliation, educational background, employment status, and other pertinent characteristics. Each attribute is meticulously detailed to reflect the diversity and representativeness of the sample, offering insights into how these sociodemographic parameters may influence or correlate with the study outcomes.

The study included 499 elderly respondents, the majority of whom were male and aged 60-64 years (51.9%). The majority were Malay (84.0%), Muslim (84.8%), and married (83.6%), indicating a nationwide trend of elderly persons in Malaysia with robust family support systems. More than half (55.7%) had secondary education, and 13.6% had higher education levels, indicating moderate digital literacy that may influence technology adoption. Respondents were virtually evenly split between public (48.9%) and private (47.7%) job histories, with 70.5% falling under the B40 income bracket, showing a low financial capacity to acquire assistive devices without subsidies. The majority of participants (74.3%) lived in multigenerational homes with more than three members, 43.5% in kampung houses, and 74.3% had stayed in the same home for more than a decade, indicating high place attachment. However, 11.4% claimed physical limitations and 47.5% had chronic illnesses, highlighting the need for accessible infrastructure and healthcare services.

Overall, the findings emphasize major socioeconomic and environmental factors that influence the adoption of assistive technology among Malaysia's elderly. Financial constraints, cultural lifestyles, and health concerns need solutions that are cost-effective, adaptive, and culturally sensitive. The results give critical insights for developing gender- and age-responsive strategies to improve aging in place and quality of life through assistive technologies and age-friendly settings.

A complete correlation study was performed to investigate the relationships between assistive technology, quality of life, an age-friendly

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environment, and aging in place. Pearson correlation analysis, a statistical method well-known for its ability to measure the strength and direction of linear correlations between variables, was used. This method is particularly well-suited for continuous data and provides a reliable metric for determining if there are positive, negative, or no correlations between the variables of interest. By employing this method, the researchers hoped to uncover the extent to which these critical aspects impact one another, resulting in a more sophisticated understanding.

Table 1: Correlation analysis of the variables

	Assistive technology	**Quality of life**	**Age-friendly environment**	**Aging in place**
Assistive technology		0.562**	0.266**	0.202**
Quality of life	0.562**		0.306**	0.427**
Age-friendly environment	0.266*	0.306**		0.288**
Aging in place	0.202**	0.427**	0.288**	

***0. Correlation is significant at the 0.01 level (2-tailed).*

The findings reveal a strong positive correlation between assistive technology (AT) and quality of life (QoL) (r = 0.562), indicating that increased use of devices like mobility aids, home safety tools, and health-related smartphone apps is associated with better perceived well-being among older adults. This supports earlier studies by Chen & Chan (2014) and Liu et al. (2020), which found that AT enhances independence, reduces reliance on caregivers, and promotes social engagement. A moderate correlation was also observed between AT and age-friendly environment (AFE) (r = 0.266), suggesting that older adults living in supportive physical and social settings—such as barrier-free homes, accessible transport, and community services—are more likely to adopt assistive technologies. This aligns with the World Health Organization's (2007) age-friendly framework. However, the correlation between AT and aging in place (AIP) is relatively weak (r = 0.202), implying that while AT contributes to independent living, other elements such as emotional ties to home, caregiver support, and community involvement are also critical, as highlighted by Lawton & Nahemow's (1973) Person–Environment Fit theory and Sixsmith & Sixsmith (2008).

In contrast, a moderately strong correlation between QoL and AIP (r = 0.427) underscores that older adults with greater autonomy, life satisfaction, and good health are more likely to remain in their homes as they age—echoing findings from van Hoof et al. (2011) and Oswald et al. (2007). This highlights QoL not just as an outcome of aging in place, but also as a necessary precondition.

Furthermore, a moderate association between QoL and AFE (r = 0.306) suggests that a well-designed, safe, and socially engaging environment significantly boosts the well-being of older adults, consistent with Menec et al. (2011). Finally, the positive relationship between AFE and AIP (r = 0.288) confirms that accessible, age-friendly physical spaces play a vital role in supporting aging in place, as supported by Buffel et al. (2012), who emphasized the importance of aligning the built environment with the evolving needs of older adults. The correlation results underscore the interrelationship of technology, environment, and personal well-being in promoting aging in place. The most robust association was observed between AT and QoL, highlighting that AT can substantially improve health outcomes, safety, and autonomy. Nonetheless, its comparatively modest direct link with AIP indicates that technology alone is inadequate to assist older adults in remaining in their residences.

The path analysis yielded a p-value of 0.000 for the path between Assistive Technology and Quality of Life, indicating a highly statistically significant relationship between the two constructs. A p-value of this magnitude suggests that the probability of the observed relationship occurring by chance is virtually zero. Given that the p-value is well below the significance threshold of 0.05, the null hypothesis, which assumes no relationship between Assistive Technology and Quality of Life, can be confidently rejected. These findings provide robust statistical evidence that Assistive Technology significantly impacts Quality of Life. This result underscores the importance of Assistive Technology as a strong predictor of Quality of Life within the proposed research model. The data provide compelling evidence for the positive influence of assistive technologies in enhancing individuals' quality of life, particularly in contexts related to aging or disabilities. Assistive technologies can mitigate challenges faced by individuals, thereby improving their overall well-being and ability to function effectively within their environments.

The implications of this highly significant relationship are substantial. The findings emphasize the critical role of Assistive Technology in programs, interventions, and policy development aimed at promoting better Quality of Life outcomes, especially for older adult or disabled populations. By enhancing mobility, communication, and daily living activities, assistive tools can substantially improve the lives of those who rely on them. Future research could further explore the specific aspects or categories of Assistive Technology that contribute most significantly to Quality of Life, offering insights for more targeted and effective applications. These findings highlight the transformative potential of Assistive Technology in fostering improved living conditions and overall well-being for vulnerable populations. Finally, the analysis revealed a p-value of 0.039 for the path between Quality of Life and Aging in Place, indicating a statistically significant relationship between these two constructs. A P-value

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below the threshold of 0.05 suggests that the observed relationship is unlikely to be due to random chance, thereby providing robust statistical evidence that Quality of Life has a meaningful influence on Aging in Place. This finding underscores the relevance of Quality of Life as a critical factor in the ability of individuals to successfully age in place. Since the p-value is less than 0.05, the null hypothesis, which posits no relationship between Quality of Life and Aging in Place, can be rejected with confidence. The results suggest that individuals who experience an enhanced Quality of Life are more likely to age in place successfully. This outcome aligns with the broader understanding that a supportive and fulfilling quality of life facilitates the capacity of aging individuals to remain at home or in familiar environments, even as their needs evolve over time.

The implications of this relationship are significant for both research and practice. From a policy perspective, the findings reinforce the need to prioritize initiatives that enhance Quality of Life among aging populations. Measures such as improving access to healthcare, fostering social engagement, and providing necessary resources can positively contribute to the ability of older adult individuals to age in place. For practitioners, this result highlights the importance of integrating quality-of-life considerations into older adult care and support systems. Future research could delve deeper into the specific dimensions of Quality of Life, such as emotional well-being, physical health, and social relationships, to identify targeted strategies for promoting Aging in Place effectively.

CONCLUSION

This study highlights the complex interplay among economic, social, and policy factors in facilitating the use of assistive technology, improving quality of life, and enabling aging in place for older adults. The results indicate that financial limitations specifically low income, with more than 70% of participants earning less than RM4,360 restrict access to assistive devices. This necessitates specific governmental measures, including subsidies and cost-reduction initiatives, to enhance affordability. The high incidence of communal living (74.3% of individuals living in households with more than three occupants) and *kampung*-style dwelling indicates that assistive technologies must be culturally relevant and suitable for traditional, shared living environments. Family members are crucial in caregiving and initiatives that inform and involve them are necessary to provide assistance for the older adults. Furthermore, most respondents have resided in the same home for over a decade, substantiating the need for age-friendly home improvements. Government incentives for retrofitting existing dwellings can facilitate the safe and independent aging of older individuals in familiar surroundings.

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The disparities in education and employment experience noted across numerous respondents may impede their capacity to engage with contemporary technologies. Initiatives for lifelong learning and digital literacy programs designed for older individuals are essential to enhance confidence and usability of assistive technologies. These educational initiatives should be conveyed through accessible, community-oriented platforms. Collectively, these findings necessitate a comprehensive and inclusive policy strategy that encompasses affordability, infrastructural adaptation, familial engagement, and technological empowerment. By matching these strategies with Malaysia's demographic and cultural contexts, stakeholders can formulate sustainable solutions that facilitate aging in place and enhance the overall quality of life for the aged population.

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A CASE STUDY ON THE DIGITAL TRANSFORMATION OF AUTOMATED DECISION-MAKING IN SEMICONDUCTOR INDUSTRY 4.0

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Abstract

Malaysia introduced the National Policy on Industry 4.0 in 2018 to drive the digital transformation of its manufacturing industry. However, due to rapidly evolving technological trends in Industry 4.0, such as artificial intelligence, machine learning, and IoT, there remains limited clarity on how Malaysian manufacturing companies can initiate digital transformation on a small scale while remaining cost-effective and competitive. This study develops a method by comparing specific Industry 4.0 elements within a semiconductor manufacturing company to achieve automated decision-making through digital transformation. The case study indicates that the nine elements of Industry 4.0 are not necessarily all relevant to the semiconductor industry; however, the framework can still be effectively applied to automate decision-making. Digital transformation activities can be implemented in phased approaches, enabling the company to clarify potential value, assess financial constraints, and fine-tune strategies to maintain competitiveness and cost efficiency.

Keywords: Digital Transformation, Industry 4.0, Automated Decision-making

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INTRODUCTION

In the semiconductor manufacturing operations, there are many tasks involved in innovating new products and mass-manufacturing it. At each task, many decisions need to be made from gathering the right data, validating, and securing the data quality, to analysing it. With Industry 4.0, many of these processes are supported by automated data collection through digital transformation. Industry 4.0 refers to the digitalization of manufacturing processes via flexible automation suitable for mass production (Shahzad et al., 2023), enabling companies to enhance productivity and operational efficiency (Dolgui et al., 2024; Che Haron, R., & Muhd Zafir, N.B., 2025).

Shahzad et al. (2023) identify nine key elements of Industry 4.0: big data analytics, the Internet of Things (IoT), cloud computing, autonomous robots, additive manufacturing, simulation, augmented reality, interconnected IT systems, and cybersecurity. While definitions vary, there is broad agreement that integration through IT systems is its core characteristic. This raises the question of whether implementing all nine elements is necessary to achieve Industry 4.0. Currently, research on the progression and scaling of digital transformation in manufacturing operations is limited (Soomro et al., 2021), and compelling case studies are crucial for guiding Malaysian manufacturers in adopting these technologies (Yeap et al., 2024).

This study aims to: (i) review Industry 4.0 progress in a Malaysian semiconductor manufacturing company that has implemented an automated decision-making blueprint and scaled digital transformation to gain firm-specific insights, (ii) simplify the Industry 4.0 concept by comparing the case study against the nine elements, and (iii) assess the impact of digital transformation on automated decision-making. The scope of this research focuses on digital transformation for automated decision-making in semiconductor manufacturing.

LITERATURE REVIEW

Digital transformation is critical for enhancing competitiveness in manufacturing through technologies such as automation, IoT, and data analytics. Despite these benefits, adoption among Malaysian manufacturing firms remains low (Abdulaziz et al., 2023; Boos, 2024). Management often cites high costs, uncertain returns, and technological complexity as barriers (Abdulaziz et al., 2023; Ahmed et al., 2024; Hose et al., 2023; M. Shuhaimi et al., 2024), while limited financial resources, lacked skilled personnel, and ineffective change management further restrict readiness (Ahmed et al., 2024; Müller et al., 2018).

Studies by Fortoul-Diaz et al. (2023) and Wu et al. (2024) demonstrate the potential of Industry 4.0 technologies but focus mainly on technical solutions, offering little guidance on organizational strategies for scaling transformation. To address these challenges, Abbatemarco et al. (2022) and Goecks et al. (2024)

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emphasize the need to analyse successful real-world cases that demonstrate measurable benefits of digital transformation. They suggest that management should focus on selecting use cases with clear business advantages and develop practices that make the outcomes more tangible to stakeholders. Complementing these perspectives, Yılmaz, K. Ö., (2023) proposes a practical framework for managing digital transformation, introducing "psychological asset-related elements" within a digital maturity model - including organization, culture, digital ecosystem, strategy, leadership, innovation, customer experience, digital skills, and vision. Therefore, this study aims to fill the existing gap by examining how Malaysian manufacturing firms can effectively implement and scale digital transformation strategies to strengthen decision-making and operational competitiveness.

RESEARCH METHODOLOGY

Research Framework

A research framework was developed (Figure 1) to address gaps in the literature on scaling digital transformation for automated decision-making and to gain firm-specific insights through direct engagement with manufacturing companies. This study presents a case study of a Malaysian semiconductor company, examining its Industry 4.0 roadmap and digital transformation activities across two phases. In Phase 1, a survey was conducted following the implementation of a pilot automated decision-making system. In Phase 2, after scaling the system to additional areas, a second survey was conducted. The digital transformation phases are compared with Industry 4.0 elements, the company's centralized system before and after transformation, and the transition from manual to automated decision-making models. The case study is also benchmarked against other manufacturing studies to assess broader applicability. Finally, the impact of digital transformation on automated decision-making is analysed to draw conclusions.

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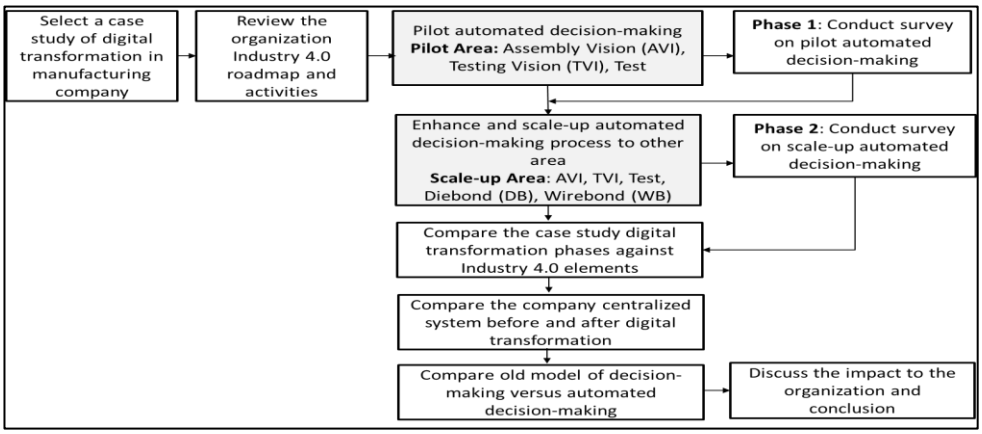


Figure 2: Research framework of case study

Case Study

Established in 2000, the case company is a local public-listed manufacturer of LED products for the automotive industry, producing 7,000–8,000 parts and operating six regional offices globally (The Edge Malaysia, 2025). The case company has committed approximately RM 1 billion for expansion, including Industry 4.0 digital transformation initiatives in Malaysia. In comparison, a global LED semiconductor firm has invested around RM 4.5 billion (equivalent to EUR 1 billion), highlighting a substantial disparity in investment scale between local and multinational firms in the sector within Malaysia (MIDA, 2025; MIDA, 2023). As of 2023, the company employs around 2800 employees with 260 in research and development (R&D), 85% of its employees aged 40 years and below with 51% of its employees are female. The company describes itself as a flexible and competitive manufacturer through extensive automation adoption (D&O Green, 2025). For the company to manufacture LED products, the raw materials will be processed in sequence through DB, followed by WB, then AVI before Test and TVI processes.

We reviewed all IT request form submissions related to digital transformation activities from 24 April 2019 to 28 November 2024. A total of 215 submissions were recorded. Examples of digital transformation activities include requests for additional data storage, data digitization, real-time reports, and interlocked recipe parameters through the IT system. IT request form submissions unrelated to digital transformation, such as new employee registration in existing IT systems, were not tracked. In 2022, the company implemented a pilot automated decision-making model in the AVI, TVI, and Test areas, focusing on process and product yield, which indirectly contributed to company profits.

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Survey of the Digital Transformation Impact towards Automated Decision-making

All surveys were conducted online at different phases of the company's digital transformation. The online survey was implemented in two phases: Phase 1 (mid-stage of the centralized system) and Phase 2 (current stage of automated decision-making). The first survey gathered feedback from engineers supporting manufacturing operations on the company's piloted dashboards in 2022, which were used for yield analysis and data-driven decision-making. After the company refined its digital transformation strategies based on the results of the first survey, the second survey was conducted at a later phase to assess the impact of these improvements.

The target respondents of the surveys were engineers involved in manufacturing operations. To be eligible for selection, respondents' job scopes had to include supporting daily operational activities related to process quality and new product manufacturability. Engineers working in preventive maintenance, planning, and logistics were excluded from this study. Survey invitations were sent via email to the targeted respondents. Table 1 summarizes the demographics of the respondents. The variation in the number of invitations sent reflects the growing involvement of stakeholders as digital transformation activities expanded across different areas of manufacturing operations.

Table 1: Demographic of Targeted Respondents in the Phase 1 and Phase 2 Surveys

Demographic	**Phase 1**		**Phase 2**	
	Number of Invitation	**Number of Respondents**	**Number of Invitation**	**Number of Respondents**
Gender				
Male	5	3	23	15
Female	5	2	22	10
Job Title				
Process Engineer	5	4	30	20
R&D Engineer	5	1	10	3
Quality Assurance (QA) Engineer	0	0	5	2
Age				
<30 years old	3	1	10	8
30 – 40 years old	5	3	30	16
>40 years old	2	1	5	1
Total	**10**	**5**	**45**	**25**

Table 2 shows the survey periods for Phase 1 and Phase 2, along with the corresponding digital transformation phases.

Table 2: Phase 1 and Phase 2 Surveys Information

Information	Phase 1	Phase 2
Period	28th December 2022 till 30th December 2022	22nd October 2024 till 6th November 2024
Digital transformation phase	Mid stage of centralized system with 6 Dashboards for yield analysis visualization	Initial stage of automated decision-making with 18 Dashboards for visualization and 6 automated decision reports
Area	AVI, TVI and Test area	DB, WB, AVI, TVI and Test area

ANALYSIS AND DISCUSSION

Industry 4.0 – Digital Transformation Roadmap and Activities

The initial results present observations from IT request records across the company's digital transformation phases, mapped against Industry 4.0 elements in relation to the automated decision-making model, followed by survey findings on digital transformation impact.

The semiconductor company follows its own Industry 4.0 roadmap (Figure 2). From 2019 to 2020, it focused on automated data collection from machines and sensors, identifying required data, ensuring quality, and standardizing formats for the internal IT system. In 2021, CSV data files were digitized into an SQL database and consolidated into a centralized web-based reporting system. Despite centralization, decision-making remained slow, as engineers still needed to export, clean, and analyse data in Excel. The company considered business intelligence tools, such as Power BI and Tableau, to accelerate data-driven decisions, but the high implementation cost relative to company size was a limiting factor.

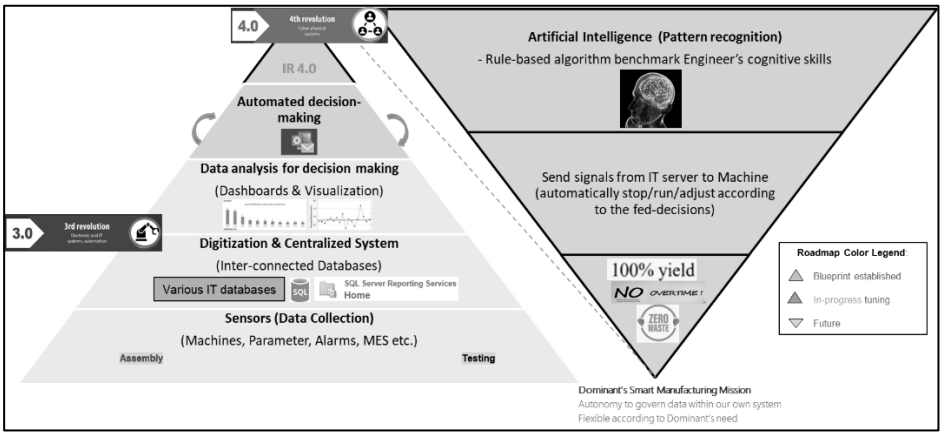


Figure 2: Industry 4.0 Roadmap of case company
Source: Courtesy from case company

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In 2022, the company piloted Excel dashboards to support yield analysis and data-driven decision-making, enabling faster integration into engineers' daily workflows. The dashboards utilized Microsoft Office tools—Power Query, Pivot Tables, and Pivot Charts—to extract, summarize, and visualize data from the centralized repository. This setup allowed engineers to quickly assess current yield, top defect types, and machine performance, reducing reliance on manual data processing.

Targeted engineers in AVI, TVI, and Test areas were trained on the dashboards, and computer hardware was upgraded to handle larger datasets. Centralized data was automatically refreshed daily, allowing engineers to update analyses with a single click and customize scenarios (e.g., yield by product, machine, or combination). The established data pipeline streamlined investigations and accelerated decision-making. JMP statistical software was also deployed for ad-hoc and routine analyses, complementing the Excel dashboards and further enhancing the automation of data-driven decisions.

In parallel with establishing the digitization and visualization blueprint for decision-making, the company began integrating additional databases and IT systems—including equipment management, machine alarms, and recipe parameters—into its centralized system. To secure these data pipelines, cybersecurity infrastructure was also enhanced. As of 2024, the company is developing its own automated decision-making system using artificial intelligence (AI) technology. In the future, the company envisions that machines will auto-adapt based on AI-driven decisions to achieve the goals of smart manufacturing: 100% yield, no overtime, and zero waste.

Table 3 presents a comparison between the case study and Industry 4.0 elements. The company has implemented five Industry 4.0 elements: IoT, autonomous robots, an interconnected IT system, cybersecurity, and big data analytics. One autonomous robot was piloted in 2021, with an additional unit deployed in 2024. The company uses SQL-based computing rather than cloud computing. Regarding the primary characteristics of Industry 4.0, the company has established an integrated and interconnected IT system.

Table 3: Comparison between Case Study Digital Transformation Phases against Industry 4.0 Elements

Case Study Digital Transformation Phases (Industry 4.0 Roadmap)		**Industry 4.0 Elements**
Sensors (Data Collection and Data Quality)	At the early phase of digital transformation, the company emphasized on automated data collection for quality data from sensors such as process parameters, vision inspection, alarms through IT network. Through-out 2019 till 2024	IoT Autonomous robot

Case Study Digital Transformation Phases (Industry 4.0 Roadmap)		Industry 4.0 Elements
	to-date, 12 types of new "sensors" were introduced in the manufacturing processes. Examples of sensors are equipment manager, automated vision inspection, automated 2D and 3D profilometers, automated destructive bondtester, autonomous mobile robots.	
Digitization and Centralized System	In this phase, they have integrated various IT databases. As of 28th Nov 2024, the company's centralized system for manufacturing activities operating at more than 50 interconnected IT databases with different machine models and software vendors. Examples of IT databases are; machine alarms, process parameters, manufacturing execution system (MES), bill-of-material (BOM), statistical process (SPC) data and vision yield into centralized system.	Interconnected IT systems Cybersecurity
Data Analysis for Decision-making	The company used SQL, Microsoft Excel and JMP software for data analysis needed in manufacturing operation. The objective is mainly to explore trends, patterns, analyse variability and perform SPC analysis before rule-based algorithm for automation can be proposed.	Big data analytics Cybersecurity
Automated Decision-making through Artificial Intelligence	The rule-based algorithm used simple mathematical modelling and conditional logics that can be understood by the engineers compared to sophisticated machine-learning algorithms. There are several automated decision reports generated from rule-based algorithm. Example: • Daily report automatically validated the missing data issue for specific product or process and email to respective engineers to act. • Daily report automatically identified problematic machine that continuously triggering alarms or generating abnormal defectives item that can only be detected at next process within a day. • Real-time auto process control (APC) that tap input signal during wire bonding such as bond force, bond power and frame vibration and automatically trigger if signal exceed specified limit.	Big data analytics Cybersecurity IoT

Source: Author's Observation

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Table 4 presents a comparison of the company's centralized systems in 2019 and 2024, including interconnected databases and SQL tables. Between 2019 and 2024, the company's IT databases and SQL tables for manufacturing operations increased by 64% and 161%, respectively. These findings highlight the importance of IT infrastructure planning in scaling digital transformation activities. Comparing the digital transformation phases against the nine Industry 4.0 elements, as well as evaluating the centralized system before and after transformation and the old versus automated decision-making model, indicates that the company implemented new technologies in phases to better understand the risks and potential value of Industry 4.0 while navigating conceptual uncertainties.

Table 4: Company Centralized System (Interconnected Databases and SQL Tables) Comparison in 2019 and 2024

System Name	Number of IT Databases		Number of SQL Table	
	2019	**2024**	**2019**	**2024**
Bill-of-materials (BOM)	2	2	141	143
Manufacturing Execution System (MES)	30	30	643	643
Machine Automated Recipe Parameters and Alarms Database	0	17	0	1,563
Machine Automated Vision Yield Database	0	1	0	15
Machine Automated Test Yield Database	0	1	0	267
Quality Database (SPC data and Production lot abnormality)	1	3	491	694
Total	**33**	**54**	**1,275**	**3,323**

Source: Author's Calculation

Comparing this case study with the research by Fortoul-Diaz et al. (2023), the common Industry 4.0 elements identified are IoT, an interconnected IT system, cybersecurity, and big data analytics with artificial intelligence. Unlike the literature case, the company in this study did not implement additive manufacturing. In our case study, the automated decision-making model uses digitalization and artificial intelligence as enablers for big data analytics, thereby simplifying the Industry 4.0 implementation.

Due to limited expertise in machine-learning technology, the company deploys a rule-based AI algorithm that mimics engineers' cognitive skills for pattern recognition. This approach also avoids the risks of AI "hallucination," such as falsely indicating critical process failures, which could disrupt manufacturing and quality activities. Figure 3 presents a comparison between the old decision-making model and the automated decision-making model.

For example, in identifying problematic WB machines, the previous method required engineers to repetitively gather and analyse data to answer several questions: (i) Which WB machine triggered non-stick on pad (NSOP) alarms continuously yesterday, and how many cases occurred? (ii) What are the affected lot details (e.g., product, lot quantity, number of alarms triggered)? (iii) Did the same WB machine also trigger abnormal WB-related vision defect losses at AVI post-WB process? (iv) If so, what were the vision defect losses detected at AVI, and how many cases occurred?

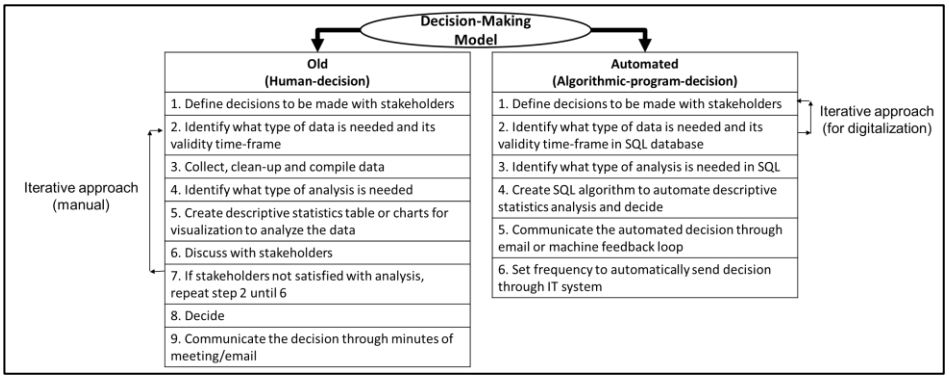


Figure 3: Comparison between the Old and Automated Decision-making Model

The above activities are time-consuming, often resulting in problematic WB machines not being identified in a timely manner and remaining undetected until they reach customers. In the current automated decision-making method, data is automatically extracted from the centralized system and systematically analysed by an SQL program to determine which WB machines are problematic. The SQL algorithm monitors continuous alarms at the WB process and/or abnormal defectives detected at AVI within a day. The thresholds for "continuous" alarms and "abnormal" defect losses are defined using a robust SPC chart (Dahari et al., 2025) and agreed upon by relevant stakeholders. Decisions are then automatically emailed to engineers to take appropriate corrective action. This eliminates the need for engineers to repeatedly gather and analyse data to identify problematic WB machines, making automated decision-making faster and more efficient than the previous model. These results suggest that other manufacturing companies can benefit from investing in automated technologies for data analysis and decision-making, which are crucial for advancing digital transformation.

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Impact on the Organization

The company conducted surveys at different phases and adjusted digital transformation activities to fit the manufacturing environment. These surveys aimed to gather firm-specific insights into engineering decision-making using big data tools, such as dashboards and automated reports. Strategies from Abbatemarco et al. (2022), like selecting pilot areas with clear advantages (e.g., AVI, TVI, and Test), were used to promote adoption within the organization. Surveys during pilot phases collected stakeholder feedback, while follow-up surveys after scale-up validated the impact on the automated decision-making model. Both phases survey responses were then merged and analysed using thematic coding, where similar responses were grouped into main themes (categories) reflecting key aspects of dashboard use and digital transformation impact.

Table 5 summarizes the first survey and second survey response rate, which also revealed a weakness in the pilot online survey, as one respondent did not answer two questions. We have improved the online survey setup in Phase 2 to ensure all respondents complete all survey questions. Whilst, Table 6 summarizes the thematic findings, integrating both qualitative responses and quantitative measures.

Table 5: 1st Survey (2022) and 2nd Survey (2024) Response Rate

Main themes	1st Survey	2nd Survey
Dashboard Usage	100%	100%
Ease of Use & Training	100%	100%
Dashboard Features / Data Scope	100%	100%
Impact on Production / Tasks	80%	100%
Additional Features / Future Tools	100%	100%
Use of Time if Issues Addressed	80%	100%

Source: Author's Survey

Table 6: Thematic Coding Analysis Result

Theme	Key Findings
Dashboard Usage	Primarily used for yield monitoring; some track top defects by product/machine for process improvements. 84% use for yield improvement, 8% for data consolidation, 4% for inventory verification.
Ease of Use & Training	Generally easy to use, though some noted inflexibility and slow loading. 44% attended training and use it effectively; 52% did not attend or were unaware.
Dashboard Features / Data Scope	Users requested additional process details, comparisons, and interconnected process links. In second survey, time spent on dashboards is mostly ≤2 hours;

Theme	Key Findings
Impact on Production / Tasks	Dashboards represent production scenarios, though some noted inaccuracies. 96% said tasks would be inefficient if analysis were done manually.
Additional Features / Future Tools	Suggestions include separating engineering vs production yield, adding machine error logs, and extra formula columns. 60% prefer other BI tools or automated systems if dashboards are unavailable.
Use of Time if Issues Addressed	80% would like to spend more time for problem-solving flagged by the system rather than data mining. Addressing dashboard gaps allows users to focus on corrective and preventive actions to improve yield.

Source: Author's Survey

The case company has proactively pursued Industry 4.0 digital transformation as part of its broader expansion initiatives, which involve a total investment of approximately RM 1 billion. While this investment is significant for a local Malaysian firm, it remains substantially smaller than that of global LED semiconductor firms, reflecting resource constraints that may limit the adoption of advanced automation and analytics. The company currently relies on Excel-based dashboards and rule-based AI systems, which provide practical, cost-effective solutions for data aggregation, visualization, and routine decision-making. However, these tools are limited in scalability, and real-time analytics compared with machine learning–driven solutions that can enable automated process optimization.

To address these limitations, the company has developed a structured Industry 4.0 roadmap, providing a phased approach to digital transformation. Initiatives include integrating IT databases into a centralized system, upgrading hardware, improving internet connectivity, and providing training to strengthen engineers' data analytics capabilities. These efforts, combined with effective change management practices such as surveys at different stages of implementation and employee engagement initiatives, demonstrate a strategic approach to digital transformation (Ahmed et al., 2024). The relatively young workforce, with 85% under 40, and a balanced gender distribution further support technology adoption, highlighting the role of workforce demographics in shaping organizational readiness.

A critical consideration in the roadmap is the deliberate choice to utilize rule-based AI over machine learning at the current stage. Rule-based systems allow the company to standardize decision-making, maintain transparency, and reduce the risks associated with untested algorithms, which is particularly relevant given resource and expertise constraints. Nonetheless, this approach inherently limits adaptability and predictive capabilities, as the system cannot learn from new data patterns without explicit reprogramming. Machine learning,

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while offering greater flexibility, predictive power, and optimization potential, requires larger datasets, computational capacity, and specialized skills—resources that may be challenging for a local firm to deploy immediately. The roadmap reflects a strategic trade-off: the company leverages rule-based AI for reliable, incremental gains while gradually building the infrastructure, skills, and culture necessary for machine learning adoption in the future.

Overall, the case illustrates a balance between incremental, resource-conscious digitalization and the transformative potential of Industry 4.0. The structured roadmap, investment in infrastructure, and targeted training initiatives reflect deliberate steps toward long-term digital maturity. By progressively incorporating scalable analytics and machine learning–enabled solutions, the company can enhance operational efficiency, competitiveness, and alignment with global industry standards. Incorporating organizational culture, leadership, and digital skills, as emphasized by Yılmaz (2023), will be critical for sustaining Industry 4.0 adoption and achieving sustainable competitive advantage in the LED sector.

CONCLUSION

This study illustrates how a local Malaysian semiconductor company successfully advanced its Industry 4.0 adoption through an automated decision-making approach, providing valuable insights for scaling digital transformation beyond pilot initiatives. Despite a smaller investment relative to global competitors, the company's phased and structured roadmap allowed it to evaluate benefits, manage costs, and iteratively refine strategies while progressively expanding digital capabilities. By integrating digitalization and AI, the automated decision-making model streamlines operations, reduces manual steps, and enables faster, more effective process and product improvements. The findings highlight a practical framework that can guide other semiconductor manufacturers in enhancing operational efficiency, fostering innovation, and strengthening industry competitiveness.

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STATISTICAL ANALYSIS OF RED-LIGHT VIOLATIONS ACROSS DIFFERENT TRAFFIC SIGNAL SYSTEMS AND OPERATING CONDITIONS

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Abstract

Red-light violations (RLVs) at signalised intersections continue to pose major safety challenges, especially where traffic flow characteristics vary across urban and suburban environments. This study examines how different traffic signal systems, traffic conditions, area types, and yellow-light durations influence RLV patterns at 13 intersections in Johor, Malaysia. Using video-based data collection and multiple statistical methods—including chi-square tests, binomial proportion analysis, and quasi-binomial logistic regression—the study identifies key factors influencing driver behaviour during the yellow–red transition. Results show that vehicle-actuated systems yield the lowest RLV rates, while suburban areas and peak-hour traffic exhibit higher violation tendencies. Longer yellow intervals significantly reduce the probability of RLVs. The findings contribute to improved understanding of driver decision-making and highlight the importance of adaptive signal control and context-sensitive timing strategies.

Keywords: Red-light running, Red-light violations, chi-square test, binomial proportion test, quasi-binomial logistic regression

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INTRODUCTION

Traffic signal control systems are fundamental to ensuring safe and efficient movement at intersections with high traffic demand. However, the transition to a yellow phase creates a well-documented dilemma zone, where drivers must make rapid decisions to stop or proceed. Studies such as Papaioannou et al. (2021), Juan Li et al. (2016), and Ritvik Chauhan et al. (2022) have shown that the uncertainty introduced at this phase contributes significantly to RLV incidents.

Red-light violation is defined as a vehicle entering an intersection after the onset of the red signal (Retting et al., 1999; Institute of Transportation Engineers, 2003). In Malaysia, a considerable portion of road accidents occur at intersections—about 20% in 2020 (Royal Malaysian Police, 2020), with human factors contributing to approximately 94% of crashes (Mohd Faizul, 2008).

While many international studies have explored driver behaviour, automated enforcement, and advanced signal technologies, such as AI-enabled adaptive control systems, research synthesising these insights within the Malaysian context remains limited. This study addresses these gaps by evaluating multiple intersection types and examining how signal technology, traffic demand, environment, and timing parameters collectively shape RLV patterns.

BACKGROUND

Traffic signal control systems in Malaysia follow warrants and criteria adapted from the Manual on Uniform Traffic Control Devices (Jabatan Kerja Raya, 2017). While such systems aim to improve safety and efficiency, intersections remain a critical point of conflict. International research has consistently shown that a substantial proportion of intersection crashes arises from red-light violations (RLVs), often linked to driver expectancy, risk perception, and the speed–distance dilemma created during the yellow phase (Retting et al., 1999; Institute of Transportation Engineers, 2003).

Early studies on RLVs primarily examined engineering and operational factors—such as cycle length, intersection geometry, and dilemma-zone characteristics (Porter et al., 2000; Milazzo et al., 2002; Martin et al., 2003; Law et al., 2005). However, more recent research has shifted toward a multidisciplinary perspective. Behavioural psychology studies have shown that impatience, sensation-seeking tendencies, perceived enforcement levels, and social norms heavily influence the decision to "beat the red" (AAA Foundation, 2023; Wang et al., 2023). Tien Dung Chu (2022) suggested that males, young motorists, less educated road users, and motorcyclists are more likely to run red lights. They also found out that the surrounding conditions, such as the behaviour of other violators, the absence of traffic police, and long waiting times, increase the possibility of violations. These findings suggest that RLV behaviour cannot

be explained solely by traffic conditions or signal timing, but is closely tied to cognitive and motivational processes.

Parallel advances in intelligent transportation systems have further expanded the RLV research landscape. Machine-learning and deep-learning approaches have been applied to model driver decision-making with higher predictive accuracy, incorporating real-time trajectory data and vehicle–infrastructure communication (Li et al., 2023; Komol et al., 2024). Studies evaluating automated enforcement technologies—including CCTV and red-light cameras—have demonstrated significant reductions in violation rates, particularly in developing-country contexts similar to Malaysia (Cohn et al., 2000; Satiennam et al., 2023). These international advancements underscore the importance of integrating behavioural and technological insights when analysing RLV trends.

Malaysian studies, although valuable, remain limited in breadth. Many focus on single intersections, narrow temporal windows, or specific user groups such as motorcyclists. For example, Kidwai et al. (2005) reported that countdown timers reduced violations, whereas Ibrahim et al. (2008) later found higher RLV rates at countdown-equipped sites—highlighting behavioural adaptation and context dependency. Other local studies (e.g., Hawa Mohamed et al., 2012) emphasised motorcyclist prevalence and the influence of short cycle lengths but did not examine wider environmental or behavioural factors. Importantly, few Malaysian studies have compared multiple types of signal systems—such as countdown timers, flashing-green systems, and vehicle-actuated control—across both urban and suburban settings. H. Mohamed Jamil et al. (2022) reported that the implementation of the Automated Awareness Safety System (also known as "AwAS") was undoubtedly timely and was found to be beneficial in terms of reducing the RLV in Malaysia.

Recent research reinforces the multidimensional nature of red-light running, with predictive driver-warning technologies showing promise (He et al., 2024), engineering measures remaining vital for compliance (Hossain et al., 2025), and behavioural studies emphasising risk perception, psychology, and demographics (Kumphong et al., 2024; Radzi et al., 2024). Malaysian work adds evidence on delivery-rider violations (Malik et al., 2023) and intersection operational analysis (Rahmat et al., 2023), underscoring the need for stronger intersection safety strategies. Nevertheless, RLV requires a broader, multi-site evaluation that integrates operational, environmental, and behavioural dimensions. This study addresses that gap by analysing 13 intersections with differing signal technologies, area types, and traffic conditions, offering new insights into how system design, driver behaviour, and context collectively shape red-light violation patterns in Malaysia.

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RESEARCH METHODOLOGY

Measurement of Red-Light Violation

A driver is considered to violate a red light if he or she enters the intersection after the red signal appears. Only drivers who arrived at the onset of the yellow signal were analysed, based on the assumption that this group faces the highest likelihood of entering the dilemma zone.

Studied Sites and Sample Size

Thirteen intersections located in Johor Bahru, Kulai, and Simpang Renggam were selected based on the following criteria: (i) representation of multiple signal technologies (fixed-time, countdown-equipped, flashing green, vehicle-actuated), (ii) variation in urban and suburban traffic environments, (iii) physical isolation from adjacent intersections to avoid upstream/downstream signal influence, (iv) suitability for clear video recording, and (v) documented safety relevance and observed prevalence of RLV cases. These sites represent typical Malaysian conditions, though the study does not claim full national representativeness.

The sample size, i.e., the minimum number of drivers approaching the intersection at the onset of the yellow period observed for the analysis, was based on Eqn. (1) (Thomas R. C., 2001; Panagiotis P., 2007).

$$N = \frac{pqK^2}{E^2} \qquad (1)$$

where N is the sample size, p is the proportion of vehicles facing a yellow signal that passed, q is the proportion of vehicles facing a yellow signal that stopped, K is the standard deviation corresponding to the desired confidence level, and E is the permitted error in the proportion estimate.

In this study, $p = q = 0.5$, $K = 1.96$ and $E = 0.05$. A value of 0.05 for E strikes a common balance between precision and sample size feasibility. Smaller error margins (e.g., 0.01) would require significantly larger sample sizes, increasing cost and time. In many survey-based or observational studies, a 5% margin of error is acceptable for estimating population proportions with reasonable confidence (Taherdoost H., 2022; Singh A.S. et al., 2022). Therefore, the minimum sample size at each intersection required for this study was 385 drivers. Only drivers who arrived at an intersection at the onset of the yellow period were considered valid samples.

Data Collection and Analysis

Data were collected using video cameras placed at appropriate vantage points. Peak and off-peak periods were explicitly defined as follows: (i) Peak hours:

7:00–9:00 AM and 4:30–6:30 PM, (ii) Off-peak hours: 10:00 AM–12:00 PM and 2:00–4:00 PM. The list of the intersections studied is given in Table 1.

Since the data is in terms of the number or frequency of RLVs out of the total motorists approaching the intersection during the yellow period, a χ^2 test (Aslam M. et al., 2023) for multiple systems was used to compare the variations of red-light violations at all intersections at a significant level of 0.05. The null hypothesis for this χ^2 test is that the frequency of RLVs is independent of the type of traffic signal system or operating conditions.

A binomial proportion test (Marciniak D., 2024) was also applied to compare the proportion of violations between two types of traffic signal systems and between two different operating conditions. The null hypothesis for this test is that the proportions of RLV are equal for both systems or operating conditions. The test is based on a z-test for two proportions.

Based on the characteristics of the intersections shown in Table 1, the data, i.e., proportions of violations and no violations, are pooled for the three factors listed in Table 2.

In the χ^2 test, the observed frequencies of violation and observed frequencies of no violation based on the pooled data for each of the three factors and attributes considered are tabulated in a contingency table, i.e., also known as the Observed Contingency Table (Aslam M. et al., 2023; Marciniak D., 2024; NIST/SEMATECH, 2013).

Table 1: Characteristics of the sites studied

Site Ref. No.	Intersection Name	Traffic Signal System	Posted Speed Limit (km/h)	Cycle Time /yellow (sec)	Type of Area
A	Permatang/Setia Tropika	Fixed-time	70	120/3.0	Suburban
B	Jalan Parit Ismail/Jalan Besar (Simpang Renggam)	Fixed-time	90	120/4.9	Suburban
C	Jalan Persisiran Perling 1	Fixed-time	60	120/3.0	Urban
D	Jalan Pontian–Muar/Pontian Kecil	Fixed-time	60	120/3.1	Suburban
E	Jalan Seri Melaka	Fixed-time (DC)	90	120/2.0	Suburban
F	Jalan Teberau/Jalan Keris	Fixed-time (DC)	70	142/4.0	Urban
G	Jalan Johor Jaya/Jalan Anggerik	Fixed-time (DC)	60	120/2.5	Urban
H	Saleng/Jalan Kulai	Fixed-time (FG)	70	160/3.0	Suburban
J	Jalan Tun Aminah/Jalan Perwira 16	Vehicle-actuated	60	Varies/2.9	Urban

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Site Ref. No.	Intersection Name	Traffic Signal System	Posted Speed Limit (km/h)	Cycle Time /yellow (sec)	Type of Area
K	Jalan Pontian/Jalan Tembaga	Vehicle-actuated	70	Varies/3.0	Suburban
L	Jalan Tun Razak (Susur 5)/Jalan Sentosa	Vehicle-actuated	60	Varies/3.1	Urban
M	Jalan Simpang Pasak	Vehicle-actuated	90	Varies/2.6	Suburban
N	Jalan Johor/Jalan Jemaluang	Vehicle-actuated	90	Varies/2.6	Suburban

Note:Fixed-time (DC) – Fixed-time with a digital countdown feature.
Fixed-time (FG) – Fixed-time with a flashing green feature.

Table 2: Factors and attributes considered in the analysis

No.	Factors	Attributes
1	Different traffic signal systems	fixed-time, fixed-time with a digital countdown, and vehicle-actuated
2	Characteristics of the area where the intersection is	urban and suburban areas
3	Conditions of traffic flow	peak hour and off-peak hour

A quasi-binomial logistic regression model (Hilbe, 2016; Shoukri, M.M., and Aleid, M.M., 2022) was developed to examine the relationship between yellow-light duration, traffic signal system type, and the likelihood of red-light violations. This statistical approach was chosen to address overdispersion in the response variable, which occurs when the variance of the observed proportions exceeds the nominal variance assumed by the binomial distribution. Overdispersion is common in traffic safety studies due to driver behavioural variability and unobserved heterogeneity, as suggested by many researchers (Lord and Mannering, 2010; Washington et al., 2020).

The response variable was the proportion of red-light violations, modelled using a two-column matrix of counts: the number of red-light violations, and the number of non-violations (i.e., vehicles that did not run the red light).

This structure enables the use of a binomial-type generalised linear model (GLM), where the probability of a red-light violation is modelled as a function of explanatory variables. The predictor variables included:

(i) Yellow-light duration (a continuous variable, in seconds), and
(ii) Traffic signal system type (a categorical variable), with three levels, i.e., Fixed-time (used as the reference category), Fixed-time with Advanced Warning Feature (AWF), and Vehicle-actuated (VA).

Dummy (indicator) variables were created for the AWF and VA signal types to allow categorical comparison against the fixed-time baseline.

The model was structured using a logit link function, which expresses the relationship between the predictors and the log-odds of a red-light violation. The general form of the model is as given in Eqn. (2).

$$\text{Log}\left(\frac{p}{1-p}\right) = \eta = \beta_0 + \beta_1 \cdot \text{YellowDuration} + \beta_2 \cdot \text{AWF} + \beta_3 \cdot \text{VA} \qquad (2)$$

where p is the probability of a red-light violation, β_0 is the intercept, β_1 is the coefficient for yellow-light duration, β_2 and β_3 are coefficients for the AWF and VA signal system types, respectively.

To compute the probability of a red-light violation from this model, the equation is transformed as Eqn. (3).

$$p = \frac{e^{\eta}}{1+e^{\eta}} \qquad (3)$$

where $\eta = \beta_0 + \beta_1 \cdot \text{YellowDuration} + \beta_2 \cdot \text{AWF} + \beta_3 \cdot \text{VA}$. All variables are as described before. Eqn. (3) allows for the estimation of the probability p once the model coefficients have been obtained.

The model was estimated using a standard quasi-binomial logistic regression procedure to account for overdispersion in the response variable (Hilbe, 2016). This approach maintains the logistic regression structure while providing robust standard errors for hypothesis testing and inference. The quasi-binomial method estimates a dispersion parameter that scales the variance, thereby adjusting the confidence intervals and significance tests without changing the estimated coefficients.

RESULTS AND DISCUSSION

Effects of Types of Traffic Signal Systems

Based on the pooled data of 18,158 drivers approaching the stop line at the yellow onset at all intersections during the off-peak hour periods, 25.67% of them violated the red-light signals. The analysis revealed that vehicle-actuated systems had the lowest RLV rate (16.14%), followed by fixed-time systems with an advanced warning feature (24.87%), and traditional fixed-time systems (39.02%). The percentages of red-light violations at each intersection ranged from 2.36% to 52.94%. Table 3 presents these aggregated RLV rates, while Figure 1 graphically illustrates these differences.

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Table 3: Aggregated percentage of RLV based on types of traffic signal systems

Types of Systems	No. of Intersections	Sample Size	No. of RLVs/(%)
Fixed-time	4	4,897	1,911 (39.02)
Fixed-time with an advanced warning feature (AWF)	4	6,979	1,736 (24.87)
Vehicle-actuated (VA)	5	6,282	1,014 (16.14)

(Note: Figures in parentheses are in per cent.)

The χ^2 and binomial proportion tests confirmed statistically significant differences in violation rates across traffic signal systems, where the p-value, which is a probability that measures how likely it is to observe the given result when the null hypothesis is true, is equal to 1.58×10^{-165}. Such a result implies that the RLV rates differ significantly across three types of traffic signal systems at a 5% level of significance.

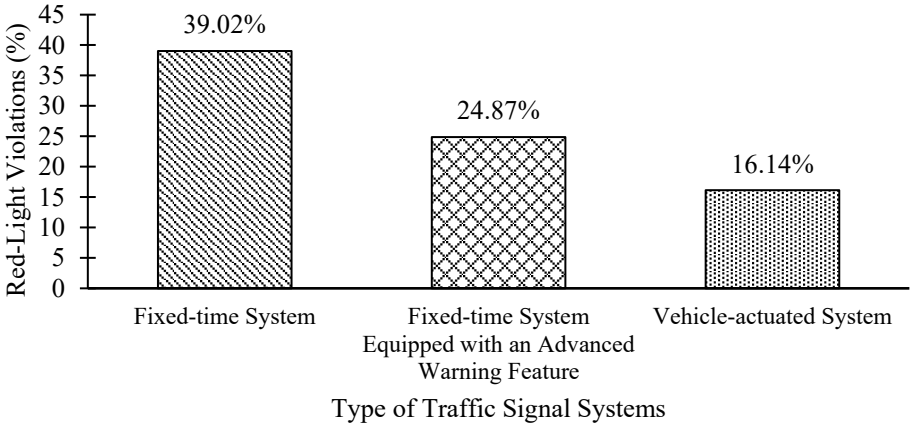


Figure 1: Effect of the type of traffic signal system on red-light violations

The superior performance of the vehicle-actuated signal system in reducing red-light violations can be attributed to its dynamic responsiveness to actual traffic conditions. Unlike fixed-time systems that follow predetermined cycles, vehicle-actuated signals detect approaching vehicles and adjust signal timing accordingly, reducing unnecessary waiting and minimising abrupt signal changes that can frustrate drivers. Although fixed-time signals equipped with countdown timers provide a warning, they lack the adaptability to traffic flow variations, limiting their effectiveness in reducing violations. By tailoring signal phases to real-time demand, vehicle-actuated systems create smoother traffic

progression and reduce driver uncertainty, thereby encouraging better compliance with traffic signals and lowering the incidence of red-light running.

Influence of Area Type

Table 4 shows that suburban intersections recorded a significantly higher RLV rate (29.05%) than urban intersections (22.03%). Both the chi-square test (χ^2 = 117.0, $p < 0.0001$) and the binomial proportion test ($z = \pm 10.81$, $p < 0.0001$) confirm that this difference is statistically significant.

Although lower traffic density may partially explain this pattern, behavioural factors offer clearer insight. International studies show that drivers tend to take greater risks in low-density or low-enforcement environments—a form of risk compensation (Wilde, 1994; Elvik, 2019; Zhao et al., 2019). Suburban roads typically have wider carriageways, fewer intersections, and lower visual complexity, reducing perceived crash risk and encouraging higher speeds. These conditions make drivers less inclined to decelerate at the onset of yellow.

Perceived enforcement also plays an important role. Research indicates that drivers are more likely to run red lights where enforcement presence is low or inconsistent (Johnson & Gardner, 2020; AAA Foundation, 2023). Many suburban intersections lack automated enforcement or regular patrols, reinforcing the belief that violations carry minimal consequences.

Thus, the statistical differences observed in Table 4 align with broader evidence that reduced traffic complexity, higher operating speeds, and lower perceived enforcement collectively increase the likelihood of RLVs in suburban settings

Table 4: χ^2 statistics for the comparison of red-light violations and no violations across different types of areas

Types of Area	Total Samples	Status	Observed	Expected	χ^2	p-value
Urban	8,750	Violation	1,928 (22.03%)	2,246.05	45.0	
		No Violation	6,822	6,503.95	15.6	
Suburban	9,408	Violation	2,733 (29.05%)	2,414.95	42.0	
		No Violation	6,675	6,993.05	14.5	
Pooled	18,158		18,158		117.0	< 0.0001

Note: $\chi^2_{(critical)} = 3.84$ at a 5% significance level and degree of freedom = 1

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Effect of Peak-Hour and Off-Peak-Hour Conditions

As summarised in Table 5, the peak-hour conditions showed significantly higher RLV rates (36.58%) than off-peak periods (29.45%). The statistical difference is confirmed by the χ^2 and binomial proportion tests, where both tests yield a p-value of less than 0.0001. This was especially pronounced at urban intersections, likely due to: (i) platoon effects, (ii) impatience during congested periods, and (iii) shorter perceived opportunity to cross. This supports the implementation of enforcement measures such as red-light cameras during peak hours in urban settings.

Effect of Duration of Yellow Period

A quasi-binomial logistic regression model was developed to estimate the probability of red-light violations as a function of yellow-light duration and type of traffic signal system. This approach was adopted to account for overdispersion observed in the binary outcome data. The model was specified with Fixed-time signals as the reference category, allowing comparisons of the other two signal types—Fixed-time with Advanced Warning Feature (AWF) and Vehicle Actuated (VA)—against this baseline. The estimated model coefficients are tabulated in Table 6.

Table 5: Pooled data of violations during off-peak and peak-hour traffic conditions in urban and suburban areas

Types of Area	No. of Intersections	Off-Peak Hour Data		Peak-Hour Data	
		Total Samples	Violations	Total Observations	Violations
Urban	4	7,266	1,893 (26.05%)	4,504	1,539 (34.17%)
Suburban	4	2,419	959 (39.64%)	2,180	906 (41.56%)
Pooled	8	9,685	2,852 (29.45%)	6,684	2,445 (36.58%)

Table 6: Estimated model coefficients

Variable	Coefficient (β)	Std. Error	z-value	p-value
Intercept (β_0)	2.749	0.030	91.12	<0.001
Yellow Duration (β_1)	-1.007	0.009	-106.70	<0.001
AWF (β_2)	-1.136	0.011	-102.63	<0.001
Vehicle Actuated (β_3)	-1.454	0.011	-131.99	<0.001

All predictor variables were found to be statistically significant (p-value < 0.001), indicating that both the duration of the yellow-light interval and the type of signal control system significantly affect the likelihood of red-light violations. The estimated logistic regression model for observed data is expressed as in Eqn. (4).

$$\text{Log}\left(\frac{p}{1-p}\right) = \eta = 2.749 - 1.007 \cdot \text{YellowDuration} - 1.136 \cdot \text{AWF} - 1.454 \cdot \text{VA} \quad (4)$$

where p is the probability of an RLV, AWF, and VA are binary indicator variables (1 if present, 0 otherwise), and the Fixed-time is the reference category.

The performance measures used to evaluate the adequacy of the quasi-binomial logistic regression model are summarised as follows:

- Dispersion parameter of 2.14 indicated overdispersion in the data, validating the use of a quasi-binomial model (Hilbe, 2016).
- McFadden's Pseudo R^2 of 0.437 indicates that the model explains approximately 43.7% of the variability in violation rates. The model is considered strong, particularly for behavioural or observational studies, such as traffic behaviour (McFadden, 1974; Long, 1997).
- Quasi-Akaike Information Criterion (QAIC) was used to assess model strength and compare alternative model structures (Pan, 2001; Burnham and Anderson, 2002). Although the QAIC was 310.5, no alternative models were evaluated, as the selected structure was theoretically grounded and designed to balance interpretability and statistical robustness. The focus was on explaining key predictors—yellow-light duration and signal type—based on prior studies. QAIC served primarily as a diagnostic metric rather than for model selection.

The model, i.e., Eqn. (4) can be used to estimate the probability of red-light violations, p, under different signal settings and yellow-light durations by substituting Eqn. (4) into Eqn. (3) to yield the following Eqn. (5). Using Eqn. (5), the predicted probability of RLVs based on yellow-light duration and signal type is exhibited in Figure 2.

$$p = \frac{e^{(2.749 - 1.007 \cdot \text{YellowDuration} - 1.136 \cdot \text{AWF} - 1.454 \cdot \text{VA})}}{1 + e^{(2.749 - 1.007 \cdot \text{YellowDuration} - 1.136 \cdot \text{AWF} - 1.454 \cdot \text{VA})}} \quad (5)$$

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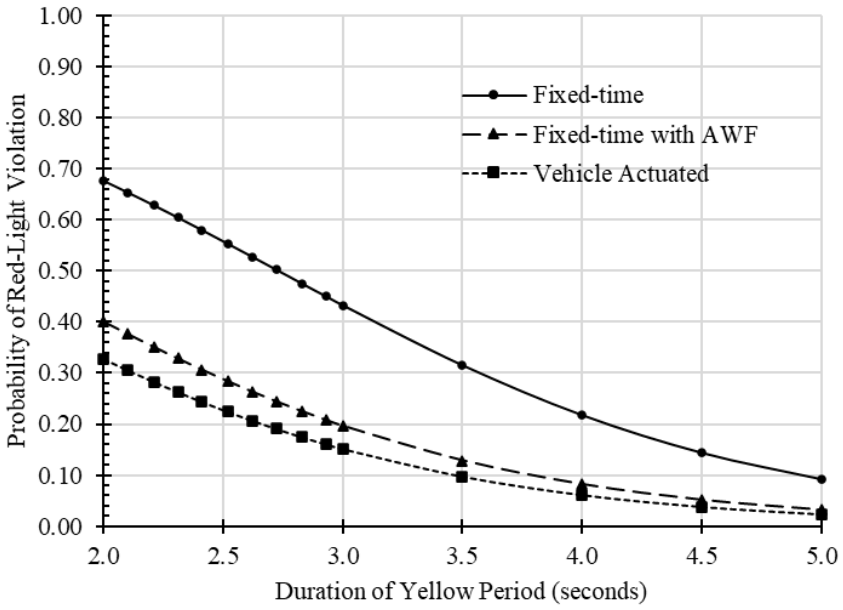


Figure 2: The predicted probability of red-light violations based on yellow-light duration and signal type

The interpretation of the model developed can be summarised as follows:

(a) Yellow-Light Duration: A coefficient of 1.007 confirms that longer yellow intervals significantly reduce red-light violations, aligning with studies by Law et al. (2005) and Bonneson et al. (2002). However, yellow times should be capped based on approach speed and intersection size—typically 3 to 6 seconds (Transportation Research Board, 2022).
(b) Signal Type:
- AWF systems lower violations by improving driver anticipation.
- Vehicle-actuated signals (VA) further reduce violations due to their adaptive nature.

Figure 2 illustrates sharper declines in violations with longer yellow durations, especially under AWF and VA systems. Predicted relationships show diminishing marginal effects beyond typical yellow durations (3–6 seconds), consistent with Transportation Research Board (2022) recommendations. The findings validate the effectiveness of combining advanced signal technologies with well-calibrated yellow intervals to improve compliance and safety.

CONCLUSION

This study offers comprehensive insight into the behavioural and operational factors influencing red-light violations in Malaysia. Key findings indicate that vehicle-actuated signals significantly reduce RLVs relative to fixed-time systems; suburban intersections experience higher violation rates due to lower traffic density and behavioural–environmental influences; peak-hour conditions intensify RLVs, particularly in urban areas; and longer yellow intervals reduce violations, though with diminishing marginal effect.

These results highlight the need for intelligent traffic systems, improved enforcement, and targeted educational measures tailored to local contexts. Priority should be given to upgrading high-risk intersections to vehicle-actuated control, with countdown timers or flashing-green displays as interim options where upgrades are not immediately feasible. Peak-hour enforcement—particularly through automated means—is vital in urban settings, while behavioural campaigns may be more effective in suburban areas. The study further underscores the importance of context-sensitive yellow timing based on approach speed and geometry.

Future research should explore machine-learning models for predicting RLV behaviour, incorporate demographic variables, conduct multi-state comparisons, differentiate vehicle types (especially motorcycles), and evaluate optimal deployment strategies for automated enforcement.

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EVALUATING THE IMPACT OF SOIL NAILING ON SLOPE STABILITY: INSIGHTS FROM MULTIPLE REGRESSION ANALYSIS

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Abstract

Slope stability is a major issue in Malaysia because of the nation's varied topography and unpredictable weather. Landslides or slope failures can happen without warning even after years of apparent stability. The ineffectiveness of conventional slope stabilization procedures may call for investigating advanced methods like soil nailing. This numerical study exclusively focused on the systematic analysis of slope stability reinforced with soil nailing. Geo-Studio 2018 (SLOPE/W) is used to determine the slope's FOS with soil nails. Nail lengths of 6m, 9m, 12m, and 15m were evaluated, with a constant drillhole diameter of 150mm and a nail inclination of 10º. Slope angles of 30º, 60º, and 90º were considered, along with various soil types characterized by cohesion values of 0, 5, 10, and 15 kN/m² and friction angles of 5º, 15º, 35º, and 45º. The unit weight of the soil was consistently maintained at 17 kN/m³. Multiple regression analysis was employed to optimize the dataset, yielding an R-squared value of 0.80. The results demonstrated that the efficacy of soil nailing in enhancing slope stability was significantly influenced by nail length, slope angle, and soil properties. It was observed that longer nails and higher cohesion values contributed to improved stability, whereas steeper slopes and lower friction angles presented more significant challenges. These results highlighted the need to take into consideration a variety of elements in order to obtain optimal stability and offered crucial insights for developing and putting into practice soil nailing systems in a range of geotechnical settings. The study shows the impact of multiple regression analysis on geotechnical design optimization, especially in nail optimization. The study used this statistical technique to determine and measure the most important variables influencing soil nail performance. This method not only improved the accuracy of the design parameters but also provided a strong foundation for further study and real-world slope stabilization applications. A more sophisticated knowledge of the relationships between different design elements is made possible by the application of multiple regression analysis, which results in soil nailing solutions that are more dependable and efficient.

Keywords: Slope stability, Slope/W, soil shear strength parameter, soil nailing

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INTRODUCTION

Malaysia experiences frequent landslides due to its humid tropical climate, deeply weathered soil profiles, and rapid urban development in hilly regions (Ali et al., 2023; Kumar et al., 2021). Steep cut slopes, high-intensity rainfall, and heterogeneous residual soils increase the likelihood of slope failures, resulting in damage to infrastructure, economic losses, and safety risks to the public (Islam et al., 2022; Jambo et al., 2023). Historical records show that slope failures occur almost every year, often triggered by localized rainfall and aggravated by insufficient design considerations (Majid, 2020), based on Figure 1. Design-related deficiencies account for more than half of documented landslide cases in Malaysia, highlighting the need for improved engineering approaches. 29 out of 49 slope failures were caused by design-related problems, as shown in Table 1 (Gue & Tan, 2006). In addition to design errors, factors such as lack of skills, carelessness, and insufficient data often play a role in the persistence of these landslides (Jamaluddin, 2006). These occurrences are linked to those in Selangor, as evidenced in Table 1.

Table 1: Factor of landslide in Malaysia

Causes of Landslides	Number of Cases	Percentage (%)
Design errors	29	60
Constructions errors	4	8
Design and Construction errors	10	20
Geological features	3	6
Maintenance	3	6
Total	49	100

Source: (Gue & Tan, 2006)

Soil nailing has emerged as an effective reinforcement method for stabilising steep slopes, particularly in residual soils. It enhances shear resistance by mobilising friction and adhesion along the soil and nail interface, improving stability without requiring extensive excavation. The performance of a soil-nailed system is fundamentally influenced by soil shear strength parameters such as cohesion (c') and friction angle (ϕ') as well as nail configuration, including length, inclination, diameter, and bonding characteristics (Mizal-Azzmi et al., 2011; Shi et al., 2020). These parameters determine the pullout resistance and overall deformation behaviour of the reinforced mass (Dixon et al., 2014). Although empirical guidelines exist, the interaction between soil properties, slope geometry, and reinforcement design requires quantitative assessment to support safer and more efficient slope engineering.

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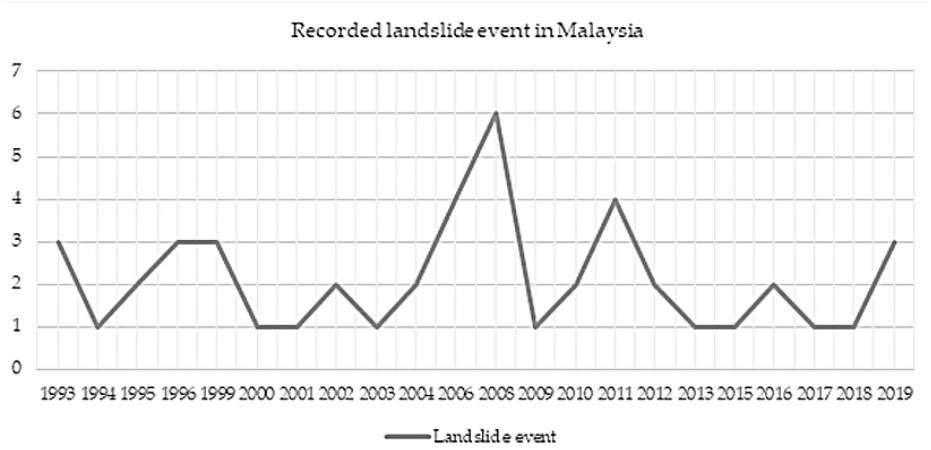


Figure 1: The Malaysian landslide record from 1993 to 2019
Source: (Majid, 2020)

Modern geotechnical analysis tools such as SLOPE/W allow a detailed evaluation of slope stability using the Limit Equilibrium Method (LEM), particularly the Morgenstern–Price method, which incorporates non-circular failure surfaces and inter-slice forces. Slope stability can also be assessed through site inspections, laboratory testing, numerical modelling, and the determination of the Factor of Safety (FOS). Previous studies have highlighted that the FOS is a critical parameter in evaluating the overall stability of a slope (Abbas, 2014; Johari & Javadi, 2012). However, numerical outputs alone may not fully reveal the relative importance of contributing variables, particularly when multiple soil and geometric factors interact simultaneously. This motivates the integration of statistical approaches such as Multiple Linear Regression (MLR), which enables parametric evaluation and identification of dominant predictors influencing the FOS (Ja'afar & Mohamad, 2021). Recent studies have demonstrated the usefulness of regression-based methods for correlating shear strength parameters, slope geometry, and reinforcement characteristics with FOS (Khan & Wang, 2021; Mohamed et al., 2023).

Despite increasing interest in regression-based approaches, limited studies have explored the combined effects of soil shear strength parameters and soil-nailing configurations across diverse slope conditions representative of Malaysian terrain (Bathini & Krishna, 2022; Sahoo et al., 2022). Moreover, empirical models developed elsewhere may not be directly applicable to residual soils, which exhibit significant variability and stress-dependent behaviour (Patil et al., 2021).

Therefore, this study aims to provide a comprehensive assessment of soil nail performance through numerical modelling and regression analysis by

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evaluating the influence of soil shear strength, slope angle, and soil nail length on the Factor of Safety (FOS) using SLOPE/W, developing a MLR model that quantifies the contribution of each parameter to slope stability, and identifying the most influential variables governing soil nail performance to assess the practical reliability of the regression model for preliminary design optimisation. Nguyen et al. (2021) demonstrated that predictive modelling techniques are useful for estimating soil shear strength, supporting the wider use of quantitative methods in geotechnical studies. Through these combined objectives, the study offers insights into the behaviour of soil-nailed slopes under varying design and soil conditions. It provides a data-driven foundation for improved geotechnical decision-making in Malaysian slope engineering practice (Alfat et al., 2019).

RESEARCH METHODOLOGY

This part describes how to reach the goals. Ultimately, this method aims to direct the creation of safer slopes in geotechnical engineering by understanding the factors affecting slope stability using Geostudio and multiple regression. GeoStudio has become increasingly important, particularly in SLOPE/W, for analyzing and designing adequate slope stability. In order to enhance the FOS of the slope, this study incorporated soil nailing into the design, utilizing Limit Equilibrium Method (LEM) through SLOPE/W software to evaluate all slope designs and suggest the most effective preventative and corrective actions. The Morgenstern-Price Method was selected among the various LEM because it was effective in handling non-circular critical slip surfaces, included both inter-slice forces, assumed an inter-slice force function, allowed the selection of various inter-slice force functions, and measured the FOS for both force and moment balance.

The effect of different soil nail parameters on slope stability with varying slope angles and soil types was examined using SLOPE/W software. In this study, a total of 300 different slope designs were carefully evaluated. Then, a cross-section of the soil slope was identified for a stability check and to determine the best preventative and remedial measures. Table 2 shows the data parameters for slope and soil properties in this study.

The main properties of soil shear strength essential for slope stability assessments are cohesiveness, friction angle, and unit weight. Each of these factors greatly influences slope stability. Cohesion values of 0, 5, 10, 15, and 20 kN/m² were investigated in this work. The cohesion value of non-cohesive soils, like loose sands, is 0 kN/m^2, meaning there is no intrinsic attraction between the particles. The 5 to 20 kN/m² range encompasses a variety of cohesive soils, from low to high cohesion, including silts and clays with different levels of particle attraction. Identifying patterns and thresholds where changes in cohesion significantly affect slope stability, as indicated by incremental values (5, 10, 15,

20 kN/m^2), the study contributes to our understanding of the relationship between soil cohesion and the FOS.

Table 2: Data parameters for slope and soil properties

Slope angle, β (º)	Slope Height, H (m)	Soil properties		
		Friction Angle, φ (°)	Cohesion, c' (kPa)	Unit weight,γ (kN/m^3)
30	7	5	0	17
		15	5	
60		25	10	
		35	15	
90		45	20	

To represent a wide range of soil types and their shear strength properties, the friction angles of 5°, 15°, 25°, 35°, and 45° were chosen. A friction angle of 5° is used to depict very loose, poorly graded soils with little internal friction, such as loose sands or silts. A 15° friction angle, characteristic of loose to medium-dense sands, denotes more compacted soils with significant internal friction. Medium-dense to dense silty sands have a 25° friction angle, a balance between loose and heavily compacted soils. Strong particle interlocking at a 35° friction angle is a symptom of dense, well-graded sands and gravels with high internal friction (Ihnatov, 2022). The maximum resistance to shear pressures, found in extremely dense, well-compacted soils or rock-like materials with unusually high internal friction, is represented by a friction angle of 45°. To get insight into the effects of friction angle variations on slope stability, the research will analyze these incremental values to ascertain how these changes impact slope stability.

For this investigation, a unit weight of 17 kN/m³ was chosen. A unit weight of 17 kN/m³ indicates an intermediate density prevalent in medium-dense or silty sands (Shiferaw, 2021). A height of seven meters was specified, and angles of 30º, 60º, and 90º were considered regarding slope inclinations. The moderate inclinations commonly found in man-made slopes, including cut slopes, dams, and natural terrains, are represented by a slope 30° (M. I. Khan & Wang, 2021). Understanding the stability of steeper slopes, which may be more likely to collapse, is made easier by the 60° slope. Some natural and manufactured situations have moderate to severe slopes, which are less frequent. The 90° slope is essential for many geotechnical applications because it provides insight into the stability of almost vertical or near-vertical faces, frequently found in cliffs, retaining walls, and other constructed structures. A height of 7 meters was chosen to guarantee uniformity across all slope angles and offer a clear comparison of

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stability data. The various slope angles and soil characteristics considered in the slope analysis are compiled in Table 3.

The primary parameter used in this study to examine how soil nails affect different slope stabilization techniques is soil shear strength. The objective is to identify the most effective drill hole diameter for slope repair and the ideal soil nail length and inclination. Table 3 lists nail design characteristics utilized in GeoStudio to examine the Factor of Safety (FOS).

Table 3: Soil nail parameter

Inclination of soil nail, i (º)	Drillhole Diameter, D_{DH} (m)	Length of Soil Nail, L_N (m)
10	0.15	6, 9, 12, 15

This range of inclination works incredibly well to guarantee stability in Malaysia's diverse soil types. A 10º inclination for soil nails was chosen because it falls within the range recommended by the Federal Highway Administration (FHWA) and Geoguide 7. Soil nails are usually set at angles ranging from 10º to 20º from the horizontal, with 15º being the most often used angle, according to the FHWA (Noor & Jamain, 2019). The grout may flow from the drill hole's base to its top at varying angles. Inclinations lower than 10 degrees are often avoided to lessen the possibility of grout voids. According to Geoguide 7, soil nails are frequently angled downward (between 5 and 20 degrees) for appropriate grouting in low-pressure or gravity environments (Elahi et al., 2022). 0.15 m drill hole diameter of soil nail had been chosen according to FHWA and Geouide 7. A soil nail drill hole's normal diameter is 6 inches, although it can be expanded to 8 inches or more if needed, according to the FHWA (M. Khan & Wang, 2021). The steel bar will be placed in the drilled holes, with a diameter ranging from 100mm to 300mm and spaced between 1m and 2m apart (Rashad et al., 2023).

In Malaysia, the length of soil nails used for slope stabilization is influenced by standard engineering practices, design guidelines, and site-specific conditions. While general design methods suggest consistent nail lengths between 6 to 9 meters, the actual length should be determined based on the slope angle, soil shear strength parameters, and geotechnical properties to ensure optimal performance (Yılmaz & Yuksek, 2007). The best length should be customized to the slope's angle and the surrounding soil properties to guarantee optimum performance. If deeper reinforcement is required due to weaker soil layers or higher loading conditions, soil nails can extend up to 12 meters. This longer length helps reach more stable soil strata, increasing the pullout resistance of the nails, and ultimately enhancing the Factor of Safety (FOS) for the slope (Sari, 2018).

RESULT AND DISCUSSION

Upon completing the design and analysis of the slope models, results were generated for each iteration of the design process. The main aim of this section is to evaluate and improve soil stability by determining the most effective soil nail length. A Multiple Linear Regression (MLR) analysis was performed using the Factor of Safety (FOS) values obtained from SLOPE/W as the dependent variable to assess the relative significance of the parameters influencing slope stability (Sari, 2018). The application of MLR in this study follows established statistical procedures, including significance testing, beta coefficient evaluation, and goodness-of-fit assessment, consistent with regression methodologies commonly applied across empirical research disciplines (Montuori et al., 2023). The approach allows a quantitative assessment of how each parameter contributes to overall slope performance. The analysis, carried out in Excel, provided a detailed understanding of the individual and combined effects of independent variables such as nail length, cohesion, friction angle, and slope angle (Wisaeng & Muangmeesri, 2025).

The regression coefficients obtained from the analysis quantify the sensitivity of the FOS to variations in each parameter, while the associated p-values indicate the statistical significance of their influence (Braun & Wang, 2020). The results establish a clear hierarchy of parameter significance, with soil nail length and cohesion showing highly significant p-values below 0.01, reflecting their strong and statistically robust contribution to slope stability (Chakraborty & Goswami, 2017). The regression model indicates that nail length, cohesion, and friction angle possess positive coefficients, signifying that increases in these parameters enhance FOS and improve slope stability, whereas slope angle exhibits a negative coefficient, showing that steeper slopes reduce stability and increase the likelihood of failure. Among all variables, soil nail length demonstrates the highest positive effect (+0.0665), confirming its dominant role in reinforcement design and its strong correlation with overall slope performance. These findings highlight that nail length exerts the most substantial influence on slope stability, while cohesion and friction angle act as critical supporting parameters. Overall, the multiple regression approach effectively quantifies the combined effects of soil shear strength and geometric parameters on slope performance, providing a reliable analytical framework for evaluating stability in soil-nailed systems (Gupta et al., 2024).

By comparing experimental FOS values with predicted FOS derived from 300 slope models, the regression analysis visually represents how slopes respond under various stability conditions. Equation (1) describes the relationship between FOS and the key soil and slope parameters, illustrating the maximum resistance to failure across different combinations of soil shear strength, slope

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angles, and soil nail lengths. This relationship is further illustrated in the correlation graph shown in Figure 2.

$$FOS = 0.0422\phi' + 0.0562C' - 0.0137\beta + 0.0665L_N + 0.388 \quad a) \quad (1)$$

The symbol ϕ' represents the friction angle of the soil in degrees (°), c′ denotes the cohesion of the soil in kilonewtons per square meter (kN/m²), β is the angle of the slope in degrees (°), and L_n indicates the length of the soil nail in meters (m).

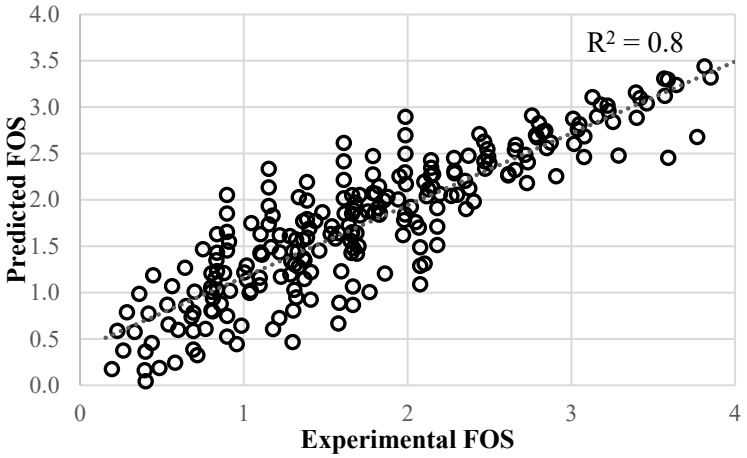


Figure 2: Correlation between actual FOS and predicted FOS.
Source: Author's calculation

The model demonstrates a high level of reliability, as indicated by its coefficient of determination (R^2) of 0.8, which explains approximately 80% of the variability in the actual FOS values based on the predicted values. In a scatter plot, the line of best fit illustrates the model's predictions, and the closer the data points are to this line, the higher the model's accuracy. With an R^2 of 0.8, most points lie near the line, reflecting strong predictive performance. In engineering and the physical sciences, R^2 values above 0.70 are generally considered indicative of a good model fit, and values ranging from 0.70 to 0.99 are commonly interpreted as demonstrating strong explanatory power (Gupta et al., 2024). The significant R^2 value confirms that key design factors, including nail length, slope angle, cohesion, and friction angle, account for a substantial portion of the variance in slope stability (Wu et al., 2020).

Considering the inherent complexity and variability of soil behaviour and slope conditions, an R^2 of 80% is regarded as adequate within geotechnical engineering applications. Although a theoretical ideal may approach 90% or higher, values between 75% and 80% are generally sufficient for practical design purposes, particularly when using multiple linear regression. The focus should be on developing an interpretable and reliable model that enables safe and effective design decisions rather than pursuing a perfect statistical fit. This model provides a sound foundation for forecasting slope stability and informing design optimisation, as evidenced by its capacity to capture a substantial portion of the underlying relationships between independent parameters and FOS (Hamilton et al., 2015; Tian et al., 2024).

Shear strength parameters, specifically cohesion and friction angle, must be considered in combination with varying slope angles and soil nail lengths to ensure optimal stability. The model's R^2 value supports the identification of suitable slope designs that minimise failure risk while satisfying the safety requirements of the Jabatan Kerja Raya (JKR). To visualise these interactions, Figure 3 presents the relationship between soil nail length (L_n) and friction angle (ϕ') for different combinations of slope angle (β) and cohesion (c'), calculated for a target FOS of 1.5. This figure was generated using Equation (2), derived by rearranging Equation (1) to solve for the required nail length, providing a practical tool for understanding the influence of soil properties and slope geometry on slope stability.

$$L_N = \frac{1.5 - 0.0422\phi' - 0.0562c' + 0.0137\beta - 0.388)}{0.0665} b) \quad (2)$$

The required length of soil nails is primarily governed by the soil's friction angle, cohesion, and slope inclination. Soils with higher friction angles exhibit greater inter-particle resistance to sliding, reducing the need for long nails as the soil mass provides sufficient shear strength to maintain stability. Conversely, soils with lower friction angles are inherently less stable and therefore require longer nails to achieve the desired Factor of Safety (FOS). Slope geometry exerts a significant influence on reinforcement demand, where gentle slopes with approximately 30° inclination typically require shorter nails due to lower gravitational driving forces, while very steep or vertical slopes approaching 90° demand substantially longer nails to resist increased sliding tendencies. Cohesion further contributes to stability enhancement for higher cohesion values, such as 15 kN/m², strengthen soil bonding and reduce reliance on external reinforcement, whereas soils with negligible cohesion depend heavily on

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frictional resistance and reinforcement length to remain stable (Pun & Shiu, 2007). Integrating these parameters enables engineers to optimise soil nail lengths to achieve both structural safety and economic efficiency. This optimisation ensures adequate support without excessive material use, thereby promoting cost-effective slope design. In weaker soils characterised by low friction and cohesion, longer nails become essential to maintain equilibrium and minimise the likelihood of slope failure. The results underscore the importance of tailoring soil nail length to site-specific conditions and geometric configurations to achieve stable, efficient, and sustainable slope reinforcement designs.

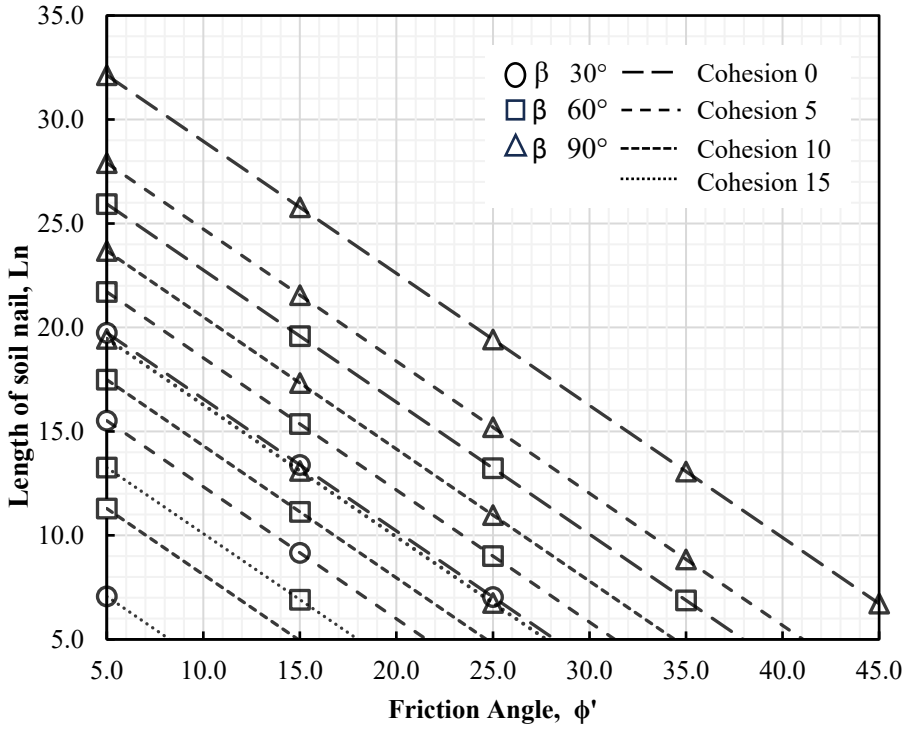


Figure 3: Impact of soil nail length on slope stability using various shear strength parameters
Source: Author's calculation

CONCLUSION

This study employed multiple regression analysis to comprehensively evaluate the influence of soil nailing on slope stability, revealing that slope angle, soil nail length, and soil shear strength parameters significantly affect the FOS. Steeper slopes and soils with lower friction angles present greater stability challenges,

whereas longer soil nails and higher cohesion values enhance stability, while gentle slopes require shorter nails due to lower gravitational driving forces (FHWA, 1998). The main contribution of this research lies in the development of a predictive regression model that integrates soil shear strength, slope geometry, and reinforcement length, achieving an R^2 value of 0.8 and explaining 80% of the FOS variability. This provides a quantitative framework for optimizing soil nail length across various soil and slope conditions, offering practical design guidance and advancing slope stabilization practices beyond conventional empirical methods. However, the study is limited to residual soil conditions typical of Malaysian sites and does not consider long-term factors such as weathering, groundwater fluctuations, or seismic loading that may influence slope performance. Future research should therefore expand the model to include these geotechnical and environmental variables, validate its performance through field observations, and develop site-specific design recommendations. Overall, this study establishes a robust, interpretable framework for understanding the interaction between soil properties, slope geometry, and reinforcement design, contributing to safer, more cost-effective, and optimized slope stabilization in geotechnical engineering practice.

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THE INTERACTION OF AGRICULTURE AND ECONOMIC FACTORS IN SHAPING EMISSIONS: INSIGHTS FROM SOUTHEAST ASIA USING PANEL QUANTILE REGRESSION

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Abstract

Environmental degradation remains a critical concern in Southeast Asia, driven by rapid economic expansion, agricultural activity, population growth and trade liberalization. This study examines the heterogeneous impact of key agricultural and economic factors, namely, trade openness, Gross Domestic Product (GDP), population growth, technology, and agricultural land use, on CO_2 emissions across Southeast Asia countries from 1996 to 2021. We employ panel quantile regression (PQR) to capture variations in emissions across different quantiles. All variables are transformed into natural logarithmic form to address skewness, ensure consistency and interpret elasticities effectively. We address cross-sectional dependence and non-stationarity using Pesaran's CD test, CADF unit root test, and Westerlund cointegration analysis. The findings reveal that trade openness significantly increases emissions across all quantiles, while GDP shows a negative association with emissions, in line with the Environmental Kuznets Curve (EKC) hypothesis. In addition, population growth, technology and agricultural land use are found to be statistically insignificant across the emission distribution. These insights offer important implications for policy formulation aimed at balancing economic growth with environmental protection in Southeast Asia.

Keywords: Agriculture, Panel Quantile Regression, Pollution, Environmental

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INTRODUCTION

Environmental pollution is a growing concern worldwide and Southeast Asia (SA) faces acute challenges from rapid economic growth, industrialization and population expansion. As prosperity increases, the environmental toll becomes visible through higher greenhouse-gas emissions, air and water pollution, and ecosystem degradation (He et al., 2024; Song et al., 2024). Agriculture, trade and technology have each contributed to these pressures, making it crucial to understand how economic activity and farming practices affect pollution. With countries at different stages of development and environmental readiness, SA requires a region-specific strategy to manage and reduce emissions effectively.

Economic growth, central to development, poses a dual challenge for environmental sustainability. The Environmental Kuznets Curve (EKC) hypothesis posits that growth first increases environmental degradation but eventually fosters sustainability through technological progress and stricter regulation (Özcan & Öztürk, 2019; Liu & Lai, 2021; Pesaran & Takashi, 2008, Potipituk, 2019). In SA, Malaysia and Thailand show signs of the inverted U relationship between GDP and emissions (Nordin et al., 2024), while lower-income economies such as Cambodia and Myanmar still experience rising emissions as resource-intensive industries expand (Madni, 2023). Balancing economic growth with sustainability policies is therefore essential for the region's long-term ecological health.

Trade liberalization, another major growth driver, has diversified SA's economies and deepened global integration, yet its environmental effects are mixed. The pollution-haven hypothesis suggests that trade openness can relocate polluting industries to countries with weaker environmental standards (Chaudhry et al., 2022; Liu et al., 2021; Weixian, 2024). At the same time, trade enables technology transfer and cleaner production in economies with stronger institutions such as Singapore. Understanding this duality is vital for crafting balanced trade and environmental policies across ASEAN.

Technological innovation also shapes emission trajectories. The adoption of automation, artificial intelligence and the Internet of Things, key elements of Industry 4.0, offers pathways to greater efficiency and circular-economy practices (Muhammad et al., 2022; Matarneh et al., 2024; Shabur, 2024). However, uneven technological readiness across ASEAN creates disparities in environmental performance. Advanced economies such as Singapore and Malaysia are integrating digital solutions for cleaner growth, whereas others face infrastructure and capacity constraints.

This study investigates how economic and agricultural factors interact to influence emissions across SA using panel quantile regression (PQR). By capturing heterogeneity across pollution levels, the analysis provides a nuanced understanding of how different drivers affect emissions in low-, medium-, and

high-polluting contexts. The findings aim to inform policymakers on designing targeted strategies that align economic development with environmental sustainability in SA.

The remainder of the paper is structured as follows: Section 2 reviews relevant literature, Section 3 describes the research methodology, Section 4 presents the empirical results and Section 5 concludes with policy implications.

LITERATURE REVIEW

Environmental sustainability has become a major concern in rapidly developing regions such as Southeast Asia (SA), where economic growth, technological progress and agricultural expansion have intensified greenhouse-gas emissions and resource depletion. Studies show that agricultural production strongly influences economic output and environmental emissions in Cambodia, Thailand, and Vietnam (Sonthaya & Witsanu, 2021). The use of fertilizers, pesticides and irrigation systems contributes to agricultural emissions, while economic factors such as GDP growth and exchange rates shape agricultural productivity (SHE et al., 2024). Promoting sustainable farming practices is crucial for reducing emissions and ensuring food security under climate change (Mishra et al., 2021). Economic indicators like GDP and foreign direct investment also affect renewable energy use and emissions (Tran, 2023), emphasizing the need for policies balancing growth and sustainability (Sangco, 2024). Although studies have explored emission drivers in SA (Shiraishi et al., 2023; Mohd et al., 2022), many overlook the varying effects of trade, agriculture and GDP across pollution levels. This study addresses that gap by using panel quantile regression (PQR) to capture these differences and provide targeted policy insights.

Evidence shows that reducing pesticide use does not necessarily lower productivity, suggesting sustainable farming can preserve yields while cutting emissions (Roberto, 2014). Government support mechanisms such as subsidies, regulations and financing are essential for advancing sustainable agriculture (Barbosa, 2014). Advanced technologies further enhance productivity and environmental efficiency, though financial and infrastructural barriers persist (Ismail et al., 2024). These findings highlight the need to integrate environmental considerations into agricultural systems to mitigate pollution and secure long-term sustainability.

Trade liberalization has driven SA's economic growth but also accelerated industrialization and environmental degradation. The pollution-haven hypothesis proposes that open trade can attract emission-intensive industries to countries with weak regulations (Chaudhry et al., 2022), as seen in Vietnam and Indonesia (Muhammad et al., 2022; Liu et al., 2021). Conversely, trade can also foster technology transfer and cleaner production, especially in advanced

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economies like Singapore (Weixian, 2024). This duality underscores the need for region-specific trade–environment strategies balancing growth and sustainability.

Agricultural expansion remains a leading cause of deforestation, biodiversity loss and carbon emissions in SA. Indonesia and Malaysia, as major palm oil producers, have experienced deforestation and peatland degradation contributing to transboundary haze pollution (Yin et al., 2024; Yujie et al., 2025). Precision agriculture and sustainable farming practices can mitigate these effects, yet policy and economic barriers limit their widespread adoption.

Technological innovation plays a key role in reducing emissions while supporting growth. The rise of Industry Revolution (IR) 4.0, automation, AI, big data analytics and IoT, offers pathways toward cleaner industrial production and circular economy adoption. Studies show that these technologies enhance sustainability by improving supply-chain efficiency and resource use (Matarneh et al., 2024), while smart manufacturing and digital monitoring further advance industrial environmental goals (Shabur, 2024). However, unequal digital capacity across ASEAN countries leads to disparities in environmental performance, with Singapore and Malaysia progressing faster than less-developed members.

Population growth and urbanization intensify environmental pressure through increased emissions, deforestation and waste generation. Rapid population growth and urbanization in SA have placed immense pressure on natural resources, contributing to increased emissions, deforestation and waste generation. Urban sprawl and the expansion of informal settlements exacerbate pollution levels, highlighting the need for sustainable urban planning and investment in eco-friendly infrastructure (Yujie et al., 2025; Leh et al., 2020). Population-driven resource demand also amplifies agricultural land use, worsening environmental degradation.

Quantile regression methods have proven valuable in examining the relationship between economic and environmental factors at different pollution levels. Traditional mean-based analyses often mask heterogeneity across SA countries with differing levels of industrialization, technology and agriculture (Ikram et al., 2023; Adnan et al., 2024). The PQR, by contrast, captures variations among low-, medium-, and high-polluting countries, accounting for outliers and country-specific effects. This makes PQR particularly suitable for identifying tailored policies across ASEAN. Despite extensive research on the economy–emissions nexus, few studies in SA have examined combined effects of trade, agriculture, technology and population growth or employed advanced approaches such as the method of moments quantile regression (MMQR) (Smarnika et al., 2023).

Overall, SA faces significant environmental challenges shaped by economic and agricultural drivers. While technological progress and economic growth offer opportunities for emission reduction, trade liberalization and

agricultural expansion continue to threaten sustainability. Existing PQR studies in OECD and BRICS contexts (Ikram et al., 2023; Işık et al., 2024; Smarnika et al., 2023) may not capture SA's unique structural diversity and policy constraints. This study therefore extends the literature by applying PQR to assess heterogeneous emission drivers across quantiles, advancing both methodological robustness and policy relevance for developing economies in the region.

RESEARCH METHODOLOGY

This study employs panel data for Southeast Asia (SA) countries from 1990 to 2021, including Brunei, Cambodia, Indonesia, Laos, Malaysia, Philippines, Thailand and Vietnam, collected from the World Development Indicators (WDI) and FAOSTAT. The dataset includes the pollution (CO_2 emissions) (metric tons per capita), representing environmental impact, trade as a percentage of GDP, indicating economic openness, GDP in constant 2015 US dollars, representing economic growth, annual population growth rate (%), the share of medium and high-tech manufacturing in total manufacturing value added to describe technological advancements and percentage of land area used for agriculture.

Panel quantile regression (PQR) was selected as it allows for the exploration of heterogeneous effects of key variables, such as trade openness and GDP, across varying emissions levels. Unlike mean-based models, PQR captures variations across quantiles, offering more profound insights into the dynamics of low, medium, and high pollution regions. This method is particularly suited to the socio-economic diversity of SA.

Before conducting further analysis, diagnostic tests, namely cross-sectional dependence (CSD), were conducted to determine whether the variables exhibit interdependencies across countries. Ignoring cross-sectional reliance can lead to biased results and invalid inferences. Pesaran's CSD test detects cross-sectional dependence in the panel data; the null hypothesis, H_o is that there is no cross-sectional dependence in the panel data. The tests are:

Pesaran (2004) CD Test, $CD = \sqrt{\frac{2}{N(N-1)} \sum_{i-1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}}$ (1)

Breush-Pagan LM Test, $LM = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}$ (2)

Pesaran Scaled LM Test, $LM_{scaled} = \frac{1}{N(N-1)} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (\hat{\rho}_{ij}^2 - 1)$ (3)

where $\hat{\rho}_{ij}$ represents the pairwise correlation of residuals between cross-section units i and j. These diagnostic tests utilize $\hat{\rho}_{ij}$ to evaluate the linear association of residuals, ensuring cross-sectional dependence is thoroughly

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examined. The Breusch-Pagan LM test evaluates cross-sectional dependence using the defined $\hat{\rho}_{ij}$ metric, computed across all panel units.

To check the stationarity of the panel data, the study employs a second-generation panel unit root test, which accounts for the CSD, CADF (Cross-sectionally Augmented Dickey-Fuller) Test. This test helps determine whether the variables are stationary at levels or first differences, guiding the choice of appropriate econometric models. For a given y_{it}, the CADF test is based on the following regression:

$$\Delta y_{it} = \alpha_i + \beta_i y_{it-1} + \gamma_i \bar{y}_{t-1} + \delta_i \Delta \bar{y}_t \sum_{j=1}^{p} \emptyset_{ij} \Delta y_{it-j} + \varepsilon_{it} \quad (4)$$

where $\Delta y_{it} = y_{it} - y_{it-1}$, $\bar{y}_t$ is the cross-sectional mean of y_t, α_i is an individual-specific intercept, β_i is the coefficient for the lagged level of y_{it}, γ_i and δ_i are coefficients for the cross-sectional mean terms and ε_{it} is the error term. The H_o is the panel contain a unit root (non-stationary) against H_a at least some cross-sectional units are stationary.

In analysing panel data, it is essential to determine whether a long-run equilibrium relationship exists among the variables. The Westerlund Error-Correction Model (ECM) Panel Cointegration Test, introduced by Westerlund (2007), is employed to assess the presence of cointegration among the variables in the panel data. Unlike traditional residual-based tests such as the Pedroni or Kao test, Westerlund's approach is based on an error correction model (ECM). It is advantageous because it accounts for CSD and provides robust results in heterogeneous panels. For a dependent variable y_{it} and explanatory variables $x_{,it}$ the ECM representation is:

$$\Delta y_{it} = \alpha_i + \delta_i (y_{it-1} - \beta_i x_{it-1}) + \sum_{j=1}^{p} \emptyset_{ij} \Delta y_{it-j} + \sum_{k=1}^{q} \varphi_{ik} \Delta x_{it-k} + \varepsilon_{it} \quad (5)$$

where δ_i is the speed of adjustment to the long-run equilibrium, $y_{it-j} - \beta_i x_{it-1}$is the long-run equilibrium relationship and ε_{it} is the error term. This test examines the H_o: There is no cointegration exists among the variables, and it provides four test statistics, *Gt* statistic, *Ga* statistic, *Pt* statistic and *Pa* statistic, to test the presence of cointegration in individual units, to test whether most units have cointegration, to test for cointegration across the whole panel and to evaluate cointegration across all units in the panel collectively.

Given the heterogeneous relationship between emissions and their determinants, PQR captures varying effects across different pollution levels. Unlike traditional regression methods focusing on mean effects, quantile regression provides a more detailed analysis of how explanatory variables

influence the conditional distribution of emissions. The empirical quantile regression model for this study is specified as follows:

$$Q_\tau(\ln CO2_{it}\,|X_{it}) = \alpha_\tau + \beta_{\tau,1} ln\ agr_{it} + \beta_{\tau,2} ln\ pop_{it} + \beta_{\tau,3} \ln tech_{it} + \beta_{\tau,4} \ln trd_{it} + \beta_{\tau,5} \ln gdp_{it} + \varepsilon_{it} \quad (6)$$

where $Q_\tau(CO2_{it}|X_{it})$ denotes the conditional quantile of emissions for the country i at time t, X_{it} represents the vector of independent variables, α_τ and β_τ are the quantile-specific intercept and coefficients, respectively. τ represents the quantile level, where $\tau\epsilon(0,1)$. The CO2, agr, pop, tech, trd and gdp indicate the variables: carbon dioxide, agricultural, population, technology trade and GDP, respectively. The data are transformed into logarithmic forms to reduce skewness, facilitate elasticity interpretation and improve the comparability of variables. Quantile levels analyzed include the 25th, 50th, 75th and 95th percentiles, enabling the analysis of varying effects across low, medium and high pollution levels. The three main advantages of PQR are its ability to capture heterogeneity, robustness to outliers and policy-related insights. Last, similar to (Sultana et al., 2023; Işık et al., 2024), the Wald test is employed to assess the joint significance of the explanatory variables in the quantile regression model across different quantiles. This provides a robust means to determine whether the variables included in the model have a statistically significant impact on CO_2 emissions. The Wald test evaluates the joint significance of the coefficients in a linear model. In a quantile regression framework, the H_o states that all coefficients for a set of explanatory variables are jointly equal to zero, $H_o: \beta_1 = \beta_2 = \cdots = \beta_k = 0$. The test statistic W follows a chi-square distribution with degrees of freedom equal to the number of restrictions (number of coefficients tested jointly), $W \sim \mathcal{X}^2(k)$ where k is the number of explanatory variables being checked for joint significance in the test.

The data analysis and econometric testing, including PQR, diagnostic checks and cointegration tests, were conducted using STATA.

ANALYSIS AND DISCUSSION

Throughout the analysis, *** indicates statistical significance at the 1% level, ** at the 5% level and * at the 10% level, applicable to all statistical tests conducted in this study. To begin, the CSD tests were conducted to examine whether the residuals of the panel data are correlated across cross-sectional units. As shown in Table 1, the Pesaran's CD test (statistic=11.08, $p < 0.01$), indicates significant cross-sectional dependence. Similarly, the Breusch-Pagan LM test (statistic=163.284, $p < 0.01$) confirms the presence of strong dependence among the cross-sectional units. The Pesaran Scaled LM test result (statistic = 11.076, p

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< 0.01) further supports this conclusion. These consistent findings suggest that ignoring cross-sectional dependence could lead to biased and inefficient estimates. The CADF test explicitly accounts for cross-sectional dependence by incorporating cross-sectional averages of the series and lagged differences in the model. This test is instrumental in panels with heterogeneous panels and cross-sectional correlations, common in macroeconomic and environmental studies. The results in Table 2 indicate that, at the level, most variables fail to reject the H_0, indicating they are non-stationary at the level (i.e., they contain a unit root). After taking the first difference, the test statistics show that the H_0 of a unit root is rejected for most variables at a 1% significance level. This implies that the variables become stationary at the first difference, $I(1)$.

The Westerlund ECM panel cointegration test examines the presence of a long-run relationship among the variables, with the H_0 stating that there is no cointegration. The results in Table 3 exhibit that the *Gt* statistic is significant at the 5% level (Z = -2.067, p < 0.05), indicating the rejection of the H_0 for some cross-sections, suggesting evidence of cointegration for specific units. However, the *Ga*, *Pt*, and *Pa* statistics are insignificant, implying that there is no firm evidence of cointegration for the panel as a whole. The results suggest that while a long-run relationship may exist for a subset of the cross-sectional units, it is not prevalent across the entire panel.

Table 1: Cross-Sectional Dependence Test Results

Test	Statistic
Pesaran (2004) CD	11.08***
Pesaran Scaled LM	11.076***
Breush-Pagan LM	163.284***

Table 2: Pesaran CADF Panel Unit Root Test Results

Variable	Lags	Level (t-bar)	First Difference (t-bar)
ln CO2	0	-1.889	-4.017***
	1	-1.726	-3.333 ***
	2	-1.296	-2.054
ln agr	0	-1.155	-3.089 ***
	1	-2.096	-1.859
	2	-2.124	-1.476
ln pop	0	-1.282	-2.525 **
	1	-2.074	-3.142 ***
	2	-1.137	-2.009
ln tech	0	-1.76	-5.347 ***
	1	-1.835	-4.087 ***
	2	-1.763	-2.741 ***

Variable	Lags	Level (t-bar)	First Difference (t-bar)
ln trd	0	2.121	-6.076 ***
	1	1.774	-4.662 ***
	2	1.598	-1.170
ln gdp	0	-2.458 **	-3.103 ***
	1	-2.824 ***	-2.805 ***
	2	-1.708	-1.641

Table 3: Westerlund ECM Cointegration Test

Statistic	Z-value
Gt	-2.067**
Ga	3.403
Pt	1.163
Pa	2.169

The empirical analysis begins with the quantile regression results in Table 4, which reveal the heterogeneous effects of the explanatory variables on pollution levels across different quantiles (0.25, 0.50, 0.75, 0.95). The variable ln pop (population) shows a consistently positive but statistically insignificant impact on pollution across all quantiles, indicating that population growth does not significantly contribute to variations in pollution levels within this context. Similarly, ln agr (agricultural land) exhibits positive coefficients across all quantiles, with an increasing trend from the lower to the upper quantiles. However, the variable remains statistically insignificant at all quantiles, suggesting that agricultural land use does not play a decisive role in pollution levels in this sample. On the other hand, ln tech (technology) presents mixed effects with generally small coefficients that are statistically insignificant across all quantiles. This implies that the level of technology adoption in the observed countries may not directly impact pollution significantly, potentially due to variations in technology quality or inconsistent implementation across regions.

The insignificant effects of population growth, agricultural land use, and technology may reflect several contextual and methodological factors. First, the population variable, measured as total growth rate, may not adequately capture urban concentration or consumption intensity, both of which are more directly linked to emissions. In SA, large portions of the population remain in rural or semi-urban areas with lower per capita energy use, diluting the overall statistical effect of population on emissions. Second, agricultural land use, while extensive, varies greatly in its environmental impact depending on crop type, intensity, and land management practices. Aggregate agricultural land data may therefore mask variations between high-emission (e.g., palm oil, rice) and low-emission (e.g., mixed cropping) systems across countries. Third, the technological indicator,

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measured by the share of medium and high-tech manufacturing, primarily reflects industrial advancement rather than green innovation or renewable adoption. As such, it may not fully capture the environmental dimension of technology, leading to its weak statistical association with emissions. Finally, the influence of these variables may exhibit lagged effects, where technological diffusion or demographic transitions impact environmental outcomes only after several years. Future studies could incorporate disaggregated or time-lagged data to better capture these delayed and sector-specific dynamics.

In contrast, ln trd (trade openness) consistently shows a positive and highly significant effect across all quantiles, indicating that trade openness is a key driver of pollution. This result supports the notion that increased trade activities are associated with higher emissions, likely due to expanded industrial activities and the transportation of goods.

The variable ln gdp (GDP per capita) has a significant negative coefficient across all quantiles, confirming its inverse relationship with pollution. The results align with the EKC hypothesis, suggesting that higher income levels are associated with pollution reduction as countries shift toward cleaner technologies and more stringent environmental regulations. The negative relationship between GDP and emissions in higher quantiles confirms that wealthier ASEAN economies are progressing along the EKC's descending path, reflecting the benefits of industrial upgrading and environmental policy maturity. However, the persistence of rising emissions in lower-income countries underscores the need for regionally differentiated strategies that support sustainable industrialization without compromising growth.

To validate the robustness of the quantile regression results, the Wald test is performed across all quantiles. The results indicate the joint significance of the explanatory variables at each quantile (Chi-squared statistics = 373.25, 711.33, 475.63, and 156.47, $p<0.01$) for the 0.25, 0.50, 0.75, and 0.95 quantiles. While only two out of the five variables are statistically significant, the results suggest that the set of variables collectively contributes to understanding pollution levels. The statistically significant factors demonstrate substantial individual impacts, while the remaining variables provide context for the broader relationships within the model.

SA's rapid growth has brought environmental challenges, mainly as trade openness drives up CO_2 emissions in countries like Malaysia and Indonesia. The study suggests that to keep growing without harming the environment, the region needs more innovative trade policies and targeted efforts to cut emissions, particularly from high-emitting industries. Promoting energy-efficient practices and tackling deforestation from activities like palm oil farming are also key. While technology and population growth play more minor roles for now, the path

forward lies in balancing economic progress with sustainability through greener practices and stronger environmental policies.

Table 4: Quantile Regression Estimation Results

Quantile	Q25	Q50	Q75	Q95
ln agr	0.1264	0.1506	0.1677	0.1896
ln pop	0.0232	0.0170	0.0126	0.0069
ln tech	-0.0253	-0.0112	-0.0013	0.0114
ln trd	0.2259***	0.2222***	0.2196***	0.2162***
ln gdp	-0.3634***	-0.3494***	-0.3395****	-0.3268***

Table 5: Wald Test Summary by Quantile

Quantile	Chi-square
0.25	373.25***
0.5	711.33***
0.75	475.63***
0.95	156.47***

CONCLUSION

This study examines the relationship between CO_2 emissions and their key drivers, including population growth, agricultural activities, technological progress, trade openness, and economic growth, using panel quantile regression (PQR). By capturing the heterogeneity of these relationships at different levels of pollution intensity, the analysis offers valuable insights into the varying impacts of these factors across quantiles. The findings emphasize the need for targeted, quantile-specific policy interventions that address diverse pollution levels effectively. Trade openness consistently shows a positive and significant impact on emissions, underscoring the role of trade-driven economic activities in contributing to pollution. Meanwhile, economic growth demonstrates a significant negative relationship with emissions at higher quantiles, supporting the Environmental Kuznets Curve (EKC) hypothesis. These results suggest that policies promoting green technologies and energy-efficient practices can mitigate emissions as economies grow. Agricultural activities reveal potential environmental risks, particularly in highly polluted areas, necessitating sustainable farming practices and reforestation efforts. Population growth and technological progress show limited immediate effects on emissions but may interact with other factors over time. The findings can inform policies that balance economic growth with environmental protection. Governments in SA could regulate trade-related emissions, prioritize sustainable agricultural practices and invest in renewable energy to address pollution challenges effectively. The policy implications of this study highlight the importance of

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adopting targeted, sector-specific, and regionally coordinated measures to reduce emissions without compromising economic growth.

In the transportation sector, countries such as Indonesia, Thailand, and the Philippines could reduce emissions by accelerating the transition to electric public transport systems, promoting cleaner fuels and improving urban mobility planning. Given that transport contributes significantly to urban air pollution, especially in megacities like Jakarta and Bangkok, investments in green infrastructure and incentives for low-emission vehicles can yield immediate benefits.

In the agricultural sector, particularly in the context of palm oil production in Malaysia and Indonesia, stricter land-use management and reforestation initiatives are vital. Policies could emphasize enforcing "no-deforestation" supply chains, supporting smallholders through sustainable certification programs and promoting precision agriculture technologies to reduce fertilizer and pesticide overuse. These measures directly address the study's findings that agricultural land use, though statistically insignificant in the short term, carries potential long-term risks for emissions and biodiversity loss.

The manufacturing sector also offers critical opportunities for emission reduction through technology upgrading and energy efficiency. Governments can support industries in adopting low-carbon technologies, renewable energy sources, and digital monitoring tools under Industry 4.0 frameworks. These transitions are especially relevant for upper-quantile countries (e.g., Malaysia, Thailand, Singapore), where GDP's inverse relationship with emissions reflects growing environmental awareness and technological advancement.

At the regional level, the ASEAN Green Recovery Plan provides an important platform for collective action. By coordinating policies on clean energy investment, carbon pricing mechanisms and sustainable trade practices, ASEAN can harmonize environmental standards and promote knowledge transfer among member states. Regional initiatives can also mobilize funding for climate adaptation projects and support low-income countries such as Laos, Cambodia, and Myanmar in accelerating their transition toward sustainable industrialization. Overall, operationalizing these sectoral and regional strategies can help SA achieve a balanced path of economic growth and environmental protection. The quantile-specific insights from this study provide policymakers with evidence to tailor interventions according to pollution intensity and development level, ensuring that mitigation policies are both equitable and effective across the region

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DISCLOSURE
There is no conflict of interest in this research.

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RIDERSHIP PREDICTION SYSTEM FOR RAPID BUS KUANTAN AND PENANG USING MULTI-FEATURE ANALYSIS

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Abstract

Public transportation systems in Malaysia, particularly bus services in urban areas such as Kuantan and Penang, often struggle with inefficient scheduling and underutilized resources due to a lack of accurate demand forecasting tools. This study addresses the problem by developing a Ridership Prediction System for Rapid Bus Kuantan and Penang, employing a multi-feature analysis approach to predict bus ridership patterns based on various influencing factors, including weather conditions, weekends, and public holidays. The system aims to enhance public transportation efficiency through data-driven decision-making. A dataset covering ridership data from 2022 to 2024 was compiled from multiple sources, including Malaysia's Official Open Data Portal, Open-Meteo, and Office Holidays. The study employs several machine learning models, including Multiple Linear Regression (MLR), Ridge Regression (RR), Support Vector Regression (SVR), Artificial Neural Networks (ANN), and Random Forest (RF), to analyze ridership trends and forecast demand. Evaluation results indicate that the Random Forest model outperforms other models, achieving the highest accuracy with an R-squared value of 0.9940, making it the optimal choice for prediction. A Graphical User Interface (GUI) is also developed to visualize ridership forecasts, enabling transit operators to make informed scheduling and resource allocation decisions. The system offers valuable insights for enhancing public transportation services and improving the passenger experience. Future improvements include integrating real-time Internet of Things (IoT)-based data collection and exploring advanced deep learning techniques to further refine prediction accuracy.

***Keywords*:** Ridership, Predictive Modelling, Machine Learning, Public Transportation.

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INTRODUCTION

Public transportation plays a vital role in promoting urban mobility by providing a cost-effective, accessible, and environmentally sustainable alternative to private vehicles. However, accurately forecasting transit demand remains a challenge due to fluctuations driven by external factors such as weather conditions, public holidays, and socio-economic activities. Reliable ridership prediction is therefore essential for efficient service planning, optimal resource allocation, and improved passenger satisfaction (Rosni et al., 2025). In Malaysia, Rapid Bus services, operated by Prasarana Malaysia Berhad, form the backbone of urban public transport in several major cities, including Kuantan, Penang, and the Klang Valley. Among these, Rapid Kuantan and Rapid Penang were selected for this study due to their contrasting ridership patterns and strategic importance in the national transit network. Penang consistently reports high passenger volumes, reflecting its status as a densely populated urban and economic hub (Aziz & Mohamad, 2020). In contrast, Kuantan experiences more modest ridership levels, despite being a key administrative and commercial center on the East Coast. These disparities present a unique opportunity to examine how different urban contexts, regional demographics, and service characteristics influence bus usage.

Recent advancements in machine learning (ML) have demonstrated superior predictive capabilities over traditional statistical models by capturing complex, non-linear relationships in public transport datasets (Rocco di Torrepadula et al., 2024). International studies have effectively applied ML techniques such as Neural Networks (NN) (Jing et al., 2020; Farahmand et al., 2023), Long-Short Term Memory (Siswanto et al., 2024), support vector regressor (SVR) (Li et al., 2020), ensemble learning (Ge et al., 2024), and others in forecasting transit demand while incorporating factors like weather, holidays, and temporal variations. Despite these advancements, a gap remains in research focusing on Malaysia's public transportation system, particularly in developing a multi-feature ridership prediction model tailored to local transit conditions.

A study by Moosavi et al. (2023) employed chi-square automatic interaction detection (CHAID), Random Forest (RF), and gradient-boosted tree (GBT) models to determine which method is most accurate for predicting bus travel times on high- and low-frequency bus routes. This study also aims to determine the most applicable route construction approach. The dataset for this study was obtained from RapidKL Bus, consisting of raw AVL data that records the time-stamped locations of buses every 5 seconds. Based on the study's results, CHAID was the most accurate model for predicting travel time on high-frequency routes, while GBT showed the best performance for low-frequency service. This study also introduced the "key stop-based" route construction method, which is an accurate, reliable, and applicable method (Moosavi et al., 2023).

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Lim et al. (2024) conducted a study focusing on public bus journey times, employing a methodology distinct from that of Moosavi et al. (2023). In this study, a basic artificial neural network (ANN) was developed and trained using a GPS dataset from a bus fleet in Johor, Malaysia. The results indicated that the model's accuracy improved compared to baseline approaches by incorporating factors such as bus stops, time of day, and travel distance (Lim et al., 2024). There have been few studies conducted on predicting ridership in Malaysia. A study by Zahir and Haron (2019) identified the factors that affect the operation of the myBAS service in Perlis. Three routes were selected as the case studies since they have the most access to popular cities. The authors utilized Atlas Ti Version 7.0 to analyze data and identify 11 factors affecting service operation. The results from the study indicated that LOS for headway pattern during peak hour on routes T101, F101, and CF109 is in the range of E (30min to 60 min) with one bus arriving per hour based on the United States Highway Capacity Manual 2010 (USHCM 2010) (Zahir & Haron, 2019). Although the findings from this study may benefit the local authority in achieving the status of a sustainable city by 2030, in line with the United Nations' declaration that focuses on green and healthy cities, the study did not apply any machine learning techniques in its prediction.

Finally, a preliminary analysis study was conducted to examine the factors influencing bus transit ridership. This study utilized correlation and multiple linear regression (MLR) analyses, focusing on ridership during peak and off-peak hours. Key factors investigated included bus commercial speed, service frequency, in-vehicle travel time, bus stop distance, and rainfall. The findings indicate that all these factors are significant and correlated with ridership. However, the regression models revealed that distance and travel time are not statistically significant in affecting ridership during peak and off-peak hours (Karunakaran et al., 2023).

Most existing local studies focus on travel time prediction (e.g., using Random Forest, GBT, or ANN models) or operational analysis, with limited attention given to direct ridership forecasting. Furthermore, these studies often rely on traditional statistical techniques or single-feature analyses without incorporating multi-dimensional external influences such as weather conditions, holiday schedules, and service-related variables. Additionally, there is a geographical imbalance, as most research focuses on the Klang Valley and Johor, leaving Kuantan and Penang relatively underexplored, despite their significance. Moreover, few studies conduct a comparative evaluation of multiple ML models under Malaysian transit conditions to identify the most effective approach. There is also a lack of practical, user-friendly tools, such as an interactive Graphical User Interface (GUI) that translates predictive models into actionable insights for transit operators and policymakers.

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This study addresses these gaps by developing a multi-feature ridership prediction system for Rapid Bus services in Kuantan and Penang. It evaluates the performance of five ML models: MLR, Ridge Regression (RR), SVR, ANN, and RF using the datasets compiled from Malaysia's Official Open Data Portal, Open-Meteo, and Office Holidays for the period from 2022 to 2024. The system incorporates external variables such as weather and public holidays. It provides a GUI for visualization, offering a practical tool for developing support to inform data-driven scheduling and resource management decisions.

RESEARCH METHODOLOGY

This research encompasses five primary processes aimed at enhancing the effectiveness and accuracy of ridership predictions for Rapid Bus services in Kuantan and Penang. The initial phase involves data collection through various platforms, including data.gov.my for ridership statistics, Open-Meteo for meteorological data, and Office Holidays for holiday schedules spanning the years 2022 to 2024. Subsequently, the acquired data undergoes processing during the data pre-processing stage. Jupyter Notebook facilitates the integration of holiday and weather data relevant to Kuantan and Penang. At the same time, pgAdmin is employed to consolidate the necessary CSV files and encapsulate ridership, holiday, and weather data into a unified database. The next step is data cleaning, conducted in Jupyter Notebook, to address missing values, inconsistencies, and noise, thereby ensuring the data's suitability for subsequent analysis.

After the data is cleaned, it is partitioned into two portions: 80% for model training and 20% for model testing. The models utilized in this study include MLR, Ridge Regression (RR), SVR, ANN, and RF. Subsequently, all the models are assessed using metrics such as R-Squared (R^2), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Mean Squared Error (MSE) to evaluate their performance. If the performance metrics are inadequate, the process will revert to the development phase for hyperparameter tuning. Once the model meets the performance standards, it is integrated into a Graphical User Interface (GUI) for deployment and use. The entire flow of this research is illustrated in Figure 1.

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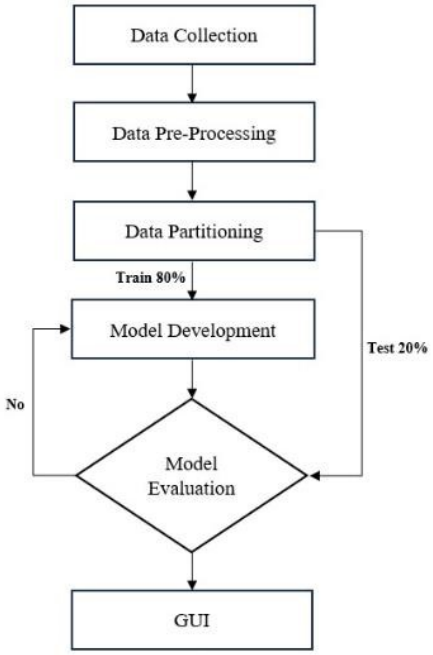


Figure 3: Research Flow Chart

Data Collection

Data for this project was collected through web scraping and downloading datasets from multiple sources. We employed scraping techniques to gather information about public holidays in Kuantan and Penang for the years 2022, 2023, and 2024 from the "Office Holidays" website, utilizing Jupyter Notebook. Additionally, a dataset with weather information for the years 2022, 2023, and 2024 was retrieved from the Open-Meteo website. We also gathered similar data on the number of public transport passengers on Prasarana Rapid Bus from 2022 to 2024 from the data.gov.my platform (Data Catalog). Table 1 describes each variable used in this study.

Table 3: Description of Each Variable

Variable	Data Type	Example	Description
date	Datetime	"2022-01-01"	The date in YYYY-MM-DD format, daily recorded
ridership_day	String	"Saturday"	Day of ridership
bus_rkn	Integer	"1722"	Amount of ridership in Rapid Bus Kuantan
bus_rkp	Integer	"39460"	Amount of ridership in Rapid Bus Penang

Variable	Data Type	Example	Description
ridership_location	String	"Kuantan"	Location of ridership
holiday_day	String	"Sunday"	Day of holiday
holiday_name	String	"Hari Raya Aidilfitri"	Name of holiday
holiday_type	String	"National Holiday"	Type of holiday
weather_day	String	"Monday"	Day of the weather
weather_code	Integer	"57"	Code for weather
temperature	Float	"23.96"	Temperature of the day in °C
rain	Float	"1.64"	Amount of rain in a day in millimeters (mm)

Data Preprocessing

In data preprocessing, multiple datasets were combined and reorganized into one dataset using Jupyter Notebook and pgAdmin. The 2022, 2023, and 2024 holiday data were first merged into a single file named "Holiday." Similarly, the weather data collected from the two areas, Kuantan and Penang, was consolidated into one file called "Weather." Finally, pgAdmin was utilized as a tool to combine the Ridership, Holiday, and Weather data into one file named “Combined Data." This transformation process ensured that all essential data was aggregated and organized, facilitating further analysis and modelling. After combining and organizing the data and thoroughly understanding the datasets during the description phase, the next step is to proceed with data cleaning. This involved processes such as formatting dates, dropping and renaming columns, checking for missing values and duplicates, and addressing outliers. Following this, exploratory data analysis was conducted, where graphs were plotted to examine the average ridership trend, the distribution of ridership, and the correlation between ridership in Kuantan and Penang.

Model Development

This section explores and explains several machine learning methods for regression problems relevant to our project, including Artificial Neural Networks (ANN), Support Vector Regression (SVR), Multiple Linear Regression (MLR), Ridge Regression (RR), and Random Forest (RF).

Artificial Neural Network

One of the machine learning models that can predict complex data patterns is the Artificial Neural Network (ANN). ANNs consist of various processing nodes, or neurons, that imitate the activity of human brain cells. The core concept of ANN is to simulate the human brain, enabling it to learn from large datasets (Paul et

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al., 2021). The network learns to make predictions resembling human thought by recognizing connections and patterns in the input data. In this study, the ANN model is trained on input data, including weather and holidays, to predict ridership. The developed model is designed to predict ridership during bad weather on public holidays. This projection aims to support Rapid Bus operations in Kuantan and Penang by enhancing the reliability of bus services, optimizing scheduling efficiency, and ensuring the effective management of bus resources. This strategy enhances public transport operational decisions by leveraging ANN's capability to learn intricate patterns and model non-linear relationships.

Support Vector Regressor

Support Vector Regression (SVR) is a machine learning method suitable for addressing regression problems. Compared to conventional linear regression algorithms, it is particularly effective for datasets with complex or non-linear patterns. This is because SVR approximates complex non-linear relationships by mapping data into higher dimensions using kernel functions. One of the benefits of using SVR is its capacity to simulate intricate relationships between different ridership variables, such as weather and holidays. For instance, the total ridership count may fluctuate when weather conditions change, such as temperature or rainfall, and on days when travel demand increases. The potential for improved accuracy lies within the SVR algorithm, which is designed to address the unique nonlinear nature and interdependencies of these issues.

Multiple Linear Regression

Multiple Linear Regression (MLR) is a statistical method in which two or more independent variables influence a dependent variable. In MLR, several explanatory variables are utilized to derive the predicted value, rather than relying on a single variable as in standard linear regression. The formula is presented in Equation 1. In this context, MLR contributes to making complex predictions and serves as an excellent technique for estimating and simulating intricate relationships. The application of MLR has shown its effectiveness in conducting efficient and reliable ridership flow analyses, as evidenced by its use in previous studies.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \varepsilon \quad (1)$$

where y is the response/dependent variable, β_0 is the y-intercept, β_1, β_2,…, β_n are the slope coefficients, x_1, x_2,…, x_n are the independent variables/ predictors, and ε is the error term.

Ridge Regression

Ridge regression is a type of linear regression that utilizes regularization to mitigate multicollinearity and prevent overfitting. It is especially beneficial when the input dataset exhibits multicollinearity, as it introduces a penalty term (L2 regularization) to the loss function. As a result, this penalty term keeps the regression coefficients from being overly influenced by data noise, enabling the model to generalize better to new data (Schreiber-Gregory, 2018). The relationship between ridership, weather, and holidays can be modelled with a ridge regression approach. Ridge regression is a method to mitigate the overfitting of regression coefficients, which is possible due to the high correlation among features, such as ridership trends.

Random Forest

Random Forest is an ensemble method in machine learning applicable to both regression and classification problems. This technique utilizes Bootstrap Aggregation (bagging), leveraging the combined strength of various decision trees. Unlike a single decision tree, Random Forest combines predictions from multiple trees to arrive at the final decision, thereby enhancing the overall model's accuracy. Each decision tree is trained on different groups of rows and features from the dataset to promote model diversity. This transformation enables the model to handle complex and non-linear relationships, making it a valuable tool for managing the intricacies of diverse data (Salman et al., 2024).

Model Evaluation

In this study, all proposed models were evaluated using statistical metrics for performance assessment: R-squared (R^2), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Mean Squared Error (MSE). Generally, MSE is the mean square of the difference between the prediction value and actual value, RMSE is the root square of MSE, MAE is the absolute value of the difference between the prediction value and actual value, and R-squared is a statistical measure that represents the proportion of variance in a dependent variable that is explained by the independent variables in a regression model. Equations 2 to 5 define the mathematical equations of all metrics used in this study, where y_t is the actual value of testing data, while is $\hat{y}_t$ the predicted value generated from the machine learning model.

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$$MSE = \frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2 \quad (2)$$

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{y}_t)^2} \quad (3)$$

$$MAE = \frac{1}{T}\sum_{t=1}^{T}|y_t - \hat{y}_t| \quad (4)$$

$$R^2 = 1 - \frac{\sum_t (y_t - \hat{y}_t)^2}{\sum_t (y_t - \bar{y})^2} \quad (5)$$

ANALYSIS AND DISCUSSION

The primary objective of this study is to develop a predictive model for ridership on Rapid Bus services in Kuantan and Penang. Before modelling, some exploratory analyses need to be conducted to observe trends, data distribution, and correlations between variables. Figure 2 illustrates Kuantan and Penang's monthly total ridership patterns from January 2022 to October 2024. Penang, represented by the orange line, has a significantly higher ridership than Kuantan, ranging from 800,000 to 1.4 million. Ridership in Penang fluctuates greatly, with frequent peaks and troughs. Sharp declines occur in the middle of 2023 and the middle of 2024, likely due to seasonal factors, service interruptions, or holidays. Penang maintains a substantial ridership despite these variations, demonstrating that public transport is widely utilized. Kuantan, represented by the blue line, has consistently had low ridership, averaging less than 200,000 during this period. Its ridership pattern remains relatively steady, with slight variation, indicating a consistent but low demand for public transportation in Kuantan. This comparison emphasizes a critical distinction between the two locations. Penang exhibits rapid and strong ridership patterns, while Kuantan shows smaller, more stable usage.

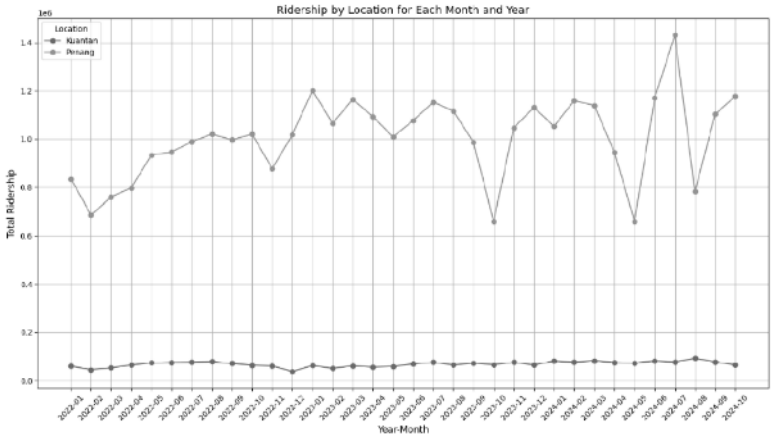


Figure 2: Comparison of Average Ridership in Kuantan and Penang by Month from 2022 until 2024

The distribution of ridership frequency across various ridership levels is shown in Figure 3. With over 700 instances of ridership below 10,000, a significant portion of the data concentrates on this lowest point, indicating numerous days with low ridership. This likely correlates with locations or times of low demand, such as Kuantan. Conversely, the distribution reveals another peak in the 30,000–40,000 ridership range, with frequencies declining as ridership exceeds 50,000. This suggests a more manageable, consistent set of high-ridership instances, likely in line with data from locations like Penang, which have robust public transportation systems. Overall, the distribution is dual, displaying two distinct ridership patterns: one with low demand and another with considerably higher levels, reflecting different trends in transportation use across the analyzed locations.



Figure 4: Distribution of Ridership

The heatmaps in Figure 4 illustrate the correlation between ridership and weather-related factors, specifically temperature, rain, and weather code for Kuantan and Penang. In Kuantan, ridership displays a weak positive correlation with temperature (r = 0.25), indicating a slight increase in ridership with rising temperatures. However, the correlation between ridership and rain (r = 0.026) as well as weather code (r = −0.09) is negligible, suggesting that rain and weather conditions have minimal impact on ridership. Additionally, there is a strong positive correlation between rain and weather code (r = 0.68), while temperature exhibits moderate negative correlations with both rain (r = −0.39) and weather code (r = −0.57).

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In Penang, ridership also demonstrates weak correlations with all-weather attributes. The correlation between ridership and temperature (r = 0.13) and between ridership and rainfall (r = 0.067) is very weak, indicating that weather conditions have a minimal influence on ridership. The correlation between ridership and weather code is almost negligible (r = −0.00047). Similar to Kuantan, rain and weather codes are strongly positively correlated (r = 0.76), while temperature has moderate negative correlations with rain (r = −0.44) and weather code (r = −0.49). Overall, the analysis highlights that weather factors, including temperature, rainfall, and weather codes, have a limited impact on ridership patterns in both Kuantan and Penang. While subtle differences exist between the two locations, the overarching impact of weather on ridership remains minimal.

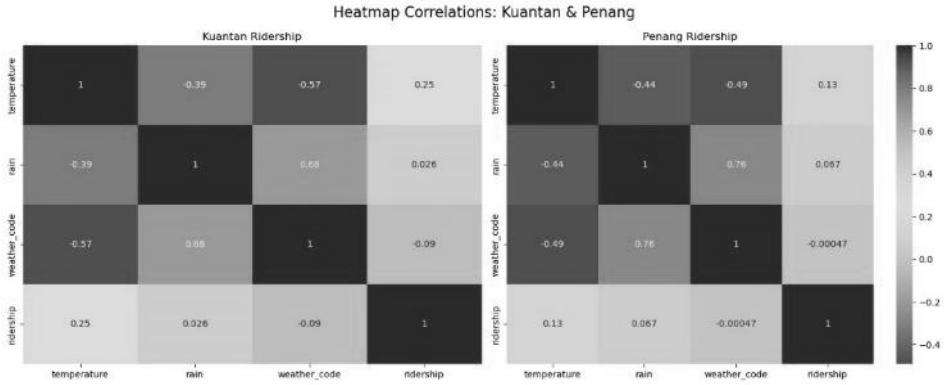


Figure 4: Heatmap Correlation: Kuantan & Penang

Although not all factors highly correlate with ridership, all factors were included in the model development. The results obtained as tabulated in Table 2, where the performance of five models: Random Forest (RF), Support Vector Regression (SVR), Multiple Linear Regression (MLR), Ridge Regression (RR), and Artificial Neural Network (ANN) was evaluated based on R^2, Mean Squared Error (MSE), Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE). Among these models, RF achieved the best performance, with an R^2 of 0.994, indicating that it explains 99.4% of the variance in the data. It also has the lowest error values, making it the most reliable model for predictions.

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Table 2 Model Comparison

Model	R^2	MSE	MAE	RMSE
RF	0.994008	2.07E+06	814.4755	1437.274
SVR	0.986775	4.56E+06	1569.635	2135.299
MLR	0.968617	1.08E+07	2590.035	3289.354
RR	0.944507	1.91E+07	2815.668	4374.062
ANN	0.020401	3.38E+08	16842.27	18377.64

Source: Author's Calculation

SVR ranks as the second-best model, achieving an R^2 of 0.987, which reflects its ability to capture 98.7% of the variance. However, its error values exceed RF's, indicating somewhat less accurate predictions. MLR and RR demonstrate moderate performance levels, with MLR recording an R^2 of 0.969 and RR at 0.944, meaning these models explain 96.8% and 94.5% of the variance, respectively. Their error metrics are significantly higher than those of RF and SVR, suggesting a challenge in accurately modelling the data's complexity. ANN exhibits the poorest performance, achieving a mere R^2 of 0.020, highlighting its failure to capture variance in the data. It also shows the highest error values (MSE: 3.38e+08, MAE: 16842.27, RMSE: 18377.64), rendering it unsuitable for this predictive task. ANN's underperformance likely stems from limited data and insufficient feature engineering. In contrast, RF and SVR's high accuracy and lower error rates suggest a preference for traditional machine learning models over deep learning methods in this context.

Based on these results, RF is the most appropriate model for predicting ridership, as it provides the highest accuracy and lowest error rates. Consequently, it is utilized for model deployment in our Graphical User Interface (GUI), as shown in Figure 5. The GUI was developed in Python with the Tkinter library.

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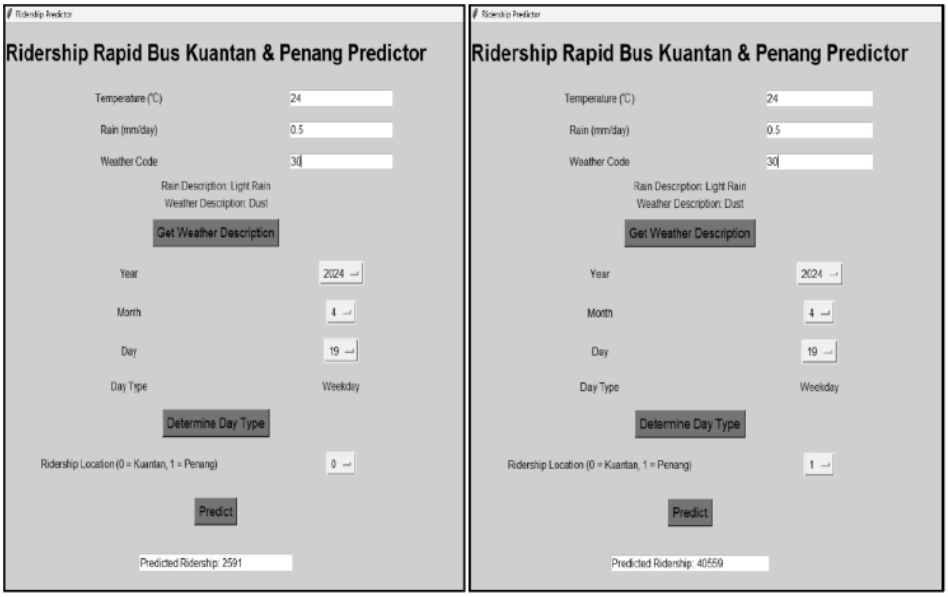


Figure 5: Ridership Prediction Rapid Bus Kuantan and Penang for Weekday.

On April 19, 2024, the Ridership Prediction System for Rapid Bus in Kuantan and Penang predicted the number of passengers under the same conditions. For Kuantan, the predicted ridership was 2,591, while for Penang, it was higher at 40,559. The day was a weekday, and the passenger count was slightly lower than during public holidays. People may ride the bus to work or school to avoid road congestion. On the other hand, the Ridership Prediction System for Rapid Bus in Kuantan and Penang estimated different passenger numbers for the two locations under similar conditions on January 1, 2024, which is a public holiday. As shown in Figure 6, for Kuantan, the predicted ridership was 2,728, while for Penang, it is much higher at 45549. Due to the New Year celebration, this date falls into the holiday category, which typically sees more passengers than weekdays or weekends. Penang is a well-known tourist destination, particularly during holidays such as New Year's. Tourists may visit Penang for celebrations or sightseeing, and many of these visitors are likely to rely on public transport. Penang may have a larger population, with more people using public transport and better service compared to Kuantan.

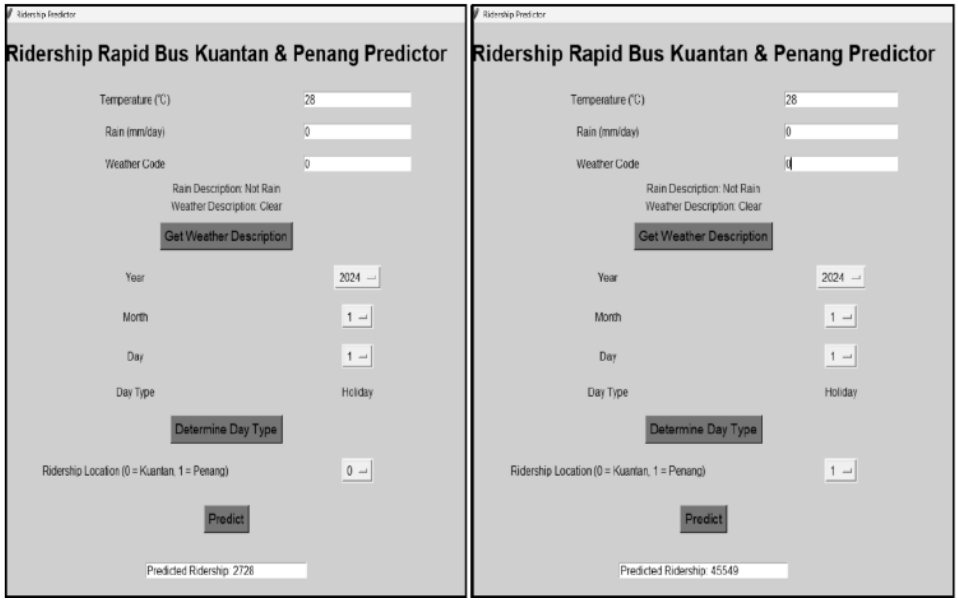


Figure 6: Ridership Prediction Rapid Bus Kuantan and Penang for Public Holiday.

CONCLUSION

This research successfully developed a ridership prediction system for Rapid Bus services in Kuantan and Penang. The project employed multi-feature analysis supported by machine learning techniques, including Artificial Neural Networks, Multiple Linear Regression (MLR), Ridge Regression, Support Vector Regression (SVR), and Random Forest (RF). The system demonstrated its ability to accurately predict ridership patterns based on influencing factors, such as weather conditions and day type. Among the evaluated models, the RF model emerged as the top performer, achieving the best performance across R-squared, MAE, and RMSE metrics. In addition, the developed graphical user interface (GUI) enhanced accessibility and user interaction, providing a user-friendly ridership predictor for Rapid Bus Kuantan and Penang.

The proposed ridership prediction system offers significant benefits to Rapid Bus management, particularly in strategic decision-making related to scheduling, route optimization, and resource allocation. It can help identify ridership trends, improve service efficiency, and reduce operational costs, thereby supporting sustainable public transport initiatives. Moreover, passengers could benefit from a more reliable schedule and accurate occupancy information, which would increase their confidence in and reliance on public transport services.

Despite these achievements, several limitations were encountered in this study. First, the dataset obtained from the data.gov.my open data platform

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lacked a clear description of its sample size (i.e., the total number of records), making it difficult to assess data representativeness. Second, the dataset contained incomplete ridership records and omitted important socio-economic variables, such as population density, income levels, and employment distribution, which could significantly influence ridership behavior. These data constraints may have contributed to the extremely poor performance of the ANN model ($R^2 = 0.02$), indicating that deep learning methods require richer and more comprehensive datasets to perform effectively.

For future work, the system could be enhanced by integrating Internet of Things (IoT) sensors on buses to collect real-time ridership and environmental data, thereby improving prediction accuracy. Incorporating additional data sources such as passenger feedback, traffic conditions, and socio-economic indicators may also enrich model insights. Furthermore, exploring advanced deep learning architectures and hybrid modeling approaches could further strengthen the system's predictive capabilities and ensure it remains adaptive to the evolving demands of public transportation in Malaysia.

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TOURISM DEMAND FORECASTING IN MALAYSIA USING SARIMA AND LONG SHORT-TERM MEMORY (LSTM) MODEL

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Abstract

This study investigates a robust forecasting framework for predicting Malaysia's international tourist arrivals by comparing the performance of a classical Seasonal Autoregressive Integrated Moving Average (SARIMA) model and a deep learning-based Long Short-Term Memory (LSTM) model. Unlike previous studies that applied these models individually, this research provides a direct empirical comparison using recent historical data on international tourist arrivals to evaluate their suitability for Malaysia's tourism context. Model accuracy was evaluated using two statistical performance metrics. The results demonstrate that both models effectively capture tourism demand patterns, with SARIMA achieving superior forecasting accuracy (MAPE = 5.31%). The findings offer new empirical evidence on model performance in tourism demand forecasting and provide practical insights to support data-driven decision-making and strategic planning within Malaysia's tourism sector.

Keywords: Tourism Demand Forecasting, Time Series, Seasonal Autoregressive Moving Average, Long Short-Term Memory.

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INTRODUCTION

Malaysia, one of Southeast Asia's countries, comprises West Malaysia (Peninsular Malaysia) and East Malaysia. Malaysia is recognized as a fascinating and affordable tourism destination due to its well-developed tourism infrastructure, price competitiveness, diversity of races, cultures, and religions, as well as a variety of food and beverages. The tourism sector is known as a sector that significantly contributes in stimulating economic growth and indirectly has made invaluable contributions to the nation's development particularly after the outbreak of COVID-19.

Nowadays, Malaysian government is exerting significant efforts to redevelop the tourism sector and improve the quality of tourism services, in line with their long-term goal to make Malaysia a top-of-mind destination. Moreover, with strong government support and incentives, the tourism sector has become significantly more productive than the agricultural sector (Othman & Jizan, 2020). All involved practitioners, as well as the government, must play a vital role in strategic planning and development. They should also be well prepared to address the needs of future tourists while ensuring their satisfaction. Tourism forecasting is an important and essential component in the planning and decision-making processes, both in business and non-business organizations.

Forecasting can be defined as a statistical process to generate future values or outcomes by using historical time series data as inputs (Mohd Lip et al., 2020). A reliable tourism demand forecasting model that provides evidence-based insights plays an important role in supporting the Malaysian government's strategic objectives, as outlined in the Twelfth Malaysia Plan (2021–2025) or known as 12MP**,** the National Tourism Policy 2020–2030**,** and the Shared Prosperity Vision 2030 (SPV 2030)**.** One of the main focuses in the 12MP is to restore and revitalize the tourism sector after the impact of the COVID-19 pandemic (MEA, 2019; MOTAC, 2020; EPU, 2021). Through the identification of patterns and trends within time series data, forecasting serves as a potential tool for informed decision-making and developing a strategic plan to boost the performance of the tourism industry and achieve higher profit returns.

A robust forecasting framework can contribute significantly to sustaining long-term tourism growth across both urban and rural regions. Accurate projections enable tourism stakeholders to identify growing tourist hotspots and anticipate future demands, thereby facilitating the planning and development of essential infrastructure, accommodations, transport networks, healthcare facilities, community spaces, and other tourism-related amenities. Moreover, these insights support the goals of SPV 2030, particularly in empowering B40 communities in urban areas by creating job opportunities and fostering tourism-related entrepreneurship. In addition, the predictive capacity of a reliable forecasting model can aid in the formulation of comprehensive

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contingency plans, enabling stakeholders to better manage crises and employ effective recovery procedures for the tourism sector.

In tourism demand forecasting, there are several variables that can be used as indicators such as the number of tourist arrivals or number of inbound tourists, the total receipts, the number of days of stay, and total expenditure. According to Song and Li (2007), the variable that is commonly used is the volume of tourist arrivals. Hence, this study utilizes historical data on the volume of inbound international tourists in Malaysia and applies the Box-Jenkins and LSTM modelling approaches for forecasting purposes. The main objective of this study is to identify the best model for forecasting tourism demand in Malaysia. All analyses are conducted using Python. The predictive accuracy of each model was computed using RMSE and MAPE to determine the best forecasting model for the tourism sector.

LITERATURE REVIEW

Future decision-making process for tourism-related businesses are always correlated with an accurate forecasting model (Witt & Witt, 1995). The stakeholders involved in these businesses such as governments, regulatory bodies, researchers, tourism operators, or developers, can make informed decision, manage financial risks effectively and distribute resources more efficiently. A review of the literature reveals introduction of numerous forecasting models that have been improved over time to enhance the effectiveness of existing forecasting models.

Box-Jenkins model remains widely used and still relevant as an appropriate forecasting approach. For instance, Peiris (2016) conducted tourism demand forecasting using the seasonal ARIMA model and found that $\text{SARIMA}(1,0,16)(32,0,24)_{12}$ outperformed other candidate models based on the forecast accuracy. Similarly, Msofe & Mbago (2019) identified that the $\text{SARIMA}(1,1,1)(1,1,2)_{12}$ model performed effectively in forecasting international tourist arrivals to Zanzibar. In the context of Malaysia tourism, Mohd Lip et al. (2020) employed both Holt-Winter model and seasonal ARIMA model for international tourist arrivals prediction in Malaysia. The researchers used secondary time series data, which was tourist arrival volumes from Singapore, Korea, and United Kingdom. Their findings indicated that the SARIMA model was significantly effective at forecasting tourist arrivals from Singapore.

In addition, Abu et al. (2021) conducted a comparative analysis between the Holt-Winters and SARIMA model to identify the most accurate demand forecasting model for eco-tourism in Pahang. Based on the empirical results, they concluded that the $\text{SARIMA}(1,0,0)(1,0,1)_{12}$ model outperformed the Holt-Winters model in forecasting tourist arrivals to National Park Kuala

Tahan, Pahang, Malaysia. Nurhasanah et al. (2022) forecasted the inbound international tourist's volume in Indonesia and the results showed that the SARIMA model provided the most accurate forecasts, as indicated by the lowest percentage error. Kamisan et al. (2024) compared the performance of SARIMA, MLP, and a hybrid model to forecast vehicle purchase loan approvals in Malaysia. Their findings showed that the MLP model outperformed the others, offering higher accuracy than traditional models like SARIMA, with significant implications for banking decisions. However, despite its strengths, the SARIMA model, which is commonly used in time series forecasting, often struggles to capture complex and nonlinear features in tourism data influenced by behavioural factors or external shocks, as it assumes a linear relationship within the data (Wu et al., 2020).

In contrast, the LSTM model, a subclass of AI-based forecasting methods, is widely used in time series forecasting, particularly for handling nonlinear patterns and long-term dependencies in the data. In 2018, Li and Cao employed the LSTM model with two other baseline models to forecast tourism flow. The outcomes of their study indicated that the LSTM model outperformed the baseline models. Laaroussi et al. (2020) used the volume of inbound Moroccan tourists in Morocco as the input for tourism demand forecasting using LSTM, gated recurrent unit (GRU), support vector regression (SVR) and artificial neural network (ANN) models. They concluded that the LSTM and GRU models demonstrated superior performance compared to the other models in this study. In addition, Hsieh (2021) applied the LSTM, Bidirectional LSTM (Bi-LSTM) and GRU for tourism demand forecasting in Taiwan. The study identified LSTM with its variants as the best forecasting model as it provided the lowest MAPE value. Finally, the study conducted by Mukhtar et al. (2023) also revealed the LSTM model as an appropriate forecasting model for tourism industry in Indonesia.

Previous studies have typically evaluated these two baseline models separately, leaving a gap in understanding how classical linear and modern deep learning models perform under identical historical data conditions. Addressing this gap is crucial to determine whether the nonlinear learning capability of the LSTM model can translate into measurable forecasting improvements over SARIMA in real-world tourism applications. Therefore, this study conducts a systematic comparative analysis of SARIMA and LSTM models for forecasting international tourist arrivals in Malaysia, providing new empirical evidence to support both academic research and practical forecasting strategies.

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RESEARCH METHODOLOGY

Data

This study utilized monthly historical data on the international tourist arrivals volume in Malaysia, before the emergence of the COVID-19 outbreaks. The data, consisting of 242 observations (spanning from January 2000 to February 2020), was sourced from the Malaysia Tourism Satellite Account, obtained from MOTAC.

Box-Jenkins Model

In 1970, the Box-Jenkins model was developed by Box and Jenkins and is recognized as a classical forecasting model. This classical model is divided into two groups: stationary models (e.g., AR model, MA model, and ARMA model) and non-stationary models (e.g., ARIMA model and seasonal ARIMA model) (Montgomery et al., 2015).

The Box-Jenkins model is broadly utilized in the forecasting process and in line with the current situation. Several modified forecasting models were designed by maintaining ARIMA model as the base forecasting model (Kumar & Anand, 2014). According to Hyndman and Athanasopoulus (2018), the ARIMA model is highly effective for forecasting annual time series data, while the seasonal ARIMA (SARIMA) model is better suited for high-frequency time series data (such as daily, weekly and monthly). Since our time series data consisted of monthly tourist arrivals volume which normally exhibit seasonality behavior (Kumar & Sharma, 2016), this study focused on utilizing the SARIMA model for tourism demand forecasting in Malaysia.

This model is an extension of the ARIMA model that incorporates seasonality (Kumar & Anand, 2014). The seasonal ARIMA model is denoted as SARIMA$(p,d,q)(P,D,Q)_m$ where (p,d,q) and $(P,D,Q)_m$ represent the non-seasonal and seasonal parts, respectively. The parameters p, d and q indicate the order of autoregressive, degree of non-seasonal differencing and the order of moving average, respectively. Meanwhile, the parameters P, D and Q denote the order of seasonal autoregressive, degree of seasonal differencing and the order of seasonal moving average, respectively, while m represents the seasonal cycle length.

In this study, the SARIMA model followed an iterative approach comprising four stages to yield the best fitted model for forecasting. The first stage is model identification where, three major behaviours of time series data were identified: stationarity in-mean, stationarity in-variance and seasonality. A Box-Cox transformation was implemented to check the stationarity in-variance while the Augmented Dickey Fuller (ADF) test and time plot was used to check stationarity in-mean. Differencing process was carried out for non-stationary to

stationary time series transformation. Finally, the Ljung-Box Q test was used to verify the presence of serial correlation in the time series data.

Next, in stage 2, the model with the smallest AIC value is acknowledged as the most appropriate forecasting model. In stage 3, diagnostic checking, the residuals were evaluated using the Ljung-Box Q. Once the final model was obtained, it was used to forecast the future time series data.

LSTM Model

Achieving a robust forecasting model in tourism demand remains a crucial challenge for most researchers, particularly when dealing with the non-linear features of time series data. Based on previous studies, a deep learning approach, specifically the long short-term memory (LSTM) model can be adopted to handle the non-linear relationship (Laaroussi et al., 2023). The LSTM model is a specialized type of recurrent neural networks (RNN) and was designed by Hochreiter and Schmidhuber in 1997.

According to Li and Cao (2018) and Law et al. (2019), the network in LSTM consists of a cell and a gating mechanism composed forget gate, input gate, input modulation gate and output gate which interact with each other. The three gates (forget, input and output gate) responsible for the signals transfer into and out of it while the input modulation gate memorizes the values over time intervals.

The unique function of the input modulation gate enables the LSTM to implicitly learn repeating or cyclical patterns inherent in the data. In the context of tourism demand forecasting, the seasonality such as annual peaks or periodic fluctuations can be captured by the LSTM through its long-term memory state. As the network processes multiple seasonal cycles during training, it gradually identifies consistent temporal patterns and learns to associate specific time intervals with expected changes in the data. Law et al. (2019) describing the general LSTM equations introduced by Hochreiter and Schmidhuber are given as follows:

Input gate:	$i_t = \sigma(W_{xi}x_t + W_{hi}h_{t-1} + b_i)$	(1)
Forget gate:	$f_t = \sigma\left(W_{xf}x_t + W_{hf}h_{t-1} + b_f\right)$	(2)
Output gate:	$o_t = \sigma(W_{xo}x_t + W_{ho}h_{t-1} + b_o)$	(3)
Memory cell:	$c_t = f_t \times c_{t-1} + i_t \times tanh(W_{xc}x_t + W_{hc}h_{t-1} + b_c)$	(4)
Output:	$h_t = o_t \times tanh(c_t)$	(5)
Input vector:	x_t	(6)
The activation functions:	$tanh, \sigma$	(7)
Learning parameters:	W, b	(8)

In order to produce an accurate tourism demand forecasting model in this study, five stages were involved in the implementation of the LSTM. The first stage was data preparation, during which the historical time series data was

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filtered before being used in the LSTM training process. The second stage involved data normalization, a widely used technique to improve the LSTM learning acceleration rate and convergence level. In this process, the input data was rescaled within the range [0,1] using MinMaxScaler. Next, the data was split into two parts during the third stage: training data and testing data, based on a ratio of 80:20 respectively. An 80:20 ratio is commonly adopted as a standard time series split ratio for datasets of moderate size, as allocating a larger portion for training ensures that the model sufficiently learns from historical trends to predict future outcomes. This proportion has been widely applied and recommended in previous studies on time series forecasting and machine learning applications, as demonstrated by Zhang et al. (2018) and Makridakis et al. (2021). Training data is allocated for model training, while testing data is used to evaluate the model's performance. The fourth stage involved the training process of the LSTM model.

In order to prevent under-fitting or over-fitting, the hyper-parameters were modified along the process. Each hyperparameter play an important role in the operation of each gate, as they determine how effectively and how fast the gates learn to control the flow of information within the LSTM network. The LSTM architecture employed in this study was adapted from the preliminary experiments conducted by Li and Cao (2018) and Law et al. (2019). The optimal configuration of hyperparameters, which yielded the lowest forecasting error, was determined through a manual tuning process, commonly referred to as trial-and-error experimentation. Several combinations of hyperparameters, including the number of LSTM units, learning rates, and epochs were tested, while the number of inputs was fixed at one, as this study utilized univariate time series data. The number of output nodes was also fixed at one, since only one-step-ahead forecasting was considered in this study. The LSTM model employed the sigmoid activation function and the Adam optimizer with adaptive moment estimation were used to facilitate efficient gate learning and gradient stability. The final configuration, consisting of one input, four LSTM units, and 50 epochs, produced the most stable training performance. Based on the trial-and-error results, increasing the number of LSTM units did not significantly enhance validation accuracy, suggesting that a smaller number of units is sufficient for datasets with a moderate number of observations (242 data points).

Forecast Accuracy

To validate the performance of SARIMA and LSTM, the Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE) values are utilized. The model with the smallest percentage error is considered the most appropriate for tourism demand forecasting.

ANALYSIS AND DISCUSSION

The volume of inbound tourists in Malaysia before the COVID-19 pandemic was used as the input for both models in this study. There were 242 data; divided into two categories, 192 data for the training data and 50 data for the testing data. The training data of the volume of inbound tourists in Malaysia before COVID-19 pandemic is illustrated in Figure 1.

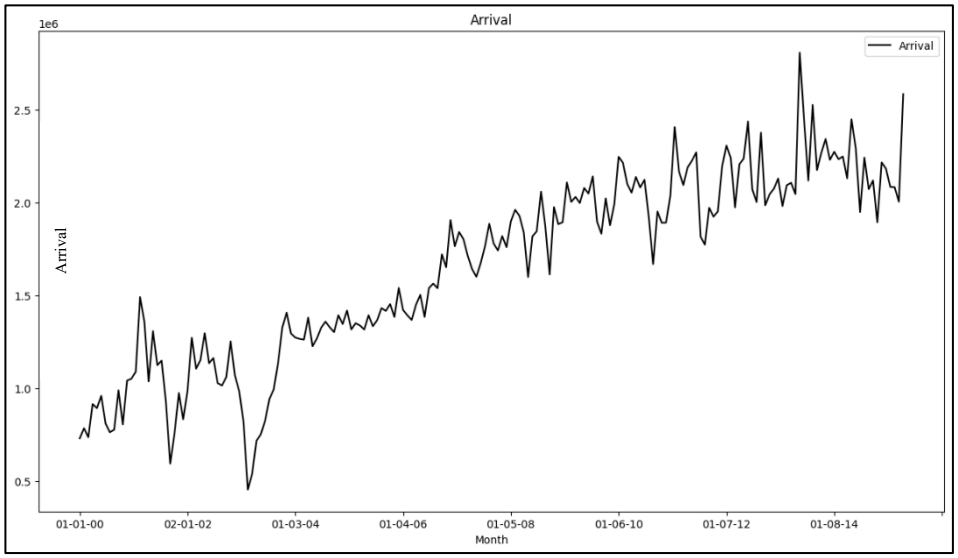


Figure 1: The Training Data of the Volume of Inbound Tourists in Malaysia before COVID-19 Pandemic

Source: Annual Report of the Malaysian Promotion Board Statistics (2021)

Based on Figure 1, the data plotting exhibits both upward and downward movements over the given period. Therefore, this time series data can be classified as non-stationary. The data series also display a linear trend since the time series data tend to increase for the same month over time. Additionally, the pattern of this data set exhibits seasonality, characterized by recurring pattern of fluctuations during specific months each year. Hence, the SARIMA model, a specific Box-Jenkins model is identified as suitable for this study.

In the parameter estimation process, 31 tentative models of SARIMA were generated using Python software. SARIMA$(2,1,1)(0,1,1)_{12}$ was chosen as the best model to forecast the number of tourist arrivals in Malaysia due to its lowest AIC value. The chosen SARIMA model is formulated as follows:

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$$(1 + 0.6618B + 0.3217B^2)(1 - B)(1 - B^{12})y_t = (1 + 0.6057B^{12})(1 - 0.4908B)a_t \quad (9)$$

For the LSTM model analysis, the process of training optimized at 46th epoch and the value of loss function obtained was 0.5%. The model was over-fitting starting from 47th epoch and onwards. Based on the observations, the hyper-parameters able to effectively control the training process.

The performance of SARIMA and LSTM models was evaluated using RMSE and MAPE. The summary of performance is tabulated in Table 1. According to [20], both models are classified as highly accurate prediction model since the MAPE values obtained for both models are smaller than 10%. This is verified from the MAPE values presented in Table 1. It can be observed that the SARIMA model performed better than the LSTM model.

Table 1: The performance evaluation of SARIMA and LSTM models

Forecast evaluation	SARIMA (2,1,1) $(0,1,1)_{12}$	LSTM
RMSE	152539.8	182382.0
MAPE	5.3120	6.8123

Source: Author's Calculation

Figure 2 illustrates the comparison between the actual and predicted values generated by the SARIMA model. It is evident that the actual values exhibit a pattern that is nearly identical to the predicted values. As depicted in Figure 3, the LSTM performed well in fitting the time series data, as the pattern of predicted values closely matched the pattern of the actual values.

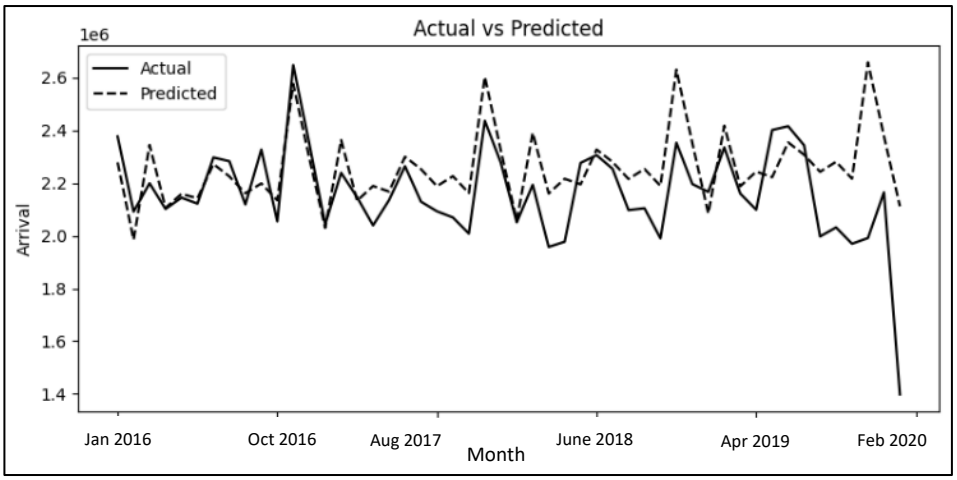


Figure 2: Actual Value versus Predicted Value using SARIMA Model
Source: Author's Calculation (2023)

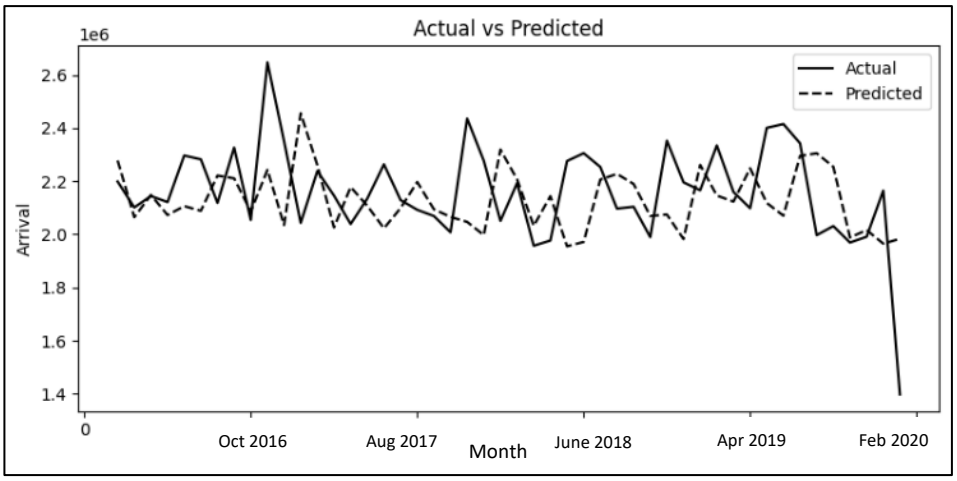


Figure 3: Actual Value versus Predicted Value using LSTM Model
Source: Author's Calculation (2023)

The characteristics of the tourism data used in this study contributed to the superior performance of the SARIMA model over the LSTM model. The data exhibited a smooth linear relationship and a clear seasonal pattern, which consistent with SARIMA's linearity assumption and its ability to capture periodic fluctuations through autoregressive (AR) and moving average (MA) components. Moreover, the nonlinear learning advantage of the LSTM model was not fully exploited in this study due to the moderate size of the tourism dataset, as LSTM models typically require a large dataset to perform effectively. The findings of this study align well with existing studies conducted by Zhang et al. (2003), Song and Li (2007), and Hyndman & Athanasopoulos (2018), which reported that classical forecasting models, such as ARIMA and SARIMA, often outperform neural network models when the time series data exhibit stable and linear seasonal patterns.

CONCLUSION

Based on the results, the SARIMA model produced a smaller percentage error compared to the LSTM model. This confirms that the traditional SARIMA model remains a reliable choice for prediction in time series analysis, particularly when dealing with stable, small to moderate-sized datasets. Although the percentage error produced by the LSTM model is larger than the SARIMA model, the LSTM model is still suitable for predicting tourist arrivals in Malaysia, as it achieved an error value of less than 10%, qualifying it as a highly accurate forecasting model according to its MAPE value (Lewis, 1982).

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The findings of this study demonstrate that a well-structured tourism demand forecasting model can be a valuable tool in supporting Malaysia's future national development. The insights generated from the model can significantly contribute to the achievement of goals outlined in the country's key development plans. These include promoting sustainable and long-term tourism growth, advancing digital transformation in the tourism sector or known as smart tourism (Amir et al., 2020), supporting environmentally responsible planning through net-zero initiatives, preserving Malaysia's cultural and historical heritage, and strengthening the niche of tourism markets. Reliable forecasts can help tourism practitioners effectively anticipate peak seasons by managing workforce distribution, allocating resources wisely, and optimizing transportation and accommodation services to meet the needs of future tourists and visitors. As a direction for future research, this study proposes extending the model by combining SARIMA and LSTM to enhance forecasting effectiveness, particularly for tourism demand in Malaysia.

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QUEENAPP: A DECISION-SUPPORT PRODUCTION SCHEDULING SYSTEMS TOWARDS IMPROVED PINEAPPLE FARMING

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Abstract

Pineapple (Ananas comosus) is one tropical fruit that is most traded worldwide. Currently, around 90 countries and areas around the world grow pineapples. In the Philippines, Queen Pineapple (QP), which is a variety of pineapple, occupies 2,525 hectares of agricultural land, and is the prime agricultural commodity in Camarines Norte, where 92% of the pineapple in the Bicol Region comes from. For many years, the production of QP in the province, as well as in the country, has relied mainly on no particular schedule and thus has no access to data-driven insights that help with decision-making. In this study, the main objective is to develop an application that will improve pineapple farming and enhance production scheduling using a rule-based algorithm. A Rational Unified Process was used to develop the system, where the Projected Planting Schedule using Timetable, Automatic Production Cost, and ROI Computation, and Data Visualizations are the main features that helped the farmer maximize the resources in planting and harvesting pineapple. The respondents agreed (4.17) with the overall perceived performance and strongly agreed (4.34) on the acceptance of the system; these results strongly suggest that the system is well-designed, promotes positive user experiences, and meets its intended objectives in optimizing pineapple farming processes. The system was well accepted by end users, thus it is usable and effective.

Keywords: Decision Support System, Pineapple Farming, Queen Pineapple

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INTRODUCTION

Pineapple (Ananas comosus) is the second most important tropical fruit worldwide after mango and remains a major revenue source for many agricultural economies. In 2017, global production reached approximately 25.8 million tons (Altendorf, 2019), with China, Brazil, the Philippines, and India as leading producers. The Philippines is among the top exporters, and Camarines Norte serves as a major production area of the Queen Pineapple (QP), cultivating about 2,525 hectares. As the flagship agro-commodity of the province, QP accounts for 92% of the Bicol Region's pineapple output and has been a primary livelihood source since the 1950s (PCAARRD ISPWEB, 2022). Despite its importance, QP production has long relied on non-standardized schedules, posing challenges to sustainability amid growing concerns about climate change and land productivity.

Pineapple yields are influenced by factors such as labor availability, farm size, fertilizer application, and pest management. Studies by Ria et al. (2021) and Oniah and Okon (2022) emphasize that variables including labor, fertilizer costs, and sucker prices significantly affect productivity. Persistent labor constraints remain a concern, as many farmers still depend on manual methods and lack access to advanced agricultural equipment (Ghazi et al., 2023). Insufficient knowledge of efficient farming practices further hinders productivity (KanjanaMongkolnipath et al., 2022).

The absence of an organized production scheduling system exacerbates these issues. In Camarines Norte, farmers typically plant without a coordinated schedule, resulting in irregular harvests and periods of oversupply. Logistics challenges—such as poor road access and high transport costs—intensify the problem (Enibe & Raphael, 2020). Price volatility and the perishability of pineapple complicate market forecasting, making profitability difficult to sustain. Research by Nahar et al. (2020) and Campita et al. (2022) highlights the crucial role of marketing channels and price stability in ensuring viable pineapple farming. These challenges underscore the need for a system that delivers timely, accurate, and actionable information to farmers.

Technology interventions have shown potential in addressing similar agricultural concerns. Previous studies have explored mobile applications and artificial intelligence (AI) for disease detection, recommendation systems, and fruit classification (Rekha et al., 2022; Bandara et al., 2022; Cuong et al., 2022; Arboleda et al., 2021). While these innovations provide useful insights, none directly address the critical problem of production scheduling—a gap that the present research seeks to fill.

This study proposes the development of QueenApp, a decision-support system designed to improve pineapple production in Camarines Norte through a rule-based scheduling algorithm. This applies predefined rules to input variables—such as farm size and soil quality—to generate optimal planting and

harvesting recommendations. Rule-based approaches are well-suited to agriculture due to their transparency, interpretability, and grounding in established farming practices.

Rule-based algorithms in decision support systems have been successfully applied in pest control, pesticide scheduling (Sumaryanti, Istanto, & Pare, 2020), irrigation management based on soil moisture and crop requirements (Yousif et al., 2018), and precision agriculture (Mehedi et al., 2024). For pineapple production, such systems can guide farmers in determining appropriate planting cycles, fertilizer timing, and harvest periods aligned with market demand.

A major limitation in current pineapple farming is inefficient data management and the absence of predictive tools to support decision-making. This leads to suboptimal scheduling, resource misallocation, and market mismatches. QueenApp aims to address these constraints by integrating real-time data, predictive analytics, and rule-based recommendations into an accessible platform for farmers. By providing accurate and timely guidance, the system supports better scheduling, enhances resource management, and reduces waste.

Effective production scheduling is essential for improving both profitability and sustainability. It enables precise application of inputs, reduces production costs, minimizes environmental impacts, and helps synchronize supply with market demand—preventing oversupply and stabilizing prices. Through these capabilities, QueenApp represents an important step toward modernizing pineapple production in Camarines Norte and strengthening its economic viability.

Overall, the challenges facing pineapple cultivation in Camarines Norte—from uncoordinated scheduling to high input costs and limited technological adoption—highlight the need for a comprehensive decision-support tool. This research introduces QueenApp, a rule-based production scheduling system designed to optimize farm operations, improve productivity, and enhance the long-term sustainability of pineapple farming. By combining real-time data, predictive modeling, and geospatial insights, QueenApp has the potential to empower farmers with informed, data-driven decision-making and contribute to the continued advancement of the pineapple industry in the region.

RESEARCH METHODOLOGY

Research Design

This study employed a developmental and quantitative research design to evaluate the usability of QueenApp. The research approach focused on system development and collecting measurable data regarding farm production, scheduling optimization, and resource management. Through statistical and computational analysis, the system's impact on farm productivity was assessed.

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Data Collection

Data collection was conducted through both primary and secondary sources to ensure a comprehensive and accurate analysis of QueenApp's impact on pineapple farming.

Primary data were gathered through surveys and structured interviews with agricultural extensionists from the Office of the Provincial Agriculturist (OPAG) in Camarines Norte. These engagements provided valuable insights into the common challenges faced by pineapple farmers, including inefficient scheduling, resource management issues, and unpredictable yields.

Secondary data comprised historical records, soil quality assessments, and climate pattern reports collected from 2020 to 2023. Additionally, relevant literature from agricultural research journals, government reports, and scientific studies was reviewed to contextualize the findings and support the development of QueenApp. These sources provided a broader understanding of existing agricultural practices, market trends, and technological advancements in precision farming.

System Development

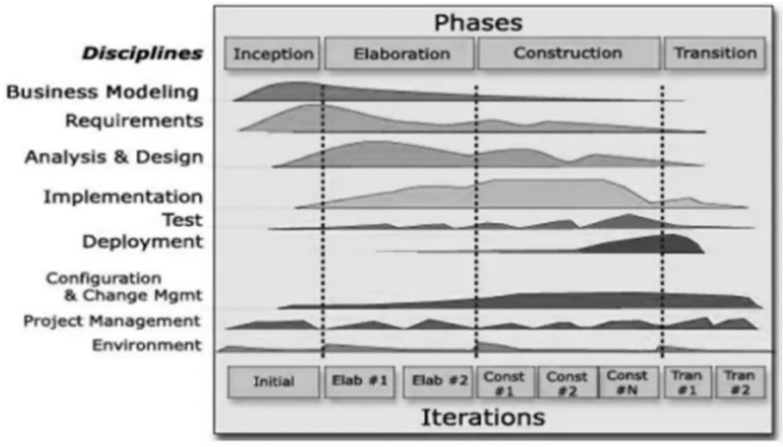


Figure 1: Rational Unified Process (RUP)

The development of QueenApp followed the Rational Unified Process (RUP) model as shown in Figure 1, ensuring a systematic and iterative approach. The Inception Phase involved understanding business needs, defining project scope, and identifying key system requirements. During the Elaboration Phase, the system architecture was designed, incorporating rule-based algorithms, machine learning components, and geo-spatial data models. In the Construction Phase, core functionalities such as geotagging pineapple farms, automated

fertilizer computation, and predictive yield analysis were implemented. The final stage, the Transition Phase, involved rigorous testing with farmers and agricultural experts. This phase included refining system performance based on feedback, ensuring usability, and finalizing deployment procedures.

System Architecture

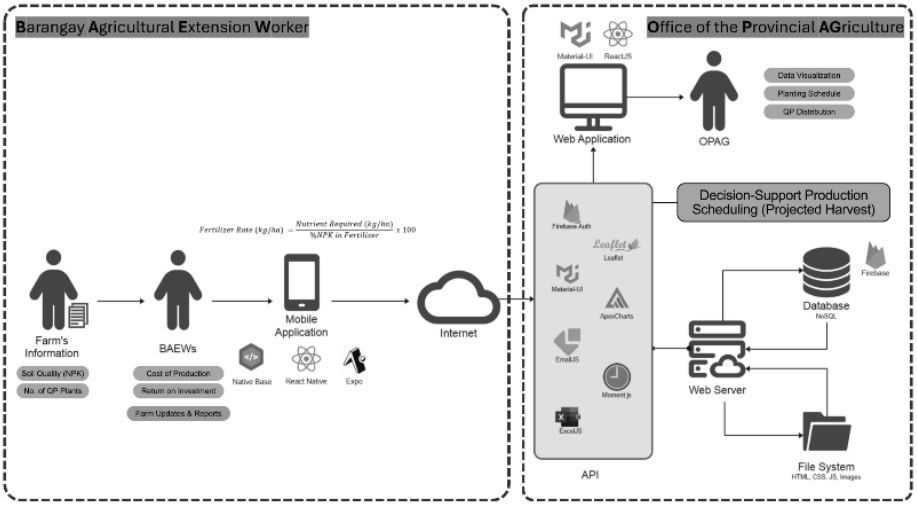


Figure 2: System Architecture

The system architecture of QueenApp in Figure 2 provides a structured framework that integrates multiple components to enhance pineapple farming operations and production scheduling. It consists of three main layers: Users, Applications, and Backend Infrastructure, ensuring real-time data processing, efficient communication, and intelligent decision support. The system serves two primary users: OPAG Admins, who manage data visualization, planting schedules, and Queen Pineapple (QP) distribution through a web application, and Barangay Agricultural Extension Workers (BAEWs), who collect and update farm-related data such as soil quality (NPK levels), costs of production, return on investment, and farm reports via a mobile application. This data is used to compute the required fertilizer rates and optimize crop management.

The application layer facilitates seamless interaction between users and the system. The web application, built with ReactJS and Material-UI, provides OPAG Admins with interactive dashboards, planting schedules, and farm distribution insights. Meanwhile, the mobile application, developed using React Native, NativeBase, and Expo, allows BAEWs to gather farm data, update reports, and monitor production costs in real-time. These applications

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communicate with the backend infrastructure over the internet, ensuring continuous synchronization and accessibility.

At the core of the backend infrastructure is the developed system, which connects the applications with the database through an API layer. The system integrates multiple technologies such as Firebase Auth for secure authentication, Leaflet for farm mapping, ApexCharts for data visualization, EmailJS for automated notifications, Moment.js for scheduling, and ExcelJS for data export and analysis. The web server processes user requests, while a NoSQL Firebase database efficiently stores farm-related data. Additionally, a file system manages resources such as HTML, CSS, JavaScript files, and images to support application functionality.

The Decision Support Production Scheduling (Projected Harvest) module is the core intelligence of the system managed by the OPAG, analyzing farm data to generate optimized planting schedules, fertilizer recommendations, and soil health insights. This module supports efficient resource allocation, prevents oversupply, and minimizes production losses by providing real-time farm updates and strategic recommendations. Through this architecture, QueenApp enhances farm management, improves scheduling, and enables data-driven decision-making, making it a scalable and efficient solution for Queen Pineapple farming in Camarines Norte.

Evaluation Matrix

Table 4: Five-Point Likert Scale and Interval

Likert-Scale Description	**Scale**	Interval
Strongly Agree (SA)	5	4.21 to 5.00
Agree (A)	4	3.41 to 4.20
Neutral (N)	3	2.61 to 3.40
Disagree (D)	2	1.81 to 2.60
Strongly Disagree (SD)	1	1.00 to 1.80

Source: Nyutu et al. (2021)

The study applied the ISO/IEC 25010:2011 software quality standard to assess the system's overall performance using a five-point Likert scale, following the approach of Afriani, Wahyuddin, and Perdana (2022) and Mt Akhir et al. (2021) in Table 1 and the app development evaluation method used by Nicart et al. (2024). The assessment focused on three key metrics: Functional Suitability, Performance Efficiency, and Reliability. Functional Suitability was measured by the system's ability to optimize farming operations, such as scheduling and fertilizer management. Performance Efficiency was assessed through system response time, data processing speed, and overall computational effectiveness (Mohamed et al., 2021). Reliability metrics included uptime stability, fault tolerance, and error handling in real-time operations

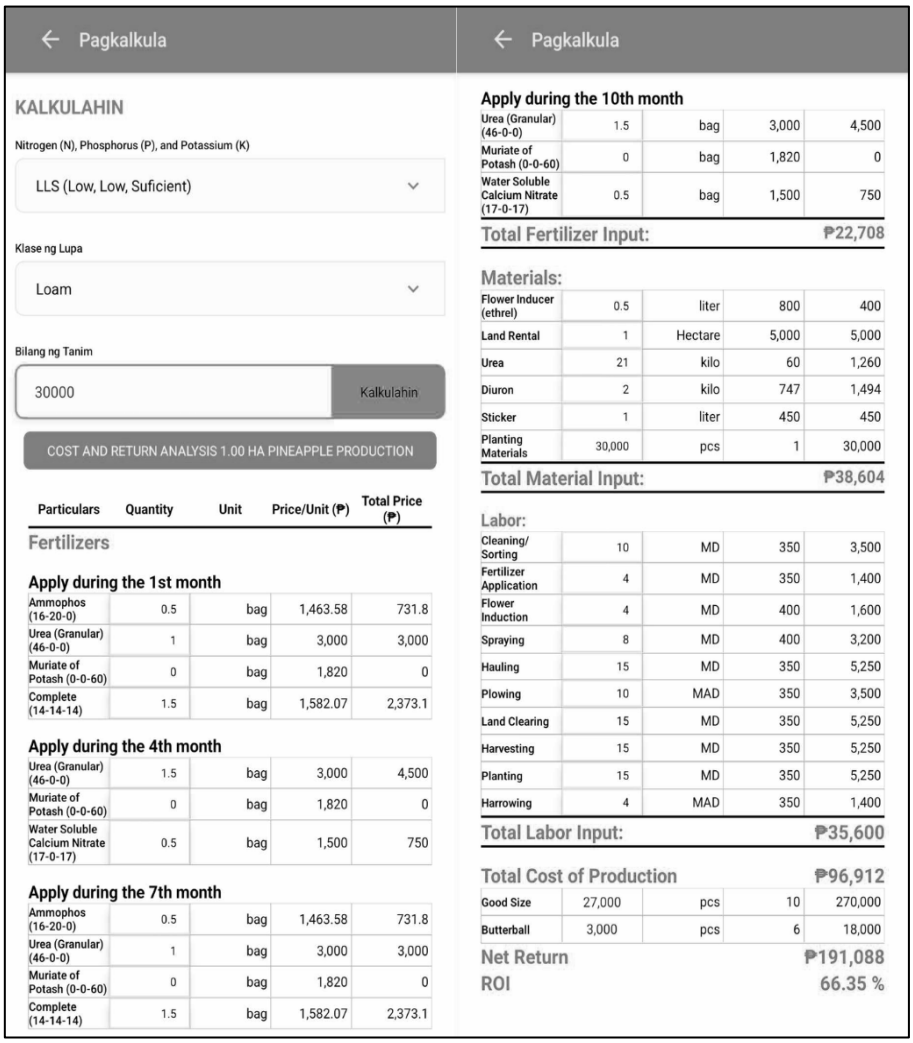
(Karunathilake et al., 2023). Additionally, a user acceptance test was conducted using the Technology Acceptance Model (TAM) framework. This evaluation measured users' perceived ease of use, attitudes toward technology adoption, and intention to use the system in real-world farming scenarios (Cai et al., 2023). The researchers used Cronbach's Alpha to measure the internal consistency reliability of a set of questions on a scale.

RESULTS AND DISCUSSION

Key Features

QueenApp, like in the study of Chen et al. (2024), was developed to enhance efficiency in pineapple farming by integrating decision-support tools tailored for resource management and production scheduling using a mobile application as an interface for agriculture extensionists shown in Figure 3.

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Pagkalkula

KALKULAHIN

Nitrogen (N), Phosphorus (P), and Potassium (K)

LLS (Low, Low, Suficient)

Klase ng Lupa

Loam

Bilang ng Tanim

30000

Kalkulahin

COST AND RETURN ANALYSIS 1.00 HA PINEAPPLE PRODUCTION

Particulars	Quantity	Unit	Price/Unit (₱)	Total Price (₱)
Fertilizers				
Apply during the 1st month				
Ammophos (16-20-0)	0.5	bag	1,463.58	731.8
Urea (Granular) (46-0-0)	1	bag	3,000	3,000
Muriate of Potash (0-0-60)	0	bag	1,820	0
Complete (14-14-14)	1.5	bag	1,582.07	2,373.1
Apply during the 4th month				
Urea (Granular) (46-0-0)	1.5	bag	3,000	4,500
Muriate of Potash (0-0-60)	0	bag	1,820	0
Water Soluble Calcium Nitrate (17-0-17)	0.5	bag	1,500	750
Apply during the 7th month				
Ammophos (16-20-0)	0.5	bag	1,463.58	731.8
Urea (Granular) (46-0-0)	1	bag	3,000	3,000
Muriate of Potash (0-0-60)	0	bag	1,820	0
Complete (14-14-14)	1.5	bag	1,582.07	2,373.1

Pagkalkula

Apply during the 10th month

Urea (Granular) (46-0-0)	1.5	bag	3,000	4,500
Muriate of Potash (0-0-60)	0	bag	1,820	0
Water Soluble Calcium Nitrate (17-0-17)	0.5	bag	1,500	750
Total Fertilizer Input:				**₱22,708**
Materials:				
Flower Inducer (ethrel)	0.5	liter	800	400
Land Rental	1	Hectare	5,000	5,000
Urea	21	kilo	60	1,260
Diuron	2	kilo	747	1,494
Sticker	1	liter	450	450
Planting Materials	30,000	pcs	1	30,000
Total Material Input:				**₱38,604**
Labor:				
Cleaning/ Sorting	10	MD	350	3,500
Fertilizer Application	4	MD	350	1,400
Flower Induction	4	MD	400	1,600
Spraying	8	MD	400	3,200
Hauling	15	MD	350	5,250
Plowing	10	MAD	350	3,500
Land Clearing	15	MD	350	5,250
Harvesting	15	MD	350	5,250
Planting	15	MD	350	5,250
Harrowing	4	MAD	350	1,400
Total Labor Input:				**₱35,600**
Total Cost of Production				**₱96,912**
Good Size	27,000	pcs	10	270,000
Butterball	3,000	pcs	6	18,000
Net Return				**₱191,088**
ROI				**66.35 %**

Figure 3: Production Cost and ROI Computation

In the previous study, Esteban and Santos (2021) used data science to develop an online platform for crop production with a decision support system to help the younger generation of Filipino farmers. The purpose of the system is to monitor farming activities, costs, and meteorological data to increase crop productivity. All farmers will benefit significantly from the Decision Support System's agricultural chronology and weather data, which is also anticipated to improve the country's economic status by boosting smallholder productivity. Moreover, Bucci et al. (2020) presented that the economic advantages of a higher crop yield and lower input costs (such as seed, fertilizer, and agrochemicals), as

well as lower fuel consumption, must be considered, as must the environmental advantages of more accurate fertilizer and agricultural chemical targeting. Additional elements considered in production planning procedures include fertilization to guarantee the quantity of nutrients in the soil (Albornoz, Véliz, Ortega, & Ortíz Araya, 2020) and economical seed planting (Ahsan & Dankowicz, 2019).

$$(1)\ \ Fertilizer\ Rate\ \left(\frac{kg}{ha}\right) = \frac{Nutrient\ Requirement\ \left(\frac{kg}{ha}\right)}{\%\ NPK\ in\ Fertilizer} * 100$$

The system's Automated Fertilizer Calculation feature, using (1), helps farmers apply precise amounts of fertilizer based on real-time soil data, reducing costs and promoting sustainable practices. For the Return On Investment (ROI), the system calculates the total net return divided by the gross return and then multiplied by 100 based on the (2) used by the OPAG.

$$(2)\ \ ROI = \left(\frac{Net\ Return}{Gross\ Return}\right) * 100$$

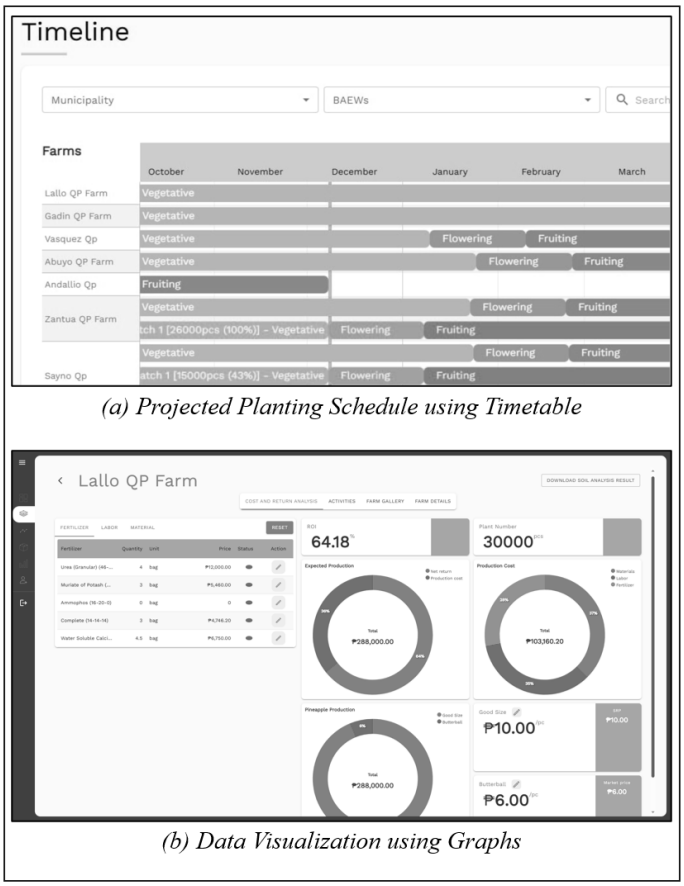
```
function getFertValue(N, P, K, fertilizerOptions) {
  let options = [];
  const { lowest, field, fertilizers } = getFunction(N, P, K, fertilizerOptions);
  for (const f1 of fertilizers) {
    let n1 = N; let p1 = P; let k1 = K;
    const percent1 = f1[field] / 100;
    const amount1 = (lowest / percent1);
    n1 = n1 - (amount1 * (f1.N / 100));
    p1 = p1 - (amount1 * (f1.P / 100));
    k1 = k1 - (amount1 * (f1.K / 100));
    ...
    if (fertObj1 === null) { continue }
    const price1 = fertObj1.price
    const totalPrice1 = price1 * amnt1;
    if (n1 <= 0 && p1 <= 0 && k1 <= 0) {
      const len = options.length;
      options.push(
        [{
          ...fertObj1,
          qntyPrice: amnt1,
          price: formatNum(price1),
          totalPrice: formatNum(totalPrice1),
        }]);
      continue;
    }
  ...
  const sortedOptions = options.sort((a, b) => {
    const sumA = a.reduce((sum, fert) => sum + fert.totalPrice, 0);
    const sumB = b.reduce((sum, fert) => sum + fert.totalPrice, 0);
    return sumA - sumB;
  }).slice(0, 5);
  return sortedOptions;
}
```

Figure 4: Code Implementation

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Figure 4 presents the actual code that implements the mathematical formulas labeled as (1) and (2). These formulas are used in a mobile application designed specifically for agricultural extensionists. The implementation uses a rule-based algorithm, which means the system follows a set of predefined rules or conditions like "if-then" logic. These rules are derived from domain knowledge, likely based on farming practices or agricultural research. The purpose of the code is to automate the calculations or decisions derived from formulas (1) and (2), helping the users analyze farm data more efficiently, make consistent, data-driven recommendations, and support decision-making for improved farming operations.

The Projected Planting Schedule using the Timetable in Figure 5 (a) incorporates crop maturity to recommend optimal harvesting times, ensuring higher profitability and improved product quality (Badmus & Aderinto, 2019).



(a) Projected Planting Schedule using Timetable

(b) Data Visualization using Graphs

Figure 5: Other Key Features

This feature collectively supports a more systematic and data-driven approach to pineapple farming, ultimately enhancing productivity and sustainability. In previous work, Sajid and Hu (2022) proposed a two-stage crop planting model that suggests planting dates based on logistical and capacity constraints and plant growth. The best planting dates are then chosen using a rule-based algorithm to ensure that weekly harvesting amounts don't surpass the storage capacity. Additionally, Huang et al. (2020) created a model that schedules crops in a commercial plant factory to optimize revenue by figuring out which crops are grown, how many are grown, and when. Crop characteristics, including cultivation duration, volume change, numerous harvest dates, and yield rates under various environmental conditions, are all taken into account by the model in addition to crop market pricing.

Data Visualization using Graphs in Figure 5 (b) allows farmers to forecast harvest volumes accurately, preventing market oversupply and financial losses (Coulibaly, Du, & Diakité, 2021). Geotagging Pineapple Farms provides real-time tracking of farm locations and soil conditions, enabling better land management and optimizing land use (Mwangi, Odhiambo, & Naminde, 2021). Charts, graphs, maps, and other visualization techniques demonstrate how well agricultural data can be represented in a form that is both meaningful and actionable (Kumari et al., 2024). Crop monitoring, weather forecasting, soil analysis, and yield prediction are just a few agricultural processes where data visualization techniques can be applied. They talked about how farmers may find patterns, trends, and anomalies by using visualizations to comprehend and analyze vast amounts of data from sensors, drones, and satellite photography. The authors also examine how cutting-edge technology like artificial intelligence and machine learning can be integrated with data visualization techniques. Similarly, Athesan and Ghazi (2024) proposed dashboard design components with multiple-view concepts from various angles, emphasizing improving smart farming's ecological sustainability, productivity, and resource management. It is anticipated that the suggested dashboard visualization will produce an efficient display that operates in accordance with its purported usage capability. By offering thorough and understandable visualizations of important environmental factors, these dashboard design components empower farmers to make well-informed decisions that maximize crop yields.

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Perceived Performance

Table 2: Overall Perceived Performance Evaluation

Indicators	Weighted Mean	Interpretation
1. Functional Suitability	4.20	Agree (A)
2. Performance Efficiency	4.20	Agree (A)
3. Reliability	4.10	Agree (A)
Overall Weighted Mean	4.17	Agree (A)

Table 2 presents the evaluation results of QueenApp using the rule-based algorithm, yielding an overall weighted mean of 4.17, which reflects strong user satisfaction with the system's functionality and performance. The highest scores were recorded in Functional Suitability and Performance Efficiency (both 4.20), indicating that the system effectively delivers its intended capabilities while operating with notable efficiency. These findings reinforce earlier definitions stating that functional appropriateness enables a system to perform as intended and reduce user difficulties (Boneza, 2023), while functional suitability ensures that explicit and implicit user needs are met through complete, correct, and reliable outputs (Vacca et al., 2024). As Wacas (2023) emphasizes, performance efficiency ensures essential processes are executed swiftly, with optimal resource utilization and responsiveness—even under heavy user demands.

Although Reliability received a slightly lower rating of 4.10, the score still signifies dependable system behavior, with minor opportunities for improvement in fault tolerance, error handling, and system recovery. Importantly, the reliability of the instrument used in the evaluation is supported by a Cronbach's alpha of 0.90, indicating excellent internal consistency among the assessment items.

Overall, the strong mean rating of 4.17 confirms that QueenApp is perceived as a functional, efficient, and reliable decision support system. These results validate its capability to enhance pineapple farming and production scheduling in Camarines Norte, while also highlighting areas for future refinement to further strengthen system stability and user confidence.

Degree of Acceptance

Table 3: Overall Degree of Acceptance Evaluation

Indicators	Weighted Mean	Interpretation
1. Perceived Ease of Use	4.42	Strongly Agree (SA)
2. Attitude Towards Using	4.27	Strongly Agree (SA)
3. Intention of Use	4.32	Strongly Agree (SA)
Overall Weighted Mean	4.34	Strongly Agree (SA)

Table 3 summarizes the overall assessment of the system's usability and acceptance based on three key indicators. The results reveal a high level of agreement among users, with an overall weighted mean of 4.34. This indicates that respondents perceive the system as highly usable, beneficial, and worth adopting. Reliability analysis further supports the robustness of these findings, with a Cronbach's alpha of 0.87, demonstrating good internal consistency among the survey items.

Among the individual indicators, Perceived Ease of Use scored the highest with a weighted mean of 4.42, reflecting that users find the system straightforward, user-friendly, and efficient in optimizing pineapple farming. This result emphasizes the system's intuitive design and practical application. Attitude Towards Using garnered a weighted mean of 4.27, showing that respondents view the system positively and appreciate its potential to enhance farming practices. While slightly lower than the other indicators, this score still demonstrates strong acceptance and satisfaction. Finally, Intention of Use received a weighted mean of 4.32, reflecting the users' willingness to adopt and recommend the system for pineapple farming. This suggests a high level of trust and belief in the system's potential to improve farming outcomes.

The evaluation is limited to important features such as the production cost and ROI computation using the mobile application, projected planting schedule using the timetable, and data visualizations using graphs available in the web application. These features were evaluated based on the degree of acceptance by end users, using inputs derived from the self-reported data provided by OPAG.

Overall, the results demonstrate that the system is well-developed, with respondents strongly agreeing on its usability, effectiveness, and value in pineapple farming. These findings underline the system's readiness for broader adoption and implementation in the agricultural sector.

CONCLUSION

The development of QueenApp as a Decision Support Production Scheduling System has demonstrated significant potential in enhancing pineapple farming efficiency in Camarines Norte. The system integrates IT-driven solutions, predictive analytics, and geospatial insights to improve fertilizer application, planting schedules, and harvest planning.

To further enhance its impact, several recommendations are proposed. Integration with IoT-enabled soil sensors and climate monitoring devices can improve real-time data accuracy, enabling more precise fertilizer application and yield forecasting. Expanding QueenApp's functionality to support other crops would allow broader agricultural adoption beyond pineapple farming. Furthermore, enhancing user training and providing continuous support through workshops and technical assistance will maximize farmer adoption and

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utilization. Collaborations with government agencies and agricultural institutions can facilitate widespread implementation and policy support for smart farming practices. Finally, integrating AI-driven analytics and machine learning models can refine QueenApp's decision-support capabilities, making it a more adaptive and intelligent agricultural management tool.

Overall, QueenApp represents a significant advancement in digital agriculture, helping farmers improve efficiency, maximize profitability, and contribute to sustainable farming practices. Its continued development and adoption have the potential to drive agricultural innovation, making farming more precise, data-driven, and economically viable.

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DISCLOSURE STATEMENT

The authors declare that there are no known financial, professional, or personal conflicts of interest that could have influenced the conduct or outcomes of this study.

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FINANCIAL BENEFITS OF POTENTIAL RAINWATER HARVESTING SYSTEM INITIATIVE FOR HOSTEL

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Abstract

Higher Education Institutions (HEI) have been considered 'small cities' with various buildings, services, and activities. Proposing a Rainwater Harvesting System (RWHS) in the HEI environment is an initiative towards greening the campus as well as action toward achieving global targets of Sustainable Development Goal (SDG) and UI GreenMetric World University Rankings. Thus, a study on the potential RWHS is required to obtain the financial benefits of RWHS installation and investment. This research focuses on the potential of RWHS for hostel buildings at one of the HEIs in Malaysia, i.e., Politeknik Sultan Azlan Shah (PSAS). PSAS was selected to promote polytechnics as a sustainable, superior, and excellent way to implement green elements at the site and across the curriculum in the Polygreen Blueprint. This research objective is to evaluate the financial benefits of potential RWHS as a sustainable initiative for hostel buildings in terms of Reliability (R) and Payback Period (PBP). Data collected from related documents are used to simulate calculation for R and PBP. The daily water mass balance model was adopted in the simulation process to obtain the financial benefits of RWHS. For hostel buildings, the RWHS initiative could potentially benefit in terms of finances with PBP from 23 to 26 years if 10 m^3 to 30 m^3 capacity High-Density Polyethylene (HDPE) water storage is installed. The R of the RWHS is between 63.14% to 74.52% with 30 years of lifespan. This study focuses on PBP, which considers local conditions that limit result generalizability.

Keywords: financial benefits, Higher Education Institution (HEI), hostel, sustainable initiative, Rainwater Harvesting System (RWHS).

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INTRODUCTION

Higher Education Institutions (HEI) are considered small cities, namely campuses with various buildings, services, and activities. Notably, initiatives toward sustainable and green campuses are planned and developed to combat global warming and foster sustainable campus growth (Muhiddin et al., 2023). The initiatives align with the global agenda of the Sustainable Development Goal (SDG) (UN, 2015) and green campus assessment of UI GreenMetric World University Rankings (UI, 2023). As such, the Rainwater Harvesting System (RWHS) in the HEI environment is one of the sustainable initiatives for greening the campus.

RWHS provides numerous useful values for the environment, economy, technology, and society (Lani et al., 2018). In terms of environmental returns and technology, the implementation of RWHS helps save water, reduces demand on public supply, and lowers runoff, which helps prevent erosion and floods (DID, 2017). Financially, RWHS can lower the cost of water treatment and lessen the government burden of constructing new water distribution infrastructure to fulfill the water demand from society (Che-Ani et al., 2009). Thus, rainwater harvesting could be adopted as an alternative to reduce freshwater use for non-potable purposes (Habibullah et al., 2023).

Even though RWHS offers tons of benefits, its application is relatively at a minimum level. Implementation of green initiatives at HEI, such as RWHS, encounters some challenges, such as financial, awareness, and knowledge (Mohd Isa, 2021). Domènech and Saurí (2011) described that the long Payback Period (PBP) is the main drawback of RWHS implementation. However, installing RWHS requires high capital costs (Sakson, 2018) and a longer period of return on investment (Lani et al., 2018). Silva et al. (2015) claimed that the economic viability of the RWHS is uncertain, thus limiting the decision on its application. Other challenges to social acceptance of RWHS are risk perception, health risk, and the water quality harvested (Campisono et al., 2017).

This study focuses on Politeknik Sultan Azlan Shah (PSAS), a HEI in Malaysia selected as a case study due to its designation to promotes the integration of green practices across campus operations and curriculum under the Blueprint Polygreen (JPP, 2015). While prior Malaysian research has primarily emphasized on general issues and barrires, this study offers a novel contribution by assessing RWHS feasibility specifically within the operational and sustainability priorities of HEI hostel buildings. This provide specific financial insights for sustainable campus strategies and decision making. Therefore, the objective of this study is to evaluate the financial benefits of implementing a potential RWHS for hostel buildings at PSAS.

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LITERATURE REVIEW

Guidelines on RWHS

In Malaysia, guidelines regarding RWHS have been developed by various government agencies to support and enhance RWHS as a sustainable initiative. Table 1 summarizes the list of agencies and guidelines developed for RWHS in Malaysia.

Table 1: Guidelines for RWHS in Malaysia

No	Ministry/Department/Agency	Guidelines	Year
1	Ministry of Housing and Local Government	Guideline for Installing a Rainwater Collection and Utilization System	1999
2	Department of Irrigation and Drainage Malaysia	Rainwater Harvesting: Guidebook on Planning and Design	2009
3	National Hydraulic Research Institute of Malaysia	Guideline on Eco-Efficiency in Water Infrastructure for Public Buildings in Malaysia	2011
4	Department of Irrigation and Drainage Malaysia	Urban Storm Water Management Manual for Malaysia, MSMA 2nd Edition	2012
5	Federal Town and Country Planning Department	Panduan Pelaksanaan Inisiatif Pembangunan Kejiranan Hijau – Sistem Pengumpulan dan Penggunaan Semula Air Hujan	2012
6	Federal Town and Country Planning Department	Garis Panduan Perancangan Kejiranan Hijau	2012
7	Federal Town and Country Planning Department, Ministry of Urban Wellbeing, Housing and Local Government	Garis Panduan Sistem Pengumpulan dan Penggunaan Air Hujan	2013
8	National Hydraulic Research Institute of Malaysia	NAHRIM Technical Guide No. 2	2014
9	Malaysian Public Works Department	Rekabentuk Sistem Penuaian Air Hujan (Panduan 06)	2014
10	Department of Standards Malaysia	Urban Storm Water Management – Part 6: Rainwater Harvesting, MS2526-6:2014	2014

Source: Adopted from Lee et al. (2016)

Storage tank

A storage tank is a component where the collected rainwater is stored or harvested for later use to reduce the main water consumption in terms of economic or environmental reasons (NAHRIM, 2014). According to DID (2017), the storage tank can be installed whether above-ground or below-ground. Alternatively,

Standards Malaysia (2014) and NAHRIM (2014) stated that the tank can be installed on the ground, underground, or roof.

Previous studies have paid particular attention to storage tanks since they are the most expensive component in RWHS installation. Temesgen et al. (2015) dictated that the largest investment of RWHS is the storage tank, which ranges from 50% to 85% of the overall installation cost. Meanwhile, Nasif and Roslan (2016) highlighted that the major investment in RWHS is the storage tank, and the increasing size will increase the cost. The oversizing of the tank can lead to the excessive initial cost of the RWHS. Hence, the optimum tank size must be determined to provide the optimal value for the money. The material and tank capacity of the tank are significant design parameters in RWHS installation (Mun and Han, 2011). In other words, the higher cost of the tank will affect the longer PBP (Nasif and Roslan, 2016).

Financial Assessment

Financial assessment is essential in evaluating the value for money of RWHS. Previous studies commonly use Payback Period (PBP) as the primary economic indicator because it is simple and widely applicable (Imteaz et al., 2021). A shorter PBP indicates better financial performance and has been used effectively to assess RWHS viability (Silva et al., 2015; Pacheco & Campos, 2017). However, findings from international contexts do not always align with Malaysian conditions. Countries with higher water tariffs often report shorter PBPs, while longer PBPs described in Malaysian studies due to lower water tariff and higher installation costs (Che-Ani et al., 2009; Habibullah et al., 2023). These differences highlight the importance of localized financial assessment because PBP outcomes are influenced by rainfall patterns, construction costs, and building specific conditions.

RESEARCH METHODOLOGY

Case Study

PSAS was selected as the case study to evaluate the potential of RWHS for sustainable campus development as identified in the Blueprint Polygreen (JPP, 2015). PSAS is located in Behrang, Perak (03º77’00” N, 101º45’01”E), covering 44.5 hectares of hilly terrain. The campus consists of administration buildings, academic blocks, and six hostel blocks accommodating the largest student population (3,082 students). Given their high water demand for non-potable uses, the six hostel blocks were selected for RWHS financial evaluation.

Daily rainfall data for a ten-year period (2008 – 2018) were obtained from the nearest meteorological station i.e Felda Gedangsa, located 13.8 km from PSAS. The dataset meets the minimum recommended duration for RWHS analysis (Ward et al., 2014) and aligns with findings that 10-year records are sufficiently reliable for evaluating RWHS performance (Mitchell, 2007). As

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RWHS efficiency is highly dependent on local rainfall patterns, these long-term records provide a meaningful evaluation basis (Su et al., 2009; Rahman, 2014).

Limitations

The methodology has several limitations that may affect the generalizability of the findings. First, the reliance on historical rainfall data from a single nearby station may not fully capture micro-climatic variations across the PSAS campus, potentially influencing reliability estimates. Second, the use of document analysis as the primary data source depends on the accuracy and completeness of available institutional records. This may present vagueness in installation and operation cost data. These limitations indicate that the results are most applicable to PSAS and similar HEIs with comparable climatic and operational conditions.

Document Analysis

Document analysis is a systematic data collection procedure for evaluating or reviewing various forms of documents to obtain accurate and detailed information (Bowen, 2009). Document analysis methods produce detailed descriptions of a single program, events, and phenomena such as case studies (Yin, 1994). The document analysis method was employed in this study to gather data needed to calculate Reliability (R) and PBP. For this study, the required documents for R and PBP calculation for RWHS simulation and financial assessment are summarized in Tables 2 and 3, respectively.

Table 2: Documents for reliability (R) analysis

Documents	Organization/ Publisher	Data Obtained	Purpose
Study site's plans	PSAS	▪ Roof area ▪ Roof covering material	Used in potential rainwater harvested calculation.
		▪ Cistern capacity	Used in water demand calculation.
		▪ Plumbing layout and header tank location	Reference in designing the proposed RWHS.
Sistem Pengurusan Maklumat Politeknik (SPMP)	PSAS	▪ Number of building occupants	Used in water demand calculation.
Historic Rainfall Data	DID	▪ Rainfall amount	Used in potential rainwater harvested calculation.
NAHRIM Technical Guide No.2	NAHRIM	▪ Runoff coefficient	Used in potential rainwater harvested calculation.

Table 3: Documents for Payback Period (PBP) analysis

Documents	Organization/ Publisher	Data Obtained	Purpose
Storage Tank Catalogue	G-FRP Industries Sdn. Bhd.	▪ Tank sizes	Used in installation cost estimation.
Water Pump Catalogue	Nanfang Pump Industries Co., Ltd	▪ Water pump capacity	Used in installation cost and operational cost estimation.
RWHS Bills of Quantities	Aura-Lite Sdn. Bhd.	▪ Price of tanks, first flush filter, piping, water pump, and plinth	Used in installation cost estimation.
Water Tariff	*Lembaga Air Perak (LAP)*	▪ Water tariff	Used in water savings estimation.

Daily Mass Balance Simulation Model

The daily mass balance simulation model is applied to calculate the R of RWHS by considering the design parameter (Su et al., 2009). This model is the most preferred tool to calculate R and the size of the storage tank (Devkota et al., 2015). In addition, the simulation model could evaluate the ideal alternatives of RWHS in terms of storage capacity for decent decision-making on the RWHS initiative (Mun and Han, 2012). Previous researchers on RWHS, such as Su et al. (2009), Rahman et al. (2014), and Lani et al. (2018), used this model in their study. The daily mass balance simulation model formula is as follows:

$$R_t = \begin{cases} D_t & \text{if } WI_t + WS_{t-1} \geq D_t \\ WI_t + WS_{t-1} & \text{if } WI_t + WS_{t-1} < D_t \end{cases} \quad (1)$$

where the *Rt* is the daily water released (m^3), *Dt* is the daily water demand (m^3), *WI* is the inflow (volume of rainfall captured from the roof) (m^3), *WSt –1* is the tank storage at the end of the previous day (m^3), and *t* is the time (day).

A spreadsheet of daily mass balance simulation models is created using Microsoft Excel. Related data from the document are inserted into the simulation model to ease the calculation of R.

Reliability (R)

As the output of the daily mass simulation model is the water released (WR) and water demand (D), the R of the RWHS for all building categories is identified using the formula as follows:

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$$R(\%) = \frac{WR}{D} \times 100\% \quad (2)$$

where R is the reliability of the RWHS use (%), WR is the annual water release (m^3), and D is the annual water demand (m^3). The R is calculated for the six hostel blocks in a year duration (Lani et al., 2018).

Payback Period (PBP)

The financial benefit of the RWHS depends on investment, operation cost and the public water supply saving. Additionally, the system, installation cost, operational cost, and the amount of savings are calculated to obtain PBP (Silva et al., 2015). The flow chart on the financial benefit assessment of RWHS using PBP is displayed in Figure 1.

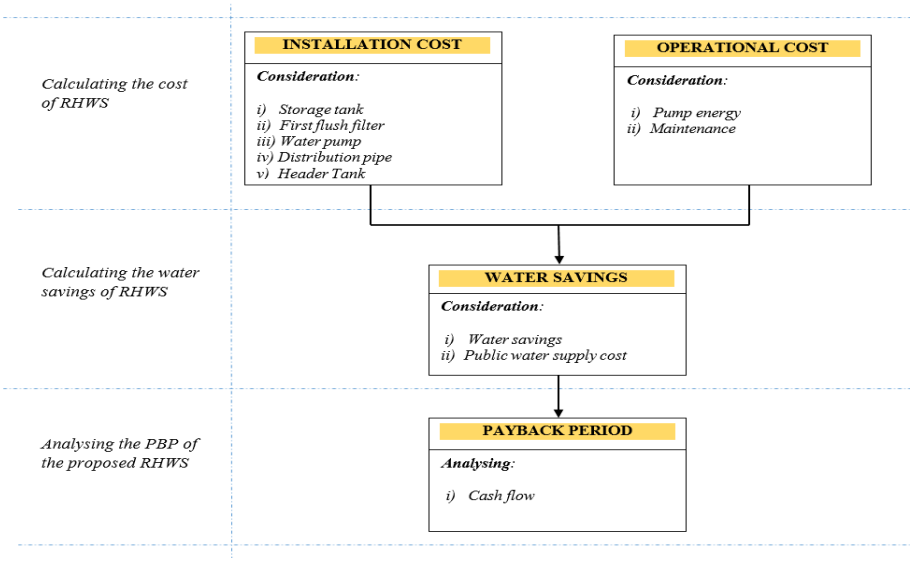


Figure 1: Flow chart of financial benefit assessment of RWHS using PBP

Financial Benefit RWHS Assessment

The financial benefit of RWHS for hostel blocks was determined based on R and the PBP. The R and the PBP were plotted in the graph along with the various sizes of storage tanks simulated in the water mass simulation model.

Two approaches have been employed to determine the optimal RWHS application for each block. The first approach is to select an optimum storage tank since the cost of RWHS is influenced by the storage tank (Temesgen et al., 2015; Mun and Han, 2012; and Zavala et al., 2018). The second approach is to consider if the optimum tank size has exceeded the system's life span. The most economic

RWHS is determined by selecting the tank size range where the PBP is still within the expected system's lifespan (Silva et al., 2015). Simultaneously, the RWHS is determined through the PBP estimation where the shorter PBP is the better financial benefit.

FINDINGS AND DISCUSSION

The financial benefits of the potential RWHS initiative for the hostel in PSAS are based on the simulation calculation for PBP and R.

Payback Period (PBP)

For PBP simulation on the potential RWHS, two types of water storage tanks, namely Fiber-Reinforced Plastic (FRP) sectional tanks and High-Density Polyethylene (HDPE) tanks, are considered due to the availability of these products in the market. Figures 2.1, 2.2, 2.3, 2.4, 2.5, and 2.6 illustrate the impact of different sizes of tanks on FRP sectional tanks and HDPE tank cost installation on the PBP of the RWHS.

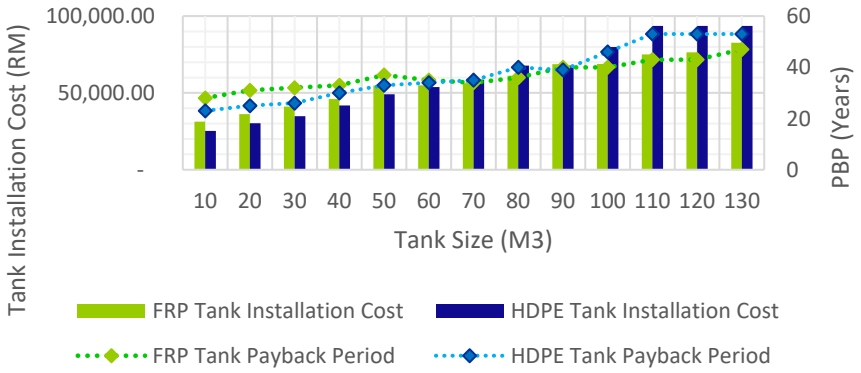


Figure 2.1: RWHS PBP on FRP and HDPE tank installation cost for hostel block V1

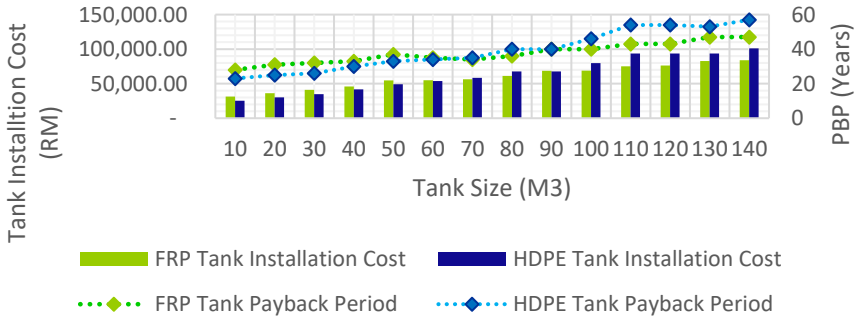


Figure 2.2: RWHS PBP on FRP and HDPE tank installation cost for hostel block V2

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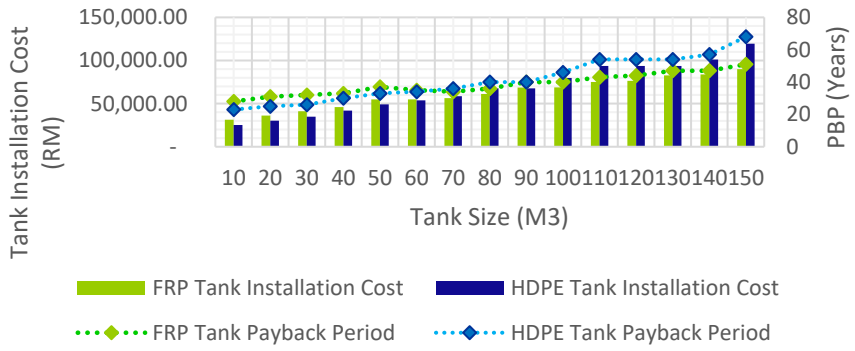


Figure 2.3: RWHS PBP on FRP and HDPE tank installation cost for hostel block V3

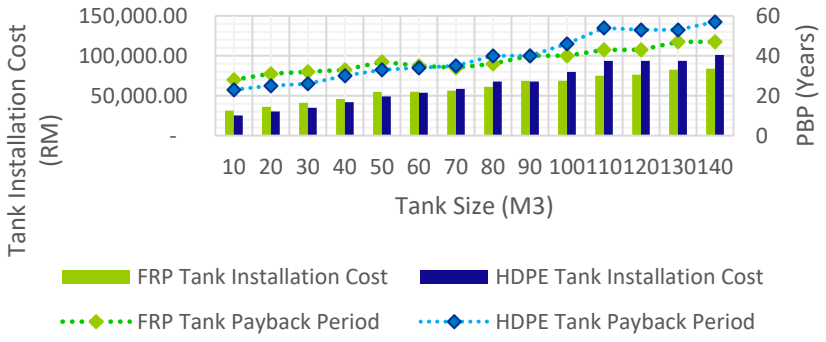


Figure 2.4: RWHS PBP on FRP and HDPE tank installation cost for hostel block V4

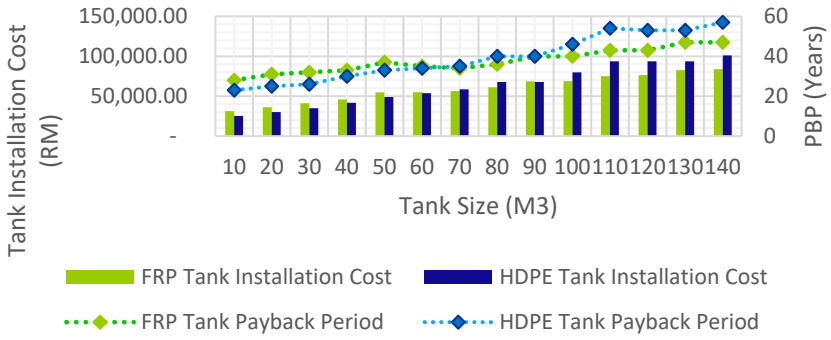


Figure 2.5: RWHS PBP on FRP and HDPE tank installation cost for hostel block V5

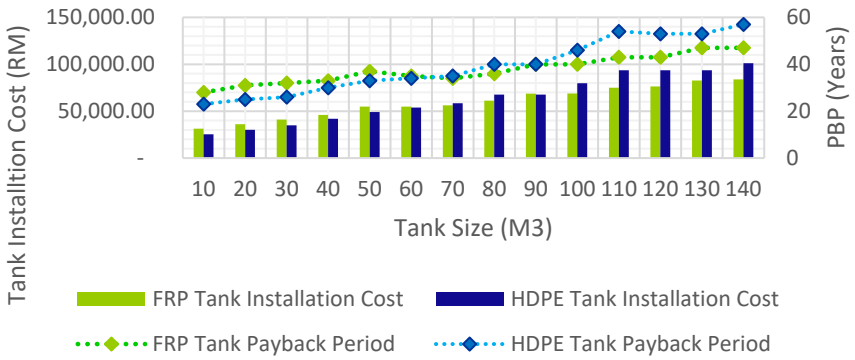


Figure 2.6: RWHS PBP on FRP and HDPE tank installation cost for hostel block V6

Figures 2.1, 2.2, 2.3, 2.4, 2.5, and 2.6 illustrate the RWHS PBP for FRP and HDPE tank installation cost for hostel blocks of V1, V2, V3, V4, V5, and V6, respectively with various tank sizes proposed. The result reveals that from the tank size of 10 m^3 to 60 m^3, the installation cost of the HDPE tank is lower than the FRP sectional tank. However, the cost of installing an HDPE tank becomes pricier than the cost of an FRP sectional tank for tank size 70 m^3 onwards. Meanwhile, for the tank size of 10 m^3 to 60 m^3, the PBP for the HDPE tank is shorter, ranging from 23 to 34 years, compared to the FRP sectional tank with 28 to 35 years. For the tank size of 70 m^3 onwards, the PBP for the HDPE tank is longer, ranging from 35 to 57 years, compared to the FRP sectional tank with 34 to 47 years.

In terms of financial benefits based on the cost of tank installation and PBP, the HDPE tank with smaller sizes, between 10 m^3 and 60 m^3, is optimum for implementation with PBP ranging from 23 to 34 years.

Reliability (R)

R simulation on the potential RWHS on the two types of water storage tanks, namely FRP sectional tank and HDPE tank, is conducted until the size of the water tanks achieves the highest target of R of RWHS, which is 100%.

The financial benefits evaluation is based on graphs plotted by combining the type of tanks, sizes of tanks, percentage of R, PBP, and lifespan of the RWHS. Figures 3.1, 3.2, 3.3, 3.4, 3.5, and 3.6 display the evaluation of different sizes of FRP and HDPE tanks to R and PBP within the potential RWHS lifespan of 30 years.

The percentages of R for the RWHS for HDPE tanks are between 63.14% and 74.52%, which is acceptable to implement when considering the system's lifespan and PBP. The 100% maximum R of RWHS with larger tank sizes for the hostel blocks is also simulated. Inappropriately, larger sizes of FRP

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and HDPE tanks, for example, 100 m^3 onwards, are not significant due to longer PBP and exceed the system's lifespan.

Financial benefits

The analysis of the six (V1, V2, V3, V4, V5, and V6) hostel blocks in PSAS demonstrates similar findings for each hostel block that the PBP of RWHS was affected by the types of storage tanks and tank sizes. In other words, tank selection in RWHS design contributes significantly to the cost implication of RWHS. These findings align with previous research by Zavala et al. (2018) and Lani et al. (2018).

Based on the Malaysia market price of water storage tanks, the cost of an HDPE tank is cheaper than FRP sectional tanks for installation of water storage tank sizes 10 m^3 to 60 m^3. However, the cost of the HDPE tank becomes more expensive than FRP sectional tanks for tank size 70 m^3 onwards.

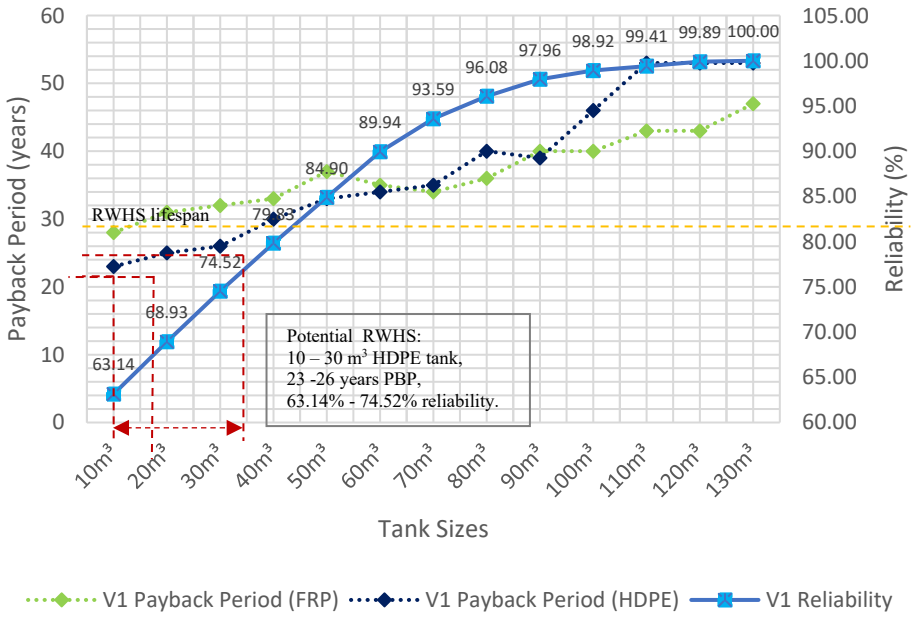


Figure 3.1: Financial benefit evaluation of potential RWHS for hostel block V1

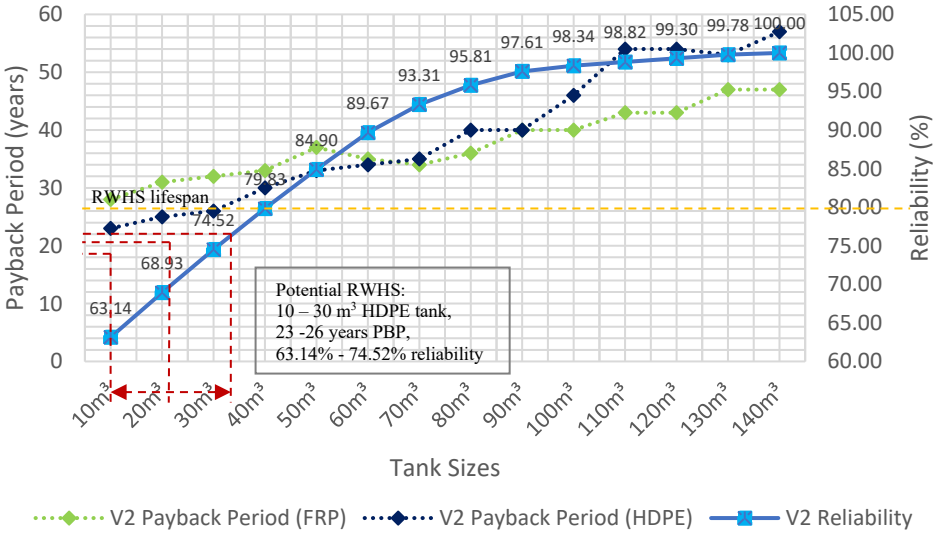


Figure 3.2: Financial benefit evaluation of potential RWHS for hostel block V2

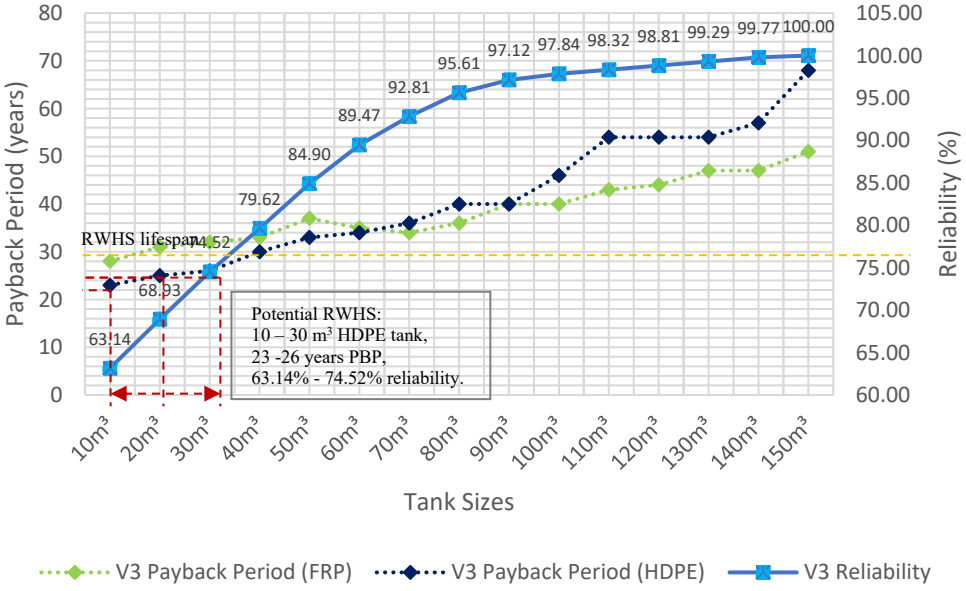


Figure 3.3: Financial benefit evaluation of potential RWHS for hostel block V3

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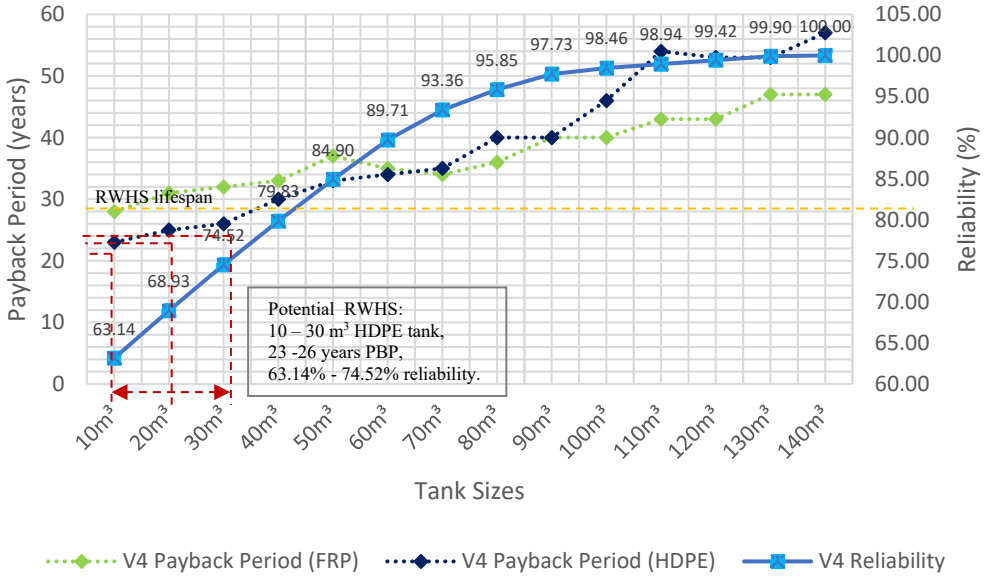


Figure 3.4: Financial benefit evaluation of potential RWHS for hostel block V4

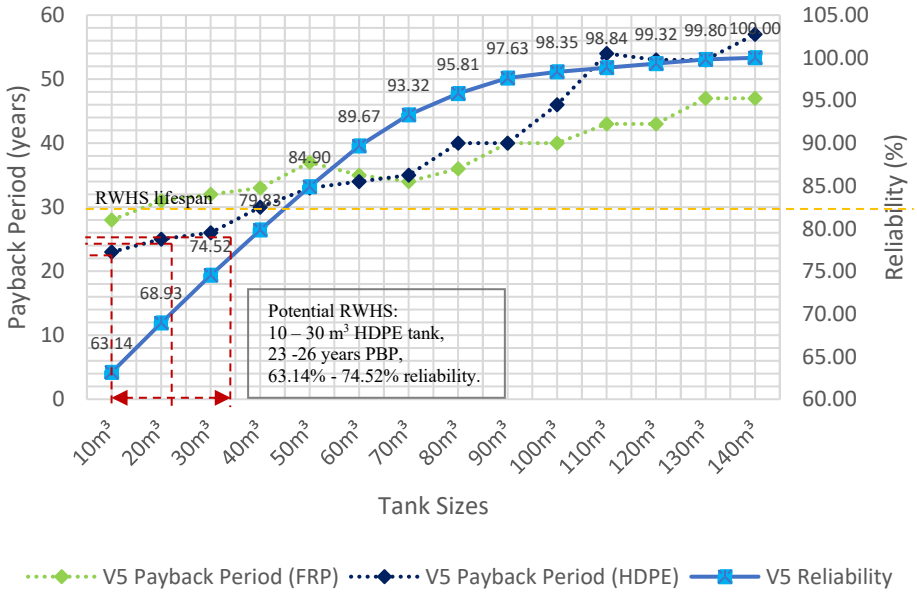


Figure 3.5: Financial benefit evaluation of potential RWHS for hostel block V5

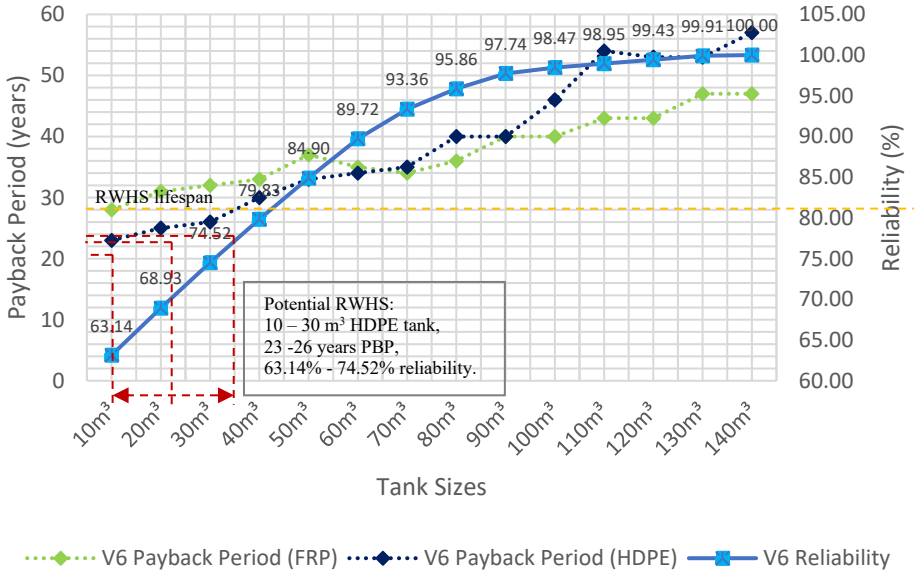


Figure 3.6: Financial benefit evaluation of potential RWHS for hostel block V6

For optimal financial benefits, the potential RWHS design must consider the R and lifespan of RWHS for 30 years. The smaller HDPE tank sizes range from 10 m^3 to 30 m^3 with 23 to 26 years of PBP, which are considered the most appropriate financial benefits of RWHS for all the hostel blocks. This is due to the acceptable R ranging between 63.14% and 74.52%, and PBP is within the RWHS expected lifespan. The maximum R of 100% on the tank sizes will result in high PBP, which exceeds the RWHS expected lifespan, which is a disadvantage in terms of finances. Silva et al. (2015) suggested that the most financial benefits of potential RWHS should be based on shorter PBP.

CONCLUSION

In conclusion, the study shows that selecting the appropriate HDPE tank size is essential for ensuring the financial feasibility of RWHS in PSAS hostel buildings. Small to medium sized tanks offer the best balance between cost and performance, particularly for institutions seeking shorter payback periods. These findings provide practical guidance for HEIs considering RWHS as part of their sustainability policies and strategies, supporting progress toward SDGs and strengthening performance in the UI GreenMetric ranking.

Even though the payback period is relatively long under current tariff rates, the financial viability of RWHS is likely to improve as water tariffs rise in the future. RWHS can serve as a strategic long-term resource management

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measure for HEIs. Future research should therefore examine how potential tariff increases could further enhance the economic value of RWHS in Malaysian HEIs.

ACKNOWLEDGEMENTS

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THE INFLUENCE OF COMPLEXITY AND COHERENCE IN PLANTING DESIGN ON STUDENT PREFERENCES AND WELL-BEING

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Abstract

Preference indicators such as complexity, coherence, legibility, and mystery play a crucial role in landscape planting design. Among these, complexity and coherence are often associated with high preference ratings in perceived landscapes. This study examines how students perceive landscapes with varying levels of complexity and coherence in planting compositions and the way these factors influence their preferences and well-being. Understanding these relationships is essential for promoting outdoor engagement and maximizing the benefits of nature for students. A photo-based questionnaire survey was conducted to assess preferences for 51 planting images. Data analysis, including descriptive and exploratory factor analysis using SPSS, revealed significant correlations between landscape complexity, coherence, and preference ratings. The findings highlight how this design elements affect students' psychological responses and overall well-being, offering valuable insights for campus landscape planning. This study contributes to integrating public perception into landscape design decision-making and enhances understanding of the relationship between planting composition and student experiences.

Keywords: Coherence, Complexity, Planting Design, Preference, Well-Being

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INTRODUCTION

The design of outdoor environments plays a fundamental role in shaping human experiences, particularly in educational settings where students spend a significant amount of time. University campuses are more than just academic spaces; they also serve as social and recreational environments that contribute to students' overall well-being. Research has shown that exposure to natural environments can reduce stress, enhance cognitive function, and improve psychological health (Jimenez et al., 2021; Liu & Green, 2023). However, the specific attributes of landscape design that maximize these benefits remain an area of ongoing research. Among the various landscape design principles, preference indicators such as complexity, coherence, legibility, and mystery are widely recognized as crucial factors influencing how individuals perceive and interact with outdoor spaces (Kaplan, 1987).

Complexity and coherence, in particular, are often associated with higher preference ratings in landscape perception. Complexity refers to the richness and variety of elements within a landscape scene, including plant species diversity, layering, and textural contrasts (Nasar, 1987). On the other hand, coherence is relevant to the visual organization and orderliness of these elements, as it ensures a harmonious and structured appearance. While both factors contribute to aesthetic appreciation, their combined effects on individuals' psychological responses and well-being have yet to be fully understood. Prior studies suggest that environments with balanced complexity and coherence tend to be more restorative and engaging (Kaplan, 1995; Herzog et al., 2003). However, few studies have specifically explored how these attributes influence students' perceptions of campus landscapes and their overall well-being.

University students often experience high levels of stress due to academic pressures, social expectations, and personal challenges. Access to well-designed green spaces has been identified as a key factor in promoting relaxation, mental restoration, and social interaction (Hartig et al., 2014; Taylor & Kuo, 2009). Therefore, understanding how planting composition particularly complexity and coherence affect students' landscape preferences and well-being is essential in creating effective outdoor spaces that support academic success and overall mental health. With proper designs, campus landscapes can function as restorative environments that encourage outdoor engagement, alleviate stress, and improve cognitive performance.

Despite the increasing recognition of landscape design's impact on psychological well-being, there remains a gap in empirical research concerning the direct relationship between complexity, coherence, and student preferences. This study aims to address this gap by examining the way university students perceive planting compositions with varying degrees of complexity and coherence. Through a photo-based questionnaire survey, this research

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investigates students' preference ratings for different landscape compositions and analyses their potential influence on well-being. By identifying key patterns and correlations, the study seeks to provide valuable insights for campus landscape planning and contribute to evidence-based design strategies that enhance students' experiences in outdoor spaces.

This study contributes uniquely to the existing body of literature by focusing on planting design and student well-being within the Malaysian context, where tropical climatic conditions, campus culture, and landscape typologies differ markedly from those commonly examined in Western research. By situating the findings within Malaysia's educational and environmental setting, this research provides localized insights that support culturally relevant landscape design strategies for university campuses.

COMPLEXITY AND COHERENCE IN LANDSCAPE PLANTING DESIGN

Complexity Preferences

Complexity is a fundamental concept in landscape design that refers to the variety, richness, and diversity of elements within a given environment. It encompasses the number of different visual components, their arrangement, and the interactions between plant species, textures, and colours (Kuper, 2017). In the context of planting design, complexity is determined by factors such as species diversity, layering of vegetation, textural contrast, and spatial arrangement (Xie et al., 2024). Complexity is often associated with a higher level of visual stimulation, which can influence how individuals perceive and respond to landscapes (Kaplan & Kaplan, 1989). Studies in environmental psychology suggest that moderately complex landscapes tend to be more engaging and aesthetically appealing, while overly simplistic or excessively intricate environments may reduce visual interest or cause cognitive overload (Ulrich, 1983; Babington et al., 2023). Therefore, complexity in planting design contributes to aesthetic preference, as people tend to be drawn to landscapes that offer a balance of variety and create a sense of depth and visual richness.

Coherence Preferences

A coherent landscape exhibits clear spatial patterns, consistent plant arrangements, and an overall sense of unity, reducing cognitive strain and making the space more inviting (Hami & Abdi, 2019). Coherence is achieved by maintaining repetitive patterns or motifs in plant selection, colour schemes, textural harmony, and spatial organization (Yilmaz, 2018). Landscapes that exhibit coherent planting designs often group the plants species that complement each other in form and texture, have gradual transitions in height and density, focal point and typically have structured pathways or recognizable pattern, as this

enhances the overall readability of the space. Coherence plays a critical role in environmental preference and psychological well-being. According to the Kaplan and Kaplan Preference Matrix (1989), coherence is one of the four primary predictors of landscape preference, alongside complexity, legibility, and mystery. Landscapes that are visually well-structured and balanced tend to be rated more positively because they provide a sense of order and predictability, which enhances comfort and relaxation (Zhang et al., 2021). In contrast, environments that lack coherence and appear chaotic or disconnected, can cause visual discomfort and cognitive fatigue (Gungor & Polat, 2018).

Balancing Complexity with Coherence in Landscape Planting Design

While complexity enhances visual interest and engagement, it must be balanced with coherence to create a harmonious and legible environment (Kaplan, 1995; Kuper, 2017). Coherence refers to the sense of order and organization in a landscape, ensuring that elements fit together cohesively rather than appearing disorganized. Research suggests that landscapes that successfully integrate both complexity and coherence are rated as more aesthetically pleasing and psychologically beneficial (Kaplan & Kaplan, 1989). A study by Liu et al. (2021) found that participants preferred landscapes with high complexity when they also exhibited clear structural patterns, such as distinct plant groupings and visible pathways. This finding aligns with the Prospect-Refuge Theory (Appleton, 1975), which suggests that humans are naturally drawn to environments that offer both visual stimulation and a sense of order or safety. In contrast, landscapes with excessive complexity but low coherence can be perceived as chaotic and may lead to cognitive fatigue rather than restoration. Therefore, striking a balance between complexity and coherence is essential in planting design to ensure landscapes are both engaging and psychologically restorative.

Well-Being Benefits of Complexity and Coherence in Planting Design

Beyond aesthetics, complexity and coherence in landscape planting design has significant implications for psychology and well-being. Research in restorative environments suggests that exposure to nature, particularly biodiverse and visually rich landscapes, can reduce stress, improve mood, and evoke positive emotional responses (Ulrich, 1983; Hartig et al., 2014) while, coherence, structured, harmonious landscapes promote relaxation, reduce mental fatigue, and support cognitive functioning (Hartig et al., 2014). The Attention Restoration Theory (Kaplan & Kaplan, 1989) argues that environments with clear visual structure are more restorative, as they require less cognitive effort to process as well as complexity helps to restore directed attention by engaging the mind without causing mental fatigue. Studies have found that complex yet organized landscapes revealed that people exhibited lower stress levels and increased

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feelings of restoration when exposed to landscapes with high visual richness and well-organized green spaces. In addition, Kurzi et al., (2024) demonstrated that coherent landscapes in urban areas were linked to lower crime rates and increased community cohesion, suggesting that visually structured environments can have broader social benefits.

Understanding the role of complexity and coherence in planting design is particularly important in university campus settings, where outdoor environments serve both functional and restorative purposes. Well-designed campus landscapes can enhance students' engagement with nature, provide spaces for relaxation, and support cognitive performance (Li & Sullivan 2016; Scholl & Gulwadi, 2018). By incorporating diverse yet organized planting compositions, universities can create outdoor spaces that are not only visually appealing but also contribute to students' well-being.

In summary, complexity and coherence is a key factor influencing landscape perception and preference, with significant implications for aesthetic appreciation and psychological well-being. While complex landscapes can enhance visual interest and mental engagement, they must be carefully balanced with coherence to avoid cognitive overload. The integration of complexity in campus planting design can contribute to more engaging, restorative, and functional outdoor spaces that support students' well-being and academic success. Future studies should continue to explore the nuanced relationships between complexity, coherence, and individual preferences to inform evidence-based landscape planning and design.

METHODOLOGY

Research in the field of landscape preference often involves surveys, interviews, or observations to gather data on people's preferences for different landscape features, styles, and characteristics. The findings can guide decision-making in landscape design, allowing designers to create environments that are visually appealing, emotionally engaging, and well-received by the intended users. This study employed a methodological approach focused on coherence and complexity design in planting, with the aim of catering to students' preference and wellbeing.

To gather preference ratings, a photo-based method was utilized, and 319 participants were involved in the study. A five-point Likert-scale questionnaire was administered to assess the participants' preferences. The questionnaire comprised 51 planting images obtained from Universiti Putra Malaysia, which were categorized into four groups based on Kaplan's Information Processing Theory. In this theory, coherence, complexity, legibility, and mystery serve as the four preference predictors. To analyse the collected data on existing plant types and configurations in the green landscape of each faculty,

SPSS or statistical analysis tool was used. It was employed to explore and derive meaningful insights from the data, shedding light on the connection between preference predictors (coherence and complexity) and students' wellbeing. By examining the associations between these variables, the study aimed to provide valuable insights for designing plant arrangements that enhance the students' overall satisfaction and comfort within the university environment.

In addition, factor analysis was conducted to further explore the relationships among the 51 planting images and to group them into the four preference predictors: coherence, complexity, legibility, and mystery. The factor analysis technique allowed for a comprehensive examination of the underlying dimensions or factors influencing participants' preferences. Through factor analysis, the 51 planting images were assessed based on their visual characteristics and attributes. This analysis aimed to identify the key factors that contributed to participants' preferences within each predictor category. By evaluating the interrelationships among the variables (planting images) and extracting underlying factors, the study aimed to gain a deeper understanding of how coherence, complexity, legibility, and mystery influenced participants' preferences and well-being. Figure 1 shows the methodological process of this study.

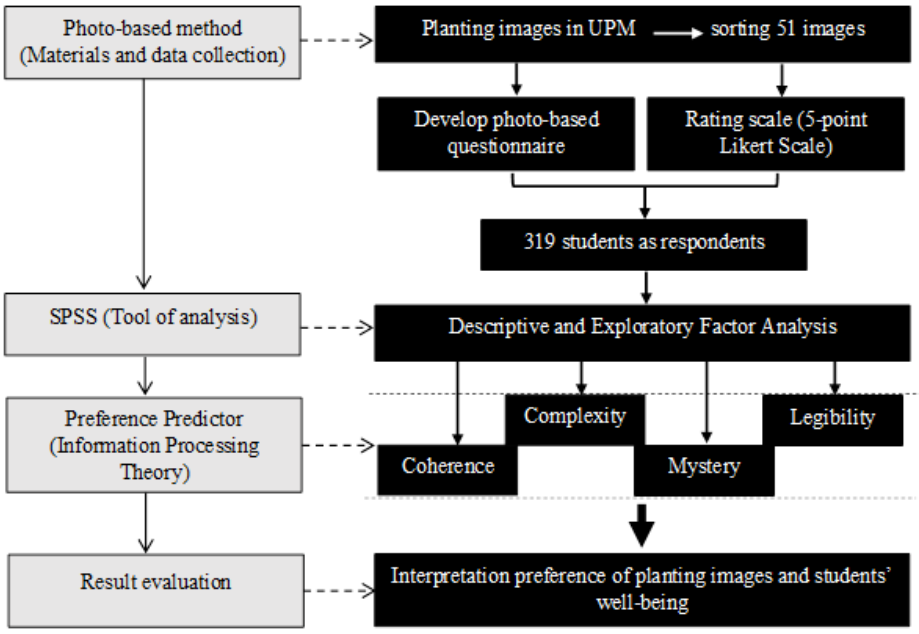


Figure 1: The flowchart of methodological process

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The results of the factor analysis provided valuable insights into the patterns and groupings within the dataset. These groupings helped in categorizing the planting images based on their shared attributes and qualities, thereby facilitating a better understanding of the factors that contribute to students' preferences and wellbeing in the context of green landscapes.

This study was conducted in accordance with the ethical research standards of Universiti Teknologi MARA (UiTM). All participants were informed about the purpose of the research, provided written consent prior to participation, and their responses were kept confidential and anonymous. The survey was approved by the Head of the Student Affairs Division, Universiti Putra Malaysia (UPM), who granted permission for the authors to conduct the study among UPM students.

FINDINGS AND DISCUSSION

The survey findings indicate that certain factors significantly contribute to higher preference ratings. To determine which components of planting principles, have a substantial impact on preference and students' well-being, factor analysis was conducted. This analysis plays a crucial role in grouping landscape planting scenes into ten components that share similar characteristics.

These ten components were identified and labelled as follows: Factor 1 (A01) — *Complexity: Variety of Plant Properties*; Factor 2 (A02) — *Coherence: Balance and Symmetry*; Factor 3 (A03) — *Mystery: Layer*; Factor 4 (A04) — *Legibility: Visual Weight*; Factor 5 (A05) — *Legibility: Scale and Proportion*; Factor 6 (A06) — *Complexity: Contrast of Texture*; Factor 7 (A07) — *Complexity: Density of Mixed Planting*; Factor 8 (A08) — *Mystery: Visual Enclosure*; Factor 9 (A09) — *Coherence: Order and Openness*; and Factor 10 (A10) — *Mystery: Visual Connection* (see Table 1). Each factor comprised more than five images representing distinct planting composition characteristics. The mean scores for each factor, presented in Table 1, provide insights into the relative preference ratings across the different planting design attributes.

According to Table 1, Factor A07, which pertains to complexity with a density of mixture plants, received a higher rating. Similarly, Factor A02, associated with coherence and balance through symmetrical arrangement, and Factor A04, representing legibility of visual weight, also obtained high ratings. However, it is worth noting that Factor A04 had only one photograph of a planting scenery with a high rating, in comparison to Factor A02. This result highlights that coherence and complexity are dominant factors in evaluating landscape characteristics, within a campus setting (Mt Akhir et al., 2021).

Table 1: Four preference characteristics with element of planting design

Planting Preference Predictors	Factor Label	Elements of Planting Design	Mean Value
Complexity	Factor 1 (A01)	Variety of plant properties	3.613
	Factor 6 (A06)	Contrast of texture	3.576
	Factor 7 (A07)	Density of mixture plants	**4.156**
Coherence	Factor 2 (A02)	Balance and symmetry	**3.833**
	Factor 9 (A09)	Orderly and openness	3.212
Mystery	Factor 3 (A03)	Layer	3.752
	Factor 8 (A08)	Visual Enclosure	3.453
	Factor 10 (A10)	Visual Connection	3.629
Legibility	Factor 4 (A04)	Visual weight	**3.847**
	Factor 5 (A05)	Scale and Proportion	3.673

Source: Author (2024)

Table 2 below shows a comprehensive overview of planting scenes ranked with high preference. Conversely, the remaining factors and photographs of the planting scenes tend to receive modest ratings.

Table 2: Photographs of planting scenery with high ranking

Factor	Photo number	Mean Value	RII	Rank
A07 (Complexity)	Photo 47	4.370	0.874	1
	Photo 46	**4.194**	**0.839**	**2**
	Photo 48	4.122	0.824	4
A02 (Coherence)	**Photo 24**	**4.194**	**0.839**	**2**
	Photo 22	4.132	0.826	3
	Photo 30	4.000	0.800	6
A04 (Legibility)	Photo 3	4.066	0.813	5

Source: Author (2024)

Coherence: Factor A02 and A09

The coherence predictor aligns with two dimensions: A02 (Balance and Symmetry) and A09 (Orderly and Openness). These dimensions meet the coherence criteria by incorporating symmetrical arrangements and orderly repetition of themes, while also allowing for clear directional views. However, it is clear that although A09 meets the coherence criteria, it does not receive high

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preference ratings. This dimension, characterized by fewer plants and an open layout, resulted in a perceived discomfort and increased exposure to heat. It is aligned with previous studies (Ozer & Baris, 2013) that mentioned students mostly prefer the semi-open landscapes more than very open landscapes and highly trimmed plants. In contrast, the dimension of A02, which exhibits symmetrical balance, emerged as a significant contributor to preference ratings. The arrangement of planting spaces that are divided equally could increase cohesive influence. The researcher believes that coherence plays a role in increasing the rating preferences of this factor.



Factor A02 (Photo 24)



Factor A09 (Photo 7)

Figure 2: These two figures fall under the category of Coherence design in planting. Notably, Photo 24 holds the second highest position in the ranking of students' preferences.

Complexity: Factor A01, A06 and A07

The complexity predictor encompasses a wide range of visual elements. The factors A01 (Variety of Plant Properties), A06 (Contrast of Texture), and A07 (Density of Mixture Plants) are pertinent in defining complexity in terms of the intricacy and richness of the scenes. Among the respondents, the majority expressed a strong preference for planting sceneries associated with this complexity predictor, particularly in relation to dimension A07. This dimension reflects the number and density of plants within the scenes. Complexity is the involvement component of a scene's capacity to keep an individual busy watching, occupied without being bored or overstimulated. It also refers to the amount of the diversity of the visual elements presented in the scene which people are interested in seeking how much is going on in the scene (Kaplan & Kaplan, 1989). Additionally, the inclusion of diverse plant features in the scenes received high ratings, thus contributing to enhanced visual preference and overall well-being within the space.

In the context of human psychology, well-being also can be referred as better quality of life, emotion, satisfaction and performance (Kaiserman, 2017;

Li & Sullivan, 2016; Southon et al., 2018; Wang et al., 2016). There is a strong relationship between high preference and human well-being. When individuals have a high preference for certain aspects of their environment, such as complexity and coherence planting scenes, it can positively impact their overall well-being. Preferences are often linked to psychological and emotional factors, and when people are surrounded by environments, they find visually appealing and enjoyable, it can contribute to their happiness and satisfaction.



Factor A07 (Photo 47)



Factor A07 (Photo 48)

Figure 3: These two figures fall under the category of Complexity design in planting. Notably, Photo 47 holds the highest position in the ranking of students' preferences.

In summary, the findings highlight significant correlations between students' preference ratings and the complexity and coherence of planting designs. The results indicate that students favoured planting compositions with higher complexity, particularly those featuring diverse species, varied textures, and layered densities. Moreover, well-organized and visually balanced landscapes were positively associated with a sense of calmness and psychological well-being.

Moreover, exposure to planting designs that achieved an optimal balance of complexity and coherence contributed to greater psychological comfort and cognitive restoration. These findings align with Attention Restoration Theory (ART) and Stress Reduction Theory (SRT), reinforcing the role of natural environments in promoting relaxation, mental rejuvenation, and overall well-being (Kaplan, 1995; Ulrich, 1983). The study underscores the importance of integrating complexity and coherence in landscape design to enhance students' experiences and foster more restorative outdoor spaces on university campuses.

CONCLUSION AND RECOMMENDATION

This study concludes that complexity and coherence in planting design play a significant role in shaping students' landscape preferences and overall well-being.

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The findings indicate that well-balanced and visually engaging planting compositions contribute to stress reduction, cognitive restoration, and enhanced psychological comfort. Landscapes that feature a diverse range of plant species, textures, and densities tend to be more aesthetically preferred, while coherent and well-organized arrangements create a sense of order and tranquillity. These results align with established environmental psychology theories, such as Attention Restoration Theory (ART) **and** Stress Reduction Theory (SRT)**,** reinforcing the positive impact of natural settings on mental rejuvenation and well-being (Kaplan, 1995; Ulrich, 1983).

Given the increasing recognition of green spaces as essential components of academic environments, it is imperative that university landscapes are designed with a thoughtful balance of complexity and coherence. Well-planned planting compositions not only enhance visual appeal but also foster restorative experiences that support students' academic performance, social interactions, and emotional resilience.

RECOMMENDATIONS

Based on the study's findings, the following recommendations are proposed to improve campus landscape planning and promote student well-being. University planners should prioritize a planting design that balances complexity and coherence. They should also increase biodiversity by incorporating a diverse range of plant species, textures, and densities which can enrich visual interest while supporting ecological sustainability. At the same time, maintaining coherence through strategic plant arrangement such as structured layouts, consistent design themes, and well-defined spatial organization can create visually harmonious environments that foster psychological comfort and ease navigation.

Lastly, future research should focus on real-time interactions between students and green spaces to provide deeper insights into the long-term effects of planting design on well-being. Investigating behavioural responses, physiological indicators, and qualitative experiences can help refine landscape planning strategies, ensuring that campus environments effectively support cognitive function, emotional resilience, and academic engagement. By integrating these principles into campus landscape planning, universities can create outdoor spaces that not only enhance aesthetic quality but also serve as restorative environments that promote student well-being. A thoughtful approach to planting design can contribute to healthier, more engaging academic settings, ultimately supporting students' cognitive function, emotional resilience, and overall quality of life.

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LIMITATIONS

This study offers insights into students' perceptions of planting design but has limitations which photo-based questionnaires method cannot capture multisensory experiences such as sound, scent, or spatial depth. The sample, limited to Malaysian university students, may restrict generalizability, and variations in image quality and size could have influenced responses. Future research should use on-site or cross-cultural approaches for a more comprehensive understanding of planting design and well-being.

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RESILIENCE IN THE FACE OF DISASTER: INTEGRATING ACEH-MUSLIM SPATIAL CULTURE INTO URBAN PLANNING

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Abstract

Urban resilience is crucial for disaster-prone regions like Aceh, Indonesia, where Islamic traditions and cultural identity significantly shape recovery and adaptation strategies. This study explores how Acehnese-Muslim spatial culture, such as communal living, mosque-centred layouts, and waqf-based spaces, can be integrated into urban and disaster planning. Data were collected through interviews with ten stakeholders and document analysis of relevant planning documents. NVivo software facilitated qualitative thematic and content analysis using a coding approach. The findings reveal that while cultural values are symbolically acknowledged, they are weakly implemented in policy and planning. The novelty of this study lies in identifying spatial indicators rooted in local culture that are relevant to resilience but underutilised in formal planning. The study recommends institutionalising these values through participatory planning processes. Future research should develop measurable frameworks to evaluate the impact of cultural practices on disaster resilience and examine the transferability of Aceh-based insights to other Muslim-majority urban contexts facing similar disaster risks.

***Keywords*:** Aceh-Muslim spatial culture, qualitative research, spatial culture, urban planning, urban resilience

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INTRODUCTION

Urban resilience has become increasingly essential in contemporary urban planning, particularly in regions vulnerable to natural disasters and social disruptions. The ability of urban systems to absorb, recover from, and adapt to various shocks is crucial for ensuring the safety, stability, and sustainability of cities globally (Meerow et al., 2016). This concept encompasses not only physical and infrastructural resilience but also the social, economic, and cultural dimensions that collectively contribute to a city's capacity to withstand and recover from adversities.

Aceh, located at the northern tip of Sumatra in Indonesia, presents a unique model for enhancing urban resilience by integrating its rich cultural heritage and Islamic traditions into spatial planning. The region has long faced significant challenges, including the devastating 2004 Indian Ocean tsunami, which claimed over 167,000 lives in Aceh, and prolonged armed conflicts that disrupted socio-economic stability (Gaillard et al., 2008). Despite these adversities, Aceh has demonstrated remarkable resilience, largely attributed to its strong cultural identity and community cohesion rooted in Islamic values (Bashori & Moerdijat, 2023).

Urban resilience has traditionally been assessed through the lens of infrastructure and economic systems, often overlooking the pivotal role of cultural and social structures (Ni'mah & Setiawan, 2022). In Aceh, with its deeply embedded Islamic traditions, there is significant potential for enhancing urban resilience through the integration of Islamic spatial culture into urban planning. However, despite the clear importance of these cultural practices, there is a notable gap in understanding and documenting how these elements contribute to urban resilience in Aceh (Zuraidi et al., 2023). The existing literature largely overlooks the nuanced relationship between cultural heritage, religious practices, and urban resilience, leaving unanswered questions about how these elements strengthen resilience (Zuraidi et al., 2020, 2021; Zuraidi & Zainol, 2025). Furthermore, the lack of empirical evidence and documentation regarding the integration of cultural practices into resilience strategies hinders the development of culturally sensitive urban resilience frameworks.

Thus, this study aims to explore the role of Aceh-Muslim spatial culture in urban resilience by identifying key cultural practices that contribute to disaster preparedness and recovery. The specific objectives of this research are: (1) to analyse how Aceh-Muslim spatial culture influences urban resilience, (2) to identify the cultural elements integrated into urban planning and resilience strategies, and (3) to assess the effectiveness of these cultural integrations in strengthening community resilience. By providing a comprehensive understanding of these dynamics, this research aims to guide policymakers, urban planners, and disaster management practitioners in incorporating cultural heritage

into resilience frameworks, ultimately fostering resilient urban communities in Aceh and beyond.

LITERATURE REVIEW

Urban Resilience and Planning

Urban resilience refers to a city's ability to absorb, recover from and adapt to the impacts of disasters while maintaining its core functions (Meerow et al., 2016). It encompasses social, economic, infrastructural, and cultural dimensions that collectively determine a city's ability to respond effectively to disasters (Godschalk, 2003). In disaster-prone regions, the integration of cultural and spatial practices into urban planning has been shown to enhance resilience by fostering community preparedness, social cohesion, and sustainable development (Ahern, 2011). In this regard, the Aceh region, which suffered catastrophic impacts during the 2004 Indian Ocean tsunami, offers a critical case for examining how Acehnese-Muslim spatial culture contributes to resilient urban form and function. Post-disaster analyses of coastal settlements such as Gampong Saney show how relocation housing, changing coastal physiography, and evolving livelihood patterns co-produce new spatial arrangements and adaptation strategies, highlighting the interdependence of environmental change, settlement morphology, and community resilience in Aceh (Elysa et al., 2020).

Urban planning is a technical and strategic process involving the systematic organisation and development of land use, infrastructure, and public spaces to support sustainable and resilient urban development (Levy, 2016). The planning process typically includes several key stages: (1) data collection and analysis, which involves assessing existing conditions, demographic trends, infrastructure needs, and environmental risks; (2) vision and goal setting, wherein long-term development objectives are established in alignment with resilience and sustainability; (3) policy formulation, which involves developing strategies for zoning, land use, transport, and disaster mitigation strategies; (4) plan implementation, through infrastructure development, legal frameworks, and governance structures; and (5) monitoring and evaluation, which ensures continuous assessment and refinement of planning strategies. Urban planning thus plays a pivotal role in fostering resilience by shaping spatial arrangements and policies that account for both physical vulnerabilities and socio-cultural strengths.

Aceh-Muslim Spatial Culture and Resilience

Acehnese-Muslim spatial culture is deeply rooted in Islamic values and local traditions, influencing both the built environment and social structures. Mosques function not only as places of worship but also as communal centres for community gatherings and emergency response (Utaberta & Asif, 2017). Islamic

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principles such as *gotong royong* (cooperation) and *waqf* (charitable endowment) strengthen communal resilience by promoting resource-sharing and collective action in times of crisis (Nurdin, 2024). Additionally, Acehnese villages (*gampong*) are traditionally organised around mosques and communal open spaces, which facilitate coordinated evacuation and community mobilisation during disasters (Mahmuddin et al., 2016).

Traditional Acehnese architecture, particularly the *Rumoh Aceh* – a stilted wooden house – is inherently resilient, designed to withstand floods and earthquakes while promoting natural ventilation (Fakriah & Edytia, 2021). During the 2004 tsunami, settlements that preserved traditional designs and coastal buffer zones experienced less structural damage than those with modern construction (Benazir et al., 2023). By contrast, empirical studies of contemporary reinforced-concrete shophouses in Banda Aceh indicate significant deficiencies in thermal and lighting comfort, resulting in high dependence on mechanical cooling and artificial lighting, which can exacerbate vulnerability when energy and infrastructure systems are disrupted (Sari et al., 2018). This recognition led to post-tsunami reconstruction efforts that embraced indigenous knowledge alongside modern engineering under the Build Back Better framework (UNDRR, 2015). Moving forward, urban planning must incorporate these cultural practices into contemporary resilience strategies. Policies should actively promote the preservation of traditional architectural heritage, mosque-based community disaster management, and participatory planning approaches rooted in local values (Vivita et al., 2023). Such integration ensures that resilience frameworks are both culturally sensitive and practically effective in disaster-prone contexts like Aceh.

Conceptual and Theoretical Framework

This study is grounded in Resilience Theory, which explains how social, ecological, and urban systems adapt and transform in response to disruptions (Holling, 1973). Specifically, it draws on the concept of social-ecological resilience, which emphasises the dynamic interdependence between human settlements and environmental processes (Wilkinson, 2012). Employing a qualitative approach, the study examines the role of cultural practices in shaping urban resilience within the context of Aceh. The conceptual framework integrates three interrelated dimensions: (1) cultural resilience (local traditions and social practices); (2) Islamic spatial planning principles (mosque-centred layouts, waqf-based spaces, and communal facilities); and (3) urban sustainability and disaster governance (policies, plans, and institutions). These dimensions interact to influence urban resilience outcomes, with community participation mediating the link between cultural practices and formal planning instruments (Figure 1).

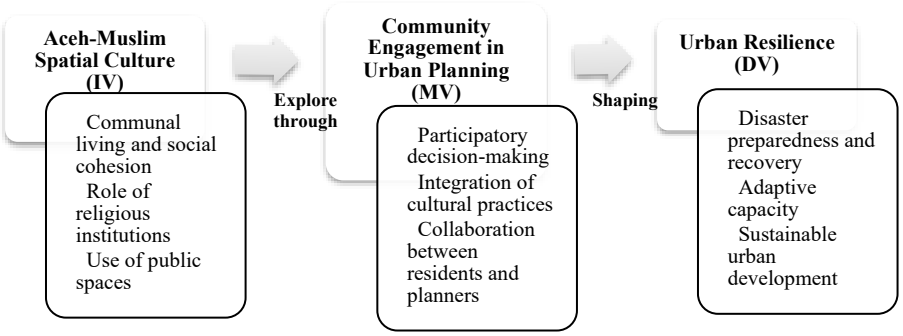


Figure 1: Conceptual framework linking Aceh-Muslim spatial culture, Islamic planning principles, and urban resilience
Source: Authors, adapted from existing literature (2024)

Cultural resilience underscores the significance of local traditions in enhancing disaster preparedness and post-disaster recovery (Berkes & Ross, 2013). Islamic spatial planning principles further reinforce this by emphasising the role of mosques, communal spaces, and traditional architectural forms in fostering resilient urban environments (Utaberta & Asif, 2017). Complementing these perspectives, the dimension of urban sustainability and disaster governance examines how cultural and religious elements can inform and enhance disaster risk reduction policies (Appleby-Arnold et al., 2018). Rather than establishing linear causal relationships, this study adopts an interpretive approach, identifying emergent themes and patterns through interviews and document analysis. Aceh-Muslim spatial culture is conceptualised as a key influence on urban resilience, mediated by community engagement in the planning process, particularly through practices such as communal living, the centrality of religious institutions, and the use of shared public spaces.

METHODOLOGY

The study was conducted in Banda Aceh, the capital of Aceh province, located on the northern coast of Sumatra, Indonesia (Figure 2). As a historically and culturally rich city shaped by centuries of Islamic influence, Banda Aceh presents a unique context for examining the intersection of cultural identity and urban resilience. The city's resilience was profoundly tested during the 2004 Indian Ocean tsunami, after which post-disaster reconstruction efforts sought to integrate cultural heritage into spatial and urban planning (Miller & Bunnell, 2014).

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Data Collection

This study employed a combination of semi-structured interviews and document analysis to gather qualitative data. Qualitative methods are particularly effective for exploring complex social phenomena and capturing the perspectives and lived experiences of individuals and communities (Crewell, 2013). A total of ten participants were interviewed, representing four key stakeholder groups: residents (3), urban planners (2), government officials (2), and academics (3) specialising in urban resilience (Table 1). Participants were selected through purposive sampling to ensure diverse demographic and professional representation. Each interview, lasting between 45 and 60 minutes, was conducted at a location convenient to the participant, recorded with consent, and transcribed verbatim to maintain accuracy for thematic analysis (Ruslin et al., 2022). To triangulate findings, key planning and policy documents were also reviewed (Table 2). Documents were selected based on their relevance to Aceh's urban development and disaster management policies.

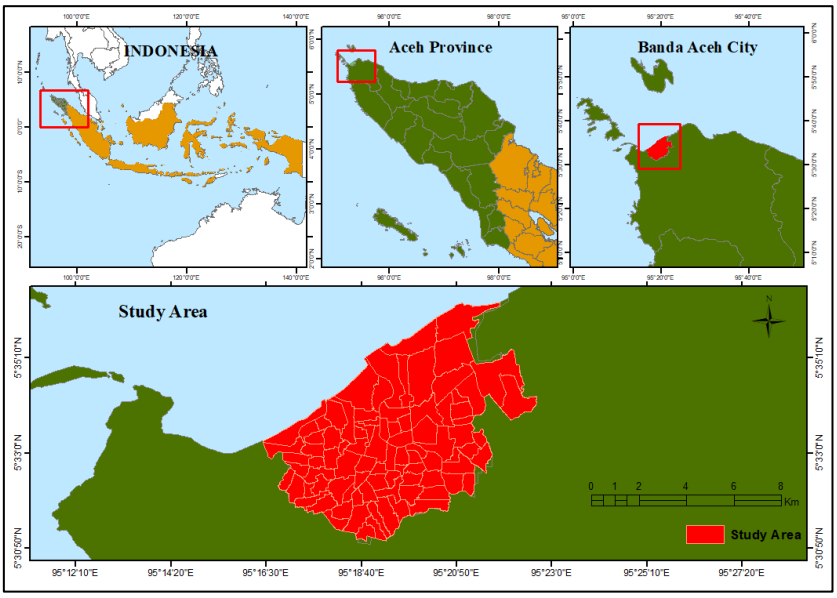


Figure 2: Study area: Banda Aceh City, Aceh Province, Indonesia.
Source: Author (2024)

Table 1: Demographic profile of stakeholders interviewed in Banda Aceh

No.	Inf. Code	Profession	Age Range	Years of Exp.
1	RE1	Residents	40-45	15-20
2	RE2	Residents	40-45	15-20
3	RE3	Residents	35-40	10-15
4	UP1	Urban Planner	40-45	15-20
5	UP2	Urban Planner	35-40	10-15
6	GO1	Government Officials	50-55	25+
7	GO2	Government Officials	45-50	15-20
8	AC1	Academic	35-40	10-15
9	AC2	Academic	45-50	15-25
10	AC3	Academic	40-45	20

Table 2. Key planning and policy documents reviewed

No	Document Title	Original Title	Type	Issuing Institution
1	Banda Aceh Spatial Plan 2009–2029	Rencana Tata Ruang Wilayah (RTRW) Kota Banda Aceh 2009–2029	Government Planning Document	City Government of Banda Aceh (Bappeda)
2	Law No. 11 of 2006 on the Governance of Aceh	Undang-Undang No. 11 Tahun 2006 tentang Pemerintahan Aceh	National Law with Regional Autonomy	Government of Indonesia (DPR-RI & President)
3	Aceh Qanun No. 4 of 2003 on Mukim Governance	Qanun Aceh No. 4 Tahun 2003 tentang Pemerintahan Mukim	Regional Regulation	Aceh People's Legislative Council (DPRA)
4	Law No. 26 of 2007 on Spatial Planning	UU No. 26 Tahun 2007 tentang Penataan Ruang	National Law	Government of Indonesia (DPR-RI & President)

Source: Authors (2024)

Data Analysis and Study Limitations

Data analysis followed an iterative and interpretive process aimed at extracting key insights related to Aceh-Muslim spatial culture and urban resilience. Interview recordings were transcribed verbatim and systematically coded to identify recurring themes. Thematic analysis, as outlined by Braun & Clarke (2006), was employed to categorise patterns and uncover underlying meanings. A constant comparative method Glaser & Strauss (1967) was also applied, enabling continuous cross-examination between interview data and documentary evidence. To ensure consistency and enhance validity, references made by interviewees to specific policies or planning documents were verified through document analysis. Rather than applying a numerical scale, the study adopted qualitative thematic evaluation to assess the degree of integration of Aceh-Muslim spatial culture into urban resilience strategies. As shown in Table 3, integration was classified into three levels (high, moderate, low) based on established qualitative evaluation criteria (Nowell et al., 2017).

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Table 3. Evaluation Criteria for Assessing the Degree of Cultural Integration

Level	Description
High	Cultural elements are extensively embedded within policies, shaping zoning regulations, land use planning, and community-based resilience strategies.
Moderate	Cultural considerations are recognised and partially reflected in planning efforts, though their application remains inconsistent across policies.
Low	Cultural factors receive limited recognition, with only minimal reference found in planning documents and academic literature.

Source: Authors (2024)

While this study provides valuable insights for integrating Aceh-Muslim spatial culture into urban resilience planning, several limitations should be acknowledged. First, the study is geographically limited to Banda Aceh, which may affect the transferability of the findings to other regions with different socio-cultural and spatial contexts. Second, the empirical basis rests on a relatively small sample of ten participants selected through purposive sampling. This is appropriate for in-depth qualitative inquiry but constrains the statistical generalisability of the results beyond Banda Aceh and similar Acehnese settings. The findings should therefore be interpreted as analytically rather than statistically generalisable, offering context-rich insights that may be adapted cautiously to other Muslim-majority cities. Second, as it is inherent in qualitative research, findings are interpretative and may be subject to researcher bias, despite efforts to maintain objectivity through triangulation and systematic analysis. Third, as is inherent in qualitative research, interpretations may be influenced by researcher subjectivity despite efforts to maintain reflexivity, triangulation, and systematic analysis. Finally, restricted access to certain government planning documents may have limited the comprehensiveness of the document review.

Ethical Compliance

All procedures in this study adhered to standard ethical principles for qualitative research. Prior to data collection, participants received an explanation of the research objectives and procedures and provided informed consent. Participation was voluntary, and interviewees were assured of confidentiality and anonymity through the use of codes (e.g., RE1, UP1) instead of personal names. The study followed the ethical guidelines of Universitas Syiah Kuala and Universiti Malaya for research involving human participants.

RESULTS

Interview Findings

Interviews with key stakeholders yielded valuable insights into the influence of Aceh-Muslim spatial culture on urban resilience. Participants consistently emphasised the importance of communal living, religious institutions, and public spaces in shaping local disaster preparedness and recovery strategies (Table 4).

Residents highlighted the strength of social cohesion within Acehnese communities, which enables rapid mobilisation of support during times of crisis. As one resident shared, "In times of crisis, neighbours become family. We don't hesitate to help one another because it's part of our culture." (RE1). Urban planners and government officials acknowledged the critical role these communal practices play in fostering resilience but noted a disconnect between grassroots initiatives and formal urban planning policies. One urban planner reflected, "We see that strong social bonds help communities recover faster but translating that into actionable policies remains a challenge." (UP2). A government official echoed this concern, stating, "There's a need to formalise these informal support networks within our disaster response strategies." (GO1). Academic participants reinforced these observations, calling for the institutionalisation of cultural resilience within official planning frameworks. As one academic argued, "Resilience planning often focuses on infrastructure, but we need to recognise and institutionalise the social and cultural systems that already work effectively." (AC1).

Table 4. Summary of interview findings

Research Objective	Themes Extracted	Sample Responses
Influence of Aceh-Muslim Spatial Culture on Urban Resilience	• Communal living • Social cohesion • Collective responsibility • Role of religious institutions	"In times of crisis, neighbours become family. We don't hesitate to help one another because it's part of our culture." (RE1) "We see that strong social bonds help communities recover faster but translating that into actionable policies remains a challenge." (UP2) "Resilience planning often focuses on infrastructure, but we need to recognise and institutionalise the social and cultural systems that already work effectively." (AC1)
Cultural Elements Integrated into Urban Planning and Resilience Strategies	• Integration into spatial plans • Preservation of communal spaces • Participatory planning approaches	"New developments often don't consider how we interact as a community. Traditional spaces for gatherings are disappearing, which weakens our ability to organise quickly during emergencies." (RE2) "We have policies that acknowledge cultural heritage, but their implementation is inconsistent. More effort is needed to ensure communal spaces remain central to planning." (GO1) "Community participation should not be symbolic—it needs to be a fundamental part of resilience planning." (AC3)
Effectiveness of Cultural Integration in Strengthening	• Enhanced disaster preparedness • Increased community participation	"After the tsunami, our mosque became our centre for survival. We found food, shelter, and emotional support there." (RE3)

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Research Objective	Themes Extracted	Sample Responses
Community Resilience	• Resilience-building through cultural practices	"We see these community-led initiatives working, but they need structured support to be sustainable in the long term." (GO2) "Without structured support, cultural resilience remains underutilised. Policies should strengthen, not replace, these existing social mechanisms." (AC2)

Residents also perceived a growing disconnect between urban development and everyday cultural practices. One resident expressed concern that "New developments often don't consider how we interact as a community. Traditional spaces for gatherings are disappearing, which weakens our ability to organise quickly during emergencies." (RE2). Urban planners and government officials acknowledged these concerns, highlighting the gap between policy and practice. As one government official noted, "We have policies that acknowledge cultural heritage, but their implementation is inconsistent. More effort is needed to ensure communal spaces remain central to planning." (GO1). Academics stressed that effective cultural integration depends on more than recognition; it requires meaningful community involvement. One academic observed, "Community participation should not be symbolic—it needs to be a fundamental part of resilience planning."(AC3).

Residents shared concrete examples of how culturally grounded practices supported them during past disasters. One resident recalled, "After the tsunami, our mosque became our centre for survival. We found food, shelter, and emotional support there." (RE3). Urban planners and government officials agreed that such practices enhance resilience but emphasized the need for institutional support. As one official explained, "We see these community-led initiatives working, but they need structured support to be sustainable in the long term." (GO2). An urban planner added, "Policies should not just acknowledge cultural resilience; they should actively strengthen and incorporate it." (UP1). Academics underscored that, without structured support, cultural resilience remains underutilised. One academic emphasised, "Policies should strengthen, not replace, these existing social mechanisms"(AC2), while another recommended that "documentation and case studies of these successful practices should be included in urban planning curricula and policymaking processes." (AC3).

Document Analysis Results

The document analysis reveals varying degrees of integration of Aceh-Muslim spatial culture into urban planning, highlighting notable differences across legal and planning frameworks (Table 5). For RO1 (influence), cultural values have a moderate influence on planning, particularly in the Banda Aceh Spatial Plan and

Law No. 11 of 2006, though these values have not been fully institutionalised. The most substantial influence is observed in Qanun No. 4 of 2003, which formally empowers *mukim* governance in spatial decision-making.

Table 5. Document assessment results

Document Title	**Cultural Integration Level**		
	RO1: Influence	**RO2: Cultural Elements**	**RO3: Effectiveness**
Banda Aceh Spatial Plan 2009–2029	**Moderate** – Reflects *gampong*-based post-tsunami layouts and Islamic land uses, but lacks formal integration into zoning or design regulations.	**Moderate** – Recognises cultural structures (e.g., mosques, *gampong*), but these are not consistently incorporated into planning strategies.	**Low** – Cultural elements are acknowledged but have limited and inconsistent impact on measurable resilience outcomes.
Law No. 11 of 2006 on Aceh Governance	**Moderate** – Grants authority to integrate Islamic/customary norms, but their application to spatial planning is general and indirect.	**Moderate** – Cultural principles are acknowledged but lack specific urban planning instruments or guidelines.	**Low** – Cultural implementation is delegated to regional qanuns; effectiveness varies and is generally limited in practice.
Qanun Aceh No. 4 of 2003 on Governance of Mukim	**High** – Strongly institutionalises traditional mukim governance structures in land use and disaster resilience planning.	**High** – Effectively integrates Islamic and customary systems such as *imeum mukim*, *musyawarah*, and *syura* into governance.	**High** – Demonstrates strong effectiveness in community-level resilience, particularly in tsunami-prone coastal zones.
Implementation of Law No. 26 of 2007 in Aceh's Context	**Moderate** – Cultural values influence discourse but are not fully aligned with national spatial planning norms.	**Moderate** – Cultural aspects are identified but insufficiently operationalised within formal planning frameworks.	**Moderate** – Effectiveness is limited by technical and institutional challenges, despite the acknowledgment of cultural values.

In terms of RO2 (cultural elements), most planning documents recognise cultural elements such as mosques, *gampong* (villages), and customary governance structures. However, only Qanun Mukim integrates these elements meaningfully into planning strategies. Other documents lack detailed guidelines or fail to consistently apply cultural principles in urban planning processes. For RO3 (effectiveness), Qanun No. 4 of 2003 demonstrates high effectiveness in supporting community resilience, especially in coastal areas. In contrast, the remaining documents are less effective, with cultural elements being either broadly defined or inadequately implemented in practice. Overall, while cultural integration is acknowledged in Aceh's spatial governance, Qanun Mukim

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remains the most effective legal instrument in ensuring practical integration of cultural elements for resilience-building.

The overall findings reveal that Aceh-Muslim spatial culture is moderately to highly reflected in planning documents, particularly through the institutionalisation of traditional governance structures such as *mukim* and the role of *imeum mukim*, as detailed in Qanun Aceh No. 4/2003 (Table 6). Cultural elements, such as mosque-centred layouts and *gampong*-based settlement patterns, are acknowledged across several documents. However, their translation into formal planning instruments, such as zoning regulations or design standards, remains limited and inconsistently applied. The effectiveness of these cultural integrations is most evident at the local level, where traditional governance remains active. Their impact diminishes at the city and provincial levels due to gaps in regulatory frameworks, institutional support, and implementation.

Constant Comparative Analysis

The constant comparative analysis indicates that Aceh-Muslim spatial culture plays a significant role in enhancing urban resilience, particularly through communal living, religious institutions, and social cohesion (Table 7). Interview data emphasises the strength of informal community networks in disaster response, though these networks are not fully institutionalised in planning policies. Document analysis concurs, showing moderate recognition of cultural values in most planning instruments, with Qanun No. 4/2003 standing out for formalising *mukim* governance in resilience planning.

Table 6. Synthesis of document findings by research objectives

Research Objective	Integration Level	Summary Insight
RO1: Influence	Moderate–High	Most documents acknowledge cultural influence, with Qanun Mukim showing the highest impact due to its institutionalisation of localised governance structures.
RO2: Cultural Elements	Moderate	Cultural features, especially in traditional governance systems (*mukim*, *gampong*), are recognised; however, their full integration across policies remains limited.
RO3: Effectiveness	Low–Moderate	The effectiveness of cultural integration is most pronounced at the local level, where cultural governance is firmly embedded, but it diminishes in broader city-wide or national regulatory frameworks.

Table 7. Comparative analysis of interview and document analysis findings

Research Objective	Interview Findings	Document Analysis	Synthesis	Comparative Reflections
RO1: Influence	Culture promotes social cohesion, mutual aid, and	Culture moderately reflected; Qanun 4/2003 shows	Cultural values aid resilience but lack formal	Shared recognition, but weak institutionalisation

Research Objective	Interview Findings	Document Analysis	Synthesis	Comparative Reflections
	informal resilience.	strongest integration.	planning adoption.	beyond local governance.
RO2: Integration into Planning	Loss of communal spaces; participation often symbolic.	Cultural elements acknowledged but rarely operationalised; Qanun 4/2003 is an exception.	Integration is fragmented and lacks consistency.	Both sources call for more structured, participatory cultural integration.
RO3: Effectiveness	Cultural spaces (e.g., mosques) proved vital in disasters; initiatives need support.	Qanun 4/2003 effective locally; others less so due to vague implementation.	Cultural practices enhance resilience if supported institutionally.	Effectiveness high locally but limited at broader planning levels without policy backing.

Both data sources acknowledge the influence of cultural values but point to their limited integration into broader planning frameworks. Interviews highlight the erosion of traditional communal spaces and the lack of meaningful community participation. Documents similarly mention cultural elements symbolically but rarely operationalise them, again with the notable exception of Qanun Mukim. Both lines of evidence affirm the effectiveness of cultural integration in strengthening resilience at the local level. However, without structured support and clearer regulatory mechanism, these cultural practices remain underutilised at city and provincial scales. Overall, cultural values are recognised both practice and policy, yet their full potential in urban resilience planning is constrained by inconsistent institutionalisation and limited implementation.

DISCUSSION

The findings of this study highlight a critical paradox: while Aceh possesses a rich tradition of spatial culture rooted in Islamic values and local wisdom, the integration of this cultural capital into formal urban planning and resilience strategies remains largely superficial. Acehnese spatial practices, deeply embedded in Islamic principles and indigenous knowledge, have historically demonstrated resilience capacities. Traditional spatial arrangements such as the *rumoh* (house compound), *meunasah* (community prayer house), and the *gampong* (village) layout embody values of communal solidarity (*ukhuwah*), mutual aid, and social proximity. These features resonate with Norris et al. (2008) conceptualisation of community resilience, which emphasized social capital, information sharing, and collective efficacy as core components of resilience. Thus, these spatial expressions not only represent cultural identity but also constitute practical mechanisms of disaster preparedness and recovery.

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However, the empirical analysis of spatial plans reveals that these culturally embedded resilience mechanisms are not systematically incorporated into formal planning processes. The neglect of traditional spatial logics in contemporary urban governance reflects what Escobar (2007) describes as the "colonisation of planning" by technocratic rationality, where indigenous and religious epistemologies are marginalised in favour of standardised, modernist models. As a result, the potential of Aceh-Muslim spatial culture as a resilience asset remains underutilised within institutional frameworks.

The degree of cultural integration in planning and resilience strategies in Aceh primarily involves the recognition and treatment of cultural elements in formal documents. While planning instruments, such as the Qanun Aceh No. 19/2013, refer Islamic and Acehnese cultural identity, these references remain largely normative and lack operational detail. This situation aligns with Yiftachel (2009) notion of "grey spaces" in planning, zones of ambiguous legitimacy where cultural inclusion is acknowledged rhetorically but not substantively implemented. The limited integration of local spatial values also mirrors critiques within cultural planning theory, particularly Evans' (2001) argument that local culture is often instrumentalised as a token of identity politics rather than as an active driver of spatial logic or urban design. In Aceh's case, this is evident in the absence of concrete planning mechanism that embed traditional spaces, such as the *meunasah* into disaster risk reduction strategies or land-use zoning policies. In contrast, several NGO-led post-disaster initiatives have demonstrated more culturally responsive planning approaches, engaging local communities in participatory design processes that respect customary layouts and collective values. These initiatives suggest that more flexible and inclusive governance mechanisms are required to mediate between formal spatial planning and lived cultural practices.

Assessing the effectiveness of cultural integration in enhancing resilience reveals that formal planning systems in Aceh have yet to translate cultural recognition into effective disaster risk governance. Institutional limitations, the absence of culturally informed technical guidelines, and a predominantly top-down bureaucratic culture collectively constrain the transformative potential of planning. This situation corresponds with Coaffee, J., & Lee's (2016) argument that resilience planning often fails when it lacks contextual sensitivity and relies excessively on universalised frameworks detached from local realities. In contrast, programs that explicitly incorporate cultural practices, particularly those guided by NGOs, have resulted in greater community engagement, legitimacy, and adaptive capacity. These outcomes reaffirm the findings of Aldrich (2012) emphasis on the role of social infrastructure and cultural cohesion in enhancing community resilience post-disaster. Traditional institutions such as the *meunasah*, when recognised as both

spiritual and spatial hubs, can function as critical nodes for information dissemination, decision-making, and collective action during emergencies. For urban planners and policymakers, the key challenge is therefore not simply to "include culture" in a symbolic sense, but to design planning instruments and governance arrangements that actively mobilise Aceh-Muslim spatial culture as a core component of urban resilience.

CONCLUSION

This study has examined how Aceh-Muslim spatial culture can inform urban planning for disaster resilience in Banda Aceh. The findings show that Acehnese spatial traditions, including the role of the *meunasah* (community prayer house), mosque-centred settlement structures, waqf-based communal spaces, and strong communal values, hold significant potential to enhance community-based resilience. Nevertheless, their integration into formal planning systems remains limited and often confined to symbolic recognition rather than substantive, operational measures. To strengthen the role of Islamic spatial values in planning, this study recommends: (1) the development of regulatory frameworks that formally incorporate local cultural principles into zoning, land-use allocation, and design standards; (2) the enhancement of institutional capacity for culturally responsive planning through technical guidelines and cross-sectoral coordination; and (3) the promotion of meaningful community participation, particularly involving religious and customary leaders, in all phases of resilience planning. These steps are crucial for bridging the gap between policy and practice and for moving from rhetorical recognition to concrete implementation. Although this research is geographically focused on Banda Aceh and based on a small purposively selected sample, its insights have broader implications for other Muslim-majority urban contexts that face recurrent disasters. The study demonstrates that Islamic spatial practices and institutions can function as important social and spatial infrastructures for resilience when they are systematically integrated into planning frameworks. Future research should therefore undertake comparative studies across different Muslim-majority cities, as well as in-depth fieldwork at the neighbourhood level, to assess how culturally grounded planning approaches can support resilient, and context-sensitive urban futures.

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EMPOWERING MADANI COMMUNITIES: SOLAR LIGHTING SOLUTIONS TO INCREASE SAFETY IN RURAL MALAYSIA

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Abstract

This research examines the potential of solar lighting to enhance safety and support sustainable development in rural Malaysia, in alignment with the Madani framework and initiatives by the Ministry of Rural and Regional Development. Focusing on underserved communities, particularly Orang Asli settlements in Perak and Pahang, the research employs a mixed-method approach combining field observations, community feedback, and technical assessments. The findings reveal that solar lighting improves nighttime visibility, reduces safety risks, enhances economic activities, and offers cost-effective and environmentally sustainable solutions. By integrating solar technologies into rural infrastructure, the study highlights their role in promoting self-reliance, community empowerment, and long-term growth. These outcomes contribute to Malaysia's national development goals, as outlined in PLAN Malaysia, and align with Sustainable Development Goal 7 (SDG 7), which advocates for affordable, reliable, and sustainable energy access. Overall, this research highlights the transformative impact of renewable energy in fostering safer, more resilient, and inclusive rural communities in Malaysia.

Keywords: Madani, Rural Development, Solar Lighting, Safety

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INTRODUCTION

In 2023, approximately 21.28% of Malaysia's population lived in rural areas. Rural development is essential to achieving social equity and sustainable progress in Malaysia, aligned with the Madani Framework's emphasis on inclusivity, compassion, and responsibility. This framework envisions a society that prioritizes ethical governance, social responsibility, and community empowerment in areas like economic stability, health, and safety (Malaysia, 2023). However, rural regions face significant challenges such as limited infrastructure and access to resources, which impede community growth and safety. Highlighted by Ngah (2006), a rural region needs to adopt the principles of a sustainable community through the fundamental aspects under this principle, which is the provision of sustainable electricity.

Recently, Malaysia shows a shift from traditional infrastructure-centric approaches to more integrated and participatory frameworks. In the past, rural development planning focused mainly on technical feasibility, such as energy supply and infrastructure performance. Study by Ahamd et al. (2024), revealed that rooftop solar-PV systems improved electricity access and increased illuminance levels by 50–80%, showing the feasibility of decentralized systems in rural Malaysia.

Solar technology presents a sustainable electricity solution that aligns with Madani principles, addressing these challenges by reducing dependence on traditional energy sources and enhancing community well-being (Ahmad et al., 2024). Solar lighting supports Malaysia's sustainability and carbon reduction goals while offering low-maintenance, affordable lighting solutions. In areas with limited or no national grid access, solar lighting enhances visibility and safety, reducing crime-related risks and promoting environmental benefits. This sense of security is essential for rural residents, fostering resilience and empowerment (Renuka Prasad et al., 2017).

According to Sakca et al. (2023), limited access to reliable lighting restricts nighttime activities vital for community growth and safety. Remote locations and challenging terrain often hinder rural areas from connecting to the national grid, and those with access frequently experience outages. This inadequate lighting increases vulnerability to accidents and hampers economic activities, especially for individuals relying on evening work or night markets. Dependence on fossil-fuel-based lighting also burdens households with high energy costs, undermining Malaysia's sustainability goals. Poor lighting infrastructure in rural Malaysia raises safety risks, as insufficient visibility on roads contributes to accidents. Dimly lit public spaces also increase crime risks, as they provide cover for criminal activities (Ahmad et al., 2024). Solar lighting can mitigate these issues by improving visibility, deterring crime, and enhancing overall safety. By extending productive hours, solar lighting supports local

businesses, markets, and community events, boosting economic resilience and quality of life.

Solar lighting aligns with Madani values by offering an eco-friendly, cost-effective alternative that supports renewable energy goals and community self-reliance. These initiatives demonstrate how sustainable technologies can enrich rural life, supporting a harmonious and progressive society in Malaysia. This research aims to determine the potential benefits of solar technologies in advancing sustainable rural development, with a specific focus on the empowerment of underserved communities. Aligned by six core values—sustainability, prosperity, innovation, respect, trust, and compassion—the research supports equitable and balanced development across both urban and rural contexts.

LITERATURE REVIEW

Overview of Solar Implementation in Malaysia

Solar power usage in Malaysia is largely limited to the domestic level, with over 10,000 households utilizing photovoltaic (PV) systems. However, large-scale commercial adoption remains minimal due to the high costs associated with PV technology, especially for mass power generation. A significant step in Malaysia's solar journey was the 1995 launch of a 100-kilowatt peak (kWp) demonstration PV project in Marak Parak, Sabah, under the Ministry of Energy, Water, and Communications, which demonstrated the feasibility of PV power technology in the country (Mahesh Vaka et al., 2020). Efforts to integrate renewable energy (RE) into Malaysia's energy mix began in the 8th Malaysia Plan (Oh et al., 2010), yet challenges like limited funding, unappealing tariffs, and lack of industry awareness hindered widespread solar adoption. By 2024, Malaysia had advanced significantly, reaching approximately 2,900 megawatts (MW) of operational solar PV capacity, with ambitious plans to expand further in alignment with the National Energy Transition Roadmap (NETR) (SEDA, 2024).

The Malaysia Renewable Energy Roadmap (MyRER) targets 31% renewable energy (13 gigawatts) by 2025 and 40% (18 gigawatts) by 2035, with a long-term goal of achieving 70% by 2050 to meet the nation's aspiration for net zero emissions (SEDA, 2024). Solar projects, such as utility-scale solar parks and floating PV installations managed by Tenaga Nasional Berhad (TNB) in partnership with local cooperatives, aim to enhance energy access and reliability across Malaysia, especially in rural areas. These projects contribute to sustainability while supporting economic empowerment, reducing dependency on conventional energy sources.

Numerous studies Malik & Ayob (2020), Sarker et al. (2023), and Safari et al. (2020) have explored the application of solar energy in Malaysia.

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Several limitations can be identified, particularly concerning its implementation in rural contexts. The existing literature tends to focus on the technical and economic feasibility of solar technologies, often overlooking the socio-cultural and community-based factors that influence adoption and long-term sustainability. As a result, the human dimension, such as community behavior responses, funding mechanism and economic conditions, remains underexplored.

Malaysia Madani Framework and Rural Development Policy 2030.

The Madani Framework, introduced by Prime Minister Anwar Ibrahim, promotes a vision of an inclusive and sustainable Malaysian society (Malaysia, 2023). Centered around six core values—sustainability, prosperity, innovation, respect, trust, and compassion—the framework seeks balanced development across urban and rural areas. It emphasizes improving quality of life, economic growth, and infrastructure for all citizens, with a strong focus on rural development. Key objectives include enhancing access to essential services and economic opportunities, primarily through education, infrastructure upgrades, and job creation initiatives (Malaysia, 2023). While the 12th Malaysia Plan and the National Energy Transition Roadmap (NETR) reinforce efforts to expand renewable energy, including solar, to enhance affordable and reliable power access in rural areas, thereby supporting economic growth and environmental sustainability.

Aligned with this, the Madani Framework complements the Rural Development Policy 2030 (RDP, 2030), which envisions "Prosperous, Inclusive, and Sustainable Rural Living" by 2030. Launched in 2019, RDP 2030 aims to bridge the infrastructure and social amenities gap between rural and urban communities. The Madani Framework and the Rural Development Policy 2030 are synergistic in their pursuit of a sustainable and inclusive Malaysia. Thus, the implementation of solar energy projects serves as a critical intersection point, advancing the shared objectives of economic development, environmental sustainability, and social well-being in rural areas.

Safety Issues in Rural Communities

Rural communities in Malaysia, safety concerns often stem from limited infrastructure, particularly the lack of reliable lighting, which affects visibility and increases risks, especially at night (Ahmad et al., 2024). Generally, traditional energy sources, such as kerosene lamps, with solar-powered lighting mitigate fire hazards, making indoor environments safer and decreasing the risk of household fires. The provision of street lighting in rural regions holds significance for the safety, convenience, and economic advancement of the populace (Kaplan, J., & Chalfin, A., 2022). Nevertheless, numerous villages confront hurdles concerning

street lighting, encompassing issues of uneven distribution and energy efficiency. Considering this, embracing the concept of smart villages becomes imperative for optimizing energy consumption, including the deployment of modern lighting systems tailored to community needs (Ahmad et al., 2024). Solar lighting reduces reliance on the main power grid and mitigates the risks associated with power outages, which can leave communities vulnerable to crime and accidents after dark (Ahmad et al., 2024)

RESEARCH METHODOLOGY

This study employs three primary methodologies to assess the impact of solar energy projects on the Orang Asli communities in Perak and Pahang: (i) case studies, (ii) numerical analysis and modeling using specific software, and (iii) questionnaire surveys. Each method is tailored to capture different dimensions of the research objectives, providing a comprehensive understanding of the solar installations' effectiveness and community benefits. According to statistics from the Department of Orang Asli Development Malaysia (2023), Pahang and Perak have the highest Orang Asli populations among all states. Therefore, these two states were selected as case study sites for this observation. The combination of these methodologies allows for a multi-level exploration of the project's impact, integrating empirical observations, quantitative analyses, and community feedback.

Data Collection

Two types of solar lights were installed in the Orang Asli settlements: mounted-type lights and pole-street lights. Specifically, a solar charging hub with battery storage and a solar inverter was set up in Case Study 1, an Orang Asli settlement in Perak, and Case Study 2, a settlement in Pahang. Installation of these solar technologies was guided by on-site empirical analysis and tailored to the specific needs identified by each community.

Case Study 1: Orang Asli Settlement in Perak



Figure 1: Case Study 1 at Kampung Sungai Tonggang, Ulu Kinta, Perak

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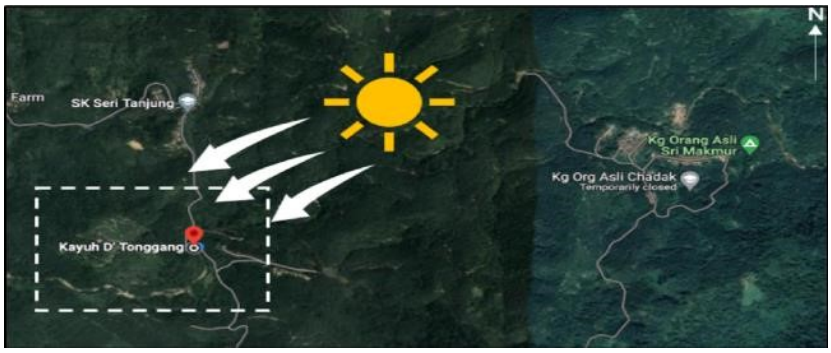


Figure 2: Sun Orientation at Kampung Sungai Tonggang (Source: Google Maps)

The Perak settlement installed solar lighting systems in key outdoor areas like pathways, community centers, and common spaces. Several factors influenced the solar lighting design, including location, shading, and community usage patterns:

1. Pathways: Remote paths required additional lighting for safety, particularly at night. Pole-mounted lights were installed at greater heights to ensure a broad area was illuminated.
2. Community Center: Roof-mounted fixtures were chosen for focused lighting to support evening gatherings and social activities.
3. Shading: Areas with dense tree cover needed additional, higher-wattage lights to counteract the lack of natural sunlight.
5. Toilets and Washing Areas: Moderate lighting with wall-mounted fixtures provided sufficient illumination for safety and hygiene, ensuring these areas were well-lit without excessive energy consumption.
6. External Courtyards: The central courtyard, a space for social events, was equipped with high-wattage lights for bright, uniform illumination to ensure visibility and a safe environment for the community.

Case Study 2: Orang Asli Settlement in Pahang



Figure 3: Case Study 2 at Sungai Kiol, Jerantut, Pahang



Figure 4: Sun Orientation at Sungai Kiol, Jerantut, Pahang (Source: Google Maps)

In the Pahang settlement, similar solar lighting systems were implemented, but adjustments were made based on the community's distinct environment and needs:

1. Pathways: Pathways connecting homes to the community center required heightened lighting due to the remote nature of the settlement. Pole-mounted lights were used to illuminate these critical areas.
2. Open Communal Spaces: Solar-powered roof-mounted lights were installed to provide focused lighting for communal gathering areas, ensuring sufficient brightness during evening gatherings.
3. Shading: Certain areas near forest edges required additional lighting due to heavy shading. High-wattage lights were installed to improve visibility in these darkened areas.
4. Water Collection Points and Toilets: The settlement's washing and water collection points were fitted with moderate lighting, providing a safe, well-lit environment for daily tasks.
5. External Courtyards: Higher-wattage lights were installed in communal spaces and courtyards to create well-lit areas for nighttime activities and social interaction.

Numerical Analysis and modelling

The numerical analysis and modeling for determining solar energy output in Perak and Pahang were conducted using PVsyst software. This software facilitated the integration of local climate data, including solar irradiance and temperature, to simulate the annual energy yield in these Malaysian regions, which differ in geographical and climatic characteristics. The model provides a comparative perspective on energy production potential between Perak and Pahang. Key parameters for estimating the optimal solar lighting power system

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included the average daily energy demand of 50 watt-hours (Wh) for each Orang Asli house, which corresponds to five hours of lighting per day. A 30% safety margin was applied to account for system inefficiencies like battery losses and panel performance, adjusting the energy requirement to 65 Wh per day. Using average monthly solar irradiance data from the model, available daily energy was calculated. The required solar panel wattage was determined by dividing the adjusted energy needs by the available energy. This modelling provides a foundation for selecting suitable solar lighting technologies, with solar-mounted panels ideal for stable, high-exposure locations and pole-type panels adaptable for pathways and residential areas, optimizing energy efficiency for community needs.

Questionnaire Surveys

To assess the impact of solar energy projects on the Orang Asli communities in Perak and Pahang, a structured questionnaire survey was conducted. The study employed a purposive sampling strategy to identify respondents who possessed relevant knowledge and experience with solar energy projects in the Orang Asli communities of Perak and Pahang. This approach allowed for the intentional selection of participants based on specific criteria such as age, location, occupation, and community background to ensure the inclusion of diverse yet contextually appropriate perspectives. A total of 100 questionnaires were distributed across both case study locations to collect quantitative data on various community development outcomes. The responses were meticulously analyzed to gauge community perceptions and evaluate the effectiveness of the solar installations. All survey procedures adhered to ethical research standards established by the institutional research ethics committee and complied with national research guidelines.

RESULT AND ANALYSIS

Empowering Orang Asli and Rural Settlements through Micro-Scale Solar Lighting Technologies

This study's empirical data shows that the implementation of micro-scale solar technologies in Orang Asli and rural settlements in Perak and Pahang as the selected case studies significantly improves energy access and enhances the community's well-being, especially in terms of safety. The solar energy systems were designed to meet the unique needs of these remote communities, providing them with a reliable and sustainable source of electricity, primarily for lighting and small appliances.

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General Considerations

For both case studies, energy-efficient LED bulbs were used throughout the settlements to ensure uniform lighting, minimize energy consumption, and avoid dark spots, significantly enhancing the safety and comfort of these communities. The solar installations have improved security, reduced reliance on unsustainable energy sources, and provided long-term benefits for the Orang Asli populations in both Perak and Pahang.

(i) Result 1 - Illuminance Analysis

The illuminance analysis simulation was modeled using Python with the Matplotlib library (Matplotlib, 2024), which allowed for the visualization of data through customizable bar charts. This program effectively demonstrates the relationship between different solar lighting wattages and their impact on illuminance levels in the selected case studies. Figure 1 illustrates the bar chart showing the increase in illuminance after the installation of solar lighting in both case studies, showcasing the effects of different wattages (10, 25, 40, and 100 watts). As the wattage increases, the corresponding illuminance levels also rise, with darker shades representing lower wattages and lighter shades indicating higher wattages.

Table 1: The Empirical Data of Solar Technologies for both Case Studies

Types of Solar Lighting Systems	**The Information for Case Studies**			
	The System Application	**The Purpose**	**Case Study 1: Perak**	**Case Study 2: Pahang**
Solar Mounted-Lights		Various power systems (watt) have been installed due to location, height and shading factors, for walkway, and external areas.	10 units of 10-watts (min), 25-watts, 40-watts (max)	10 Units of 10-watts (min), 25 watts, and 40 watts (max)

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Types of Solar Lighting Systems	**The Information for Case Studies**			
	The System Application	**The Purpose**	**Case Study 1: Perak**	**Case Study 2: Pahang**
Solar Poled-Lights		For street lighting purposes (surrounding of the village, field, farm areas) due to height and location to disperse the lighting.	5 units of 100-watts	5 Units of 100 watts

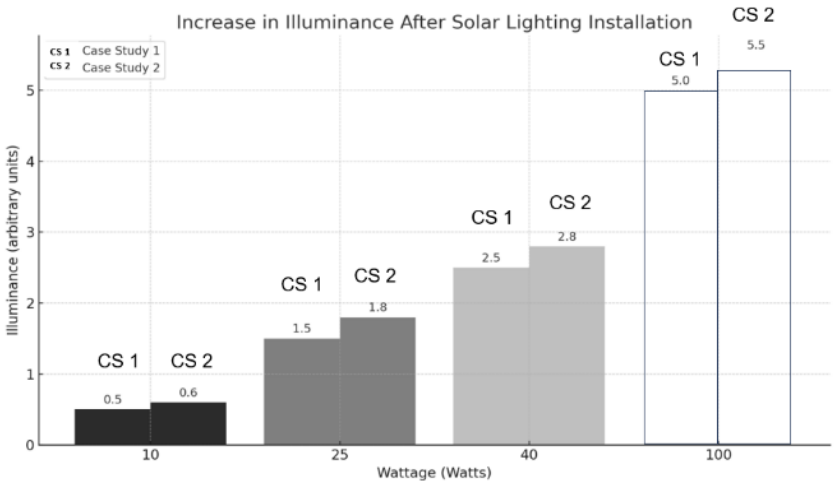


Figure 5: The Illuminance Level After Solar Lighting Installation (using Python with the Matplotlib library)

The before-and-after photos in Figure 2 clearly illustrate the improved brightness and visibility in the villages of both case studies, Kampung Sungai Tonggang in Perak (Case Study 1) and Sungai Kiol in Pahang (Case Study 2), following the installation of solar lighting systems, making the results of the project more accessible and visually impactful.



(a) Kampung Sungai Tonggang in Perak (Case Study 1) – Before and After



(b) Sungai Kiol in Pahang (Case Study 2) – Before and After

Figure 6: The Before-And-After Photos of the Case Studies

(ii) Results 2 - Determining the Solar Energy Output (for Case Study 1: Perak and Case Study 2: Pahang) for Best Solar Lighting Power System (Watt)

For a model of solar energy output in the Malaysian states of Perak and Pahang (where the case studies are located), PVsyst software (PVSyst, 2023) has been used, and local climate data has been tabulated, considering factors like solar irradiance and temperature, to estimate the potential annual energy yield. This model would allow for a comparative analysis of energy production potential in these regions, which differ in geographical and climatic conditions. To estimate the appropriate wattage for solar lighting for an Orang Asli house, below are the key considerations:

1. **Average daily energy demand for lighting:** Each house needs lighting for 5 hours daily.
2. **Lighting power requirement per day:** The energy in watt-hours (Wh) needed to power sufficient lights for each house.

System efficiency and losses: Factors like battery efficiency, panel performance and potential shading

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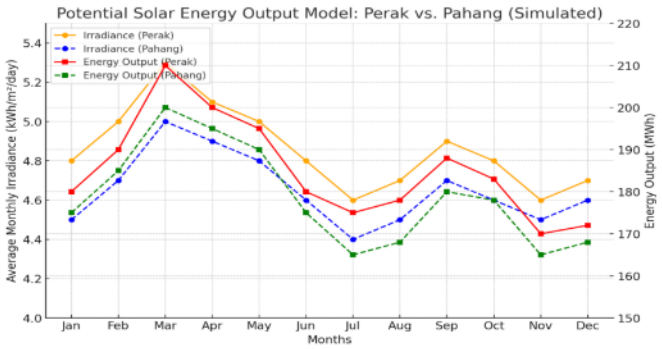


Figure 7: Potential Solar Energy Output Model using PVsyst Software

Figure 3 shows the model that visually represents the potential solar energy output in Perak and Pahang. The graph compares the monthly average solar irradiance (in kWh/m²/day) and the corresponding energy output (in MWh) for both states. The orange and blue lines show irradiance levels for Perak and Pahang, while the red and green lines represent estimated energy output for each month. This model reflects how seasonal variations and geographical differences might influence solar panel performance across these regions, providing insights into energy production trends throughout the year. Using two types of solar lighting technologies, namely Solar-Mounted vs. Pole-Types, the suitable locations for placement of these solar lighting technologies are:

- Solar-Mounted Types: Ideal for fixed locations with stable sunlight exposure, like roofs of the community center or raised platforms - Best Locations: Above the community center and near agricultural plots where they can benefit from direct sunlight.
- Pole-Types: Versatile and can be placed in various locations; easier to relocate if necessary. Best Locations: Along pathways, near homes, and at the edges of common areas.

To determine the solar panel wattage for lighting needs in Perak and Pahang, the calculations are as follows:

- Lighting requirement per day: 5 hours
- Estimated daily energy needs: 50 watt-hours (Wh) per day for each house

To account for system inefficiencies (like battery and inverter losses), a 30% safety margin will apply:

- **Adjusted daily energy needs=50 Wh×1.3=65 Wh**

Using the average monthly irradiance data from the model (see Figure 2):

- **Perak average irradiance: 4.85 kWh/m²/day**
- **Pahang average irradiance: 4.67 kWh/m²/day**

To Convert Irradiance to Daily Available Energy (in Wh/m²/day)
Since 1 kWh = 1000 Wh:

- **Available energy in Perak =4.85kWh/m²/day×1000=4850Wh/m²/day**
- **Available energy in Pahang =4.67kWh/m²/day×1000 = 4670Wh/m²/day**

The required panel area (in m²) is calculated by dividing the daily energy needs by the available solar energy:

- **For Perak = 65 Wh /4850 Wh/m² ≈ 0.0134 m² x 100 = 1.34 W**
- **For Pahang = 65 Wh /4670 Wh/m² ≈ 0.0140 m² x 100 = 1.40 W**

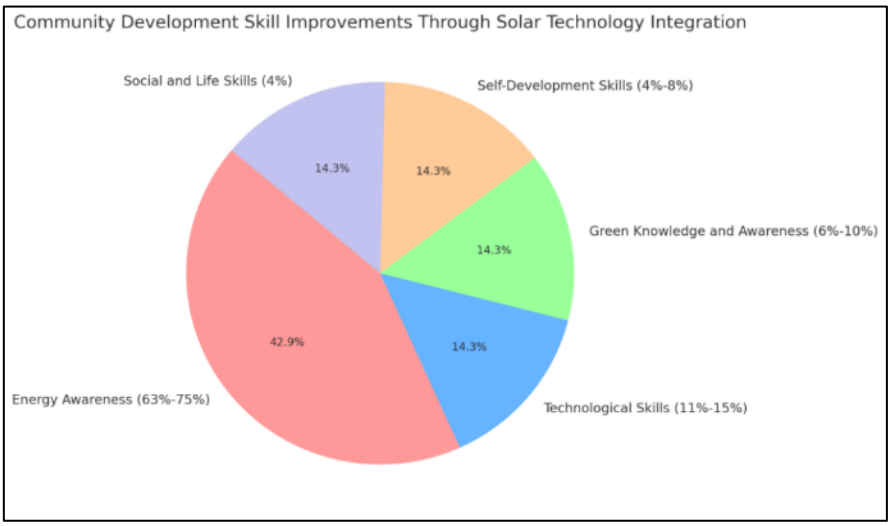
Thus, the estimated solar panel wattage required for basic lighting in an Orang Asli house is 1.34 W for Perak and 1.40 W for Pahang. This wattage can support essential lighting needs based on available sunlight in each location.

(iii) Result 3 - Positive Community Impacts

In Case Studies 1 and 2 of Orang Asli settlements in Perak and Pahang, the solar projects have contributed significantly to community development by increasing green awareness and promoting environmental education among the people. A total of 100 questionnaires were distributed to both case studies. Results indicate a positive response from community members following the installation of solar technology (see Figure 4). These questionnaires analyzed five core areas of community development as shown in the pie chart.

Integrating solar technologies within the community has provided valuable hands-on experience in renewable energy, significantly boosting community development skills. Energy Awareness saw the highest increase, rising from 63% *to* 75%, as community members became more informed about energy savings.

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Technological skills also improved, from 11% to 15%, equipping participants with the knowledge needed for sustainable energy implementation. Green knowledge and awareness increased by 6% to 10%, raising understanding of solar energy benefits. Additionally, self-development skills grew by 4% to 8% as individuals gained confidence in sustainable practices, while social and life skills improved by 4% due to collaborative activities in these programs.

DISCUSSION

Active engagement with the Orang Asli and rural villagers ensured that solar lighting technologies were culturally appropriate and met local needs. Community members were trained to manage and maintain the systems, promoting self-reliance and sustainability. Integration of solar technologies aligns with the MADANI framework by fostering sustainability, inclusivity, and empowerment. Energy awareness increased from 63% to 75%, supporting the Amanah (A) and Nurturing a Sustainable Economy (N) pillars, while technological skills improved by 11–15%, reflecting the Innovation (I) pillar. Gains in green knowledge, self-development, and social skills further demonstrate ethical stewardship under the Morality (M) pillar.

The Community-Based Approach (CBA) enhanced lighting conditions, supporting nighttime economic activities, increasing safety, and reducing risks. Villagers reported greater foot traffic, sales, and safer environments, illustrating how solar technologies improve both economic and social outcomes. These interventions demonstrate practical renewable energy solutions that reinforce the MADANI values: sustainability, prosperity, innovation, respect, trust, and compassion. Overall, the project advances SDG 7 by providing reliable, clean

energy, promoting long-term self-reliance, and supporting inclusive development in rural and indigenous communities.

1. Sustainability ("Kelestarian")
The use of solar lighting, a renewable energy source, reduces dependence on fossil fuels and minimizes environmental impact, promoting long-term ecological balance within the Orang Asli communities. By using solar-powered lights instead of diesel generators or kerosene lamps, both villages now enjoy clean energy that aligns with green development and sustainable living goals.

2. Prosperity ("Kesejahteraan")
Improved lighting enhances night-time visibility, promoting safer environments and enabling more evening social, cultural, and economic activities, contributing to overall community well-being. Villagers can now carry out evening gatherings, small businesses, and educational activities for children under well-lit and safer conditions, fostering economic and social growth.

3. Innovation ("Daya Cipta")
The project demonstrates the application of innovative green technology—solar lighting—to address rural electrification challenges in a cost-effective and adaptive manner. Tailoring solar lighting to suit the specific needs of Orang Asli settlements, including low maintenance and off-grid functionality, reflects practical innovation aligned with community context.

4. Respect ("Hormat")
By engaging the Orang Asli through a Community-Based Approach (CBA), the project respects their cultural values and prioritizes inclusive participation in decision-making. The community was consulted and involved in selecting the locations for solar light installation, acknowledging their needs and respecting indigenous knowledge and preferences.

5. Trust ("Kepercayaan")
Transparent implementation and community involvement foster mutual trust between stakeholders, including researchers, local authorities, and the Orang Asli communities. Regular meetings and updates created an open dialogue, enhancing trust in the project's intention and outcomes, and ensuring the community feels ownership over the improvements.

6. Compassion ("Ihsan")
The initiative is driven by a genuine commitment to improving the safety and quality of life of marginalized groups, demonstrating care for underserved

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communities. Prioritizing solar lighting in key communal areas like walkways, homes, and gathering spots addresses safety concerns and shows empathy for the Orang Asli's everyday challenges.

CONCLUSION

This study demonstrates that micro-scale solar technology provides significant benefits for Orang Asli and rural communities in Perak and Pahang. Energy-efficient solar lighting improved safety, access, and availability of illumination while reducing reliance on unsustainable energy sources. Illuminance analysis showed that light intensity increased linearly with wattage (10–100 W), with optimal daily requirements calculated at 1.34–1.40 W. Community engagement enhanced energy awareness (63% to 75%) and technical skills (11% to 15%), enabling residents to operate and maintain the systems sustainably, fostering self-reliance and resilience.

Solar installations included fixed lights at community centers and expandable pole-mounted lights for pathways and shared spaces, improving night-time mobility and supporting small businesses. The initiative aligns with Malaysia's MADANI framework by promoting sustainability, inclusivity, and people-centered development, while contributing to SDG 7 on affordable and clean energy. Overall, this model illustrates a practical, scalable approach for rural electrification, economic development, and renewable energy education, offering a blueprint for future community-based solar initiatives**.**

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CLIMATE-RESPONSIVE URBAN SAFETY: PREDICTIVE MODELLING OF TEMPERATURE-DRIVEN PROPERTY CRIMES FOR QUALITY OF LIFE

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Abstract

Understanding the relationship between temperature, crime, and quality of life is crucial for addressing urban challenges and fostering sustainable development. While community safety is a key focus of the Sustainable Development Goals (SDGs), the link between temperature, property crime, and quality of life remains underexplored. Most studies emphasize violent crimes, neglecting property crimes and their nuanced interactions with environmental factors. Additionally, the indirect effects of temperature and crime on quality of life lack sufficient investigation. This study addresses these gaps by analysing the relationship between temperature, property crime, and quality of life using machine learning techniques, including, Generalized Linear Model, Support Vector Machine, Gradient Boosted Tree, Decision Tree and Random Forest algorithms. Data were collected from 317 face-to-face surveys in Taman Dato' Senu, Sentul, Kuala Lumpur, alongside official crime statistics from the Royal Malaysia Police. Results indicate that property crime significantly influences quality of life, whereas temperature shows minimal direct impact. These findings highlight the complex dynamics between climate and social behaviour and demonstrate the potential of machine learning for precise, data-driven insights to support urban planning and policy decisions in tropical cities.

Keywords: Property crime, temperature, quality of life, machine learning

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INTRODUCTION

Urbanization, while driving economic growth, also creates challenges for sustainable development, requiring coordinated policies to address its adverse effects. The concept of quality of life, a cornerstone of national and international agendas like Agenda 21 and the Sustainable Development Goals (SDGs), emphasizes the holistic well-being of communities (Ali Haider & Iamtrakul, 2018). In Malaysia, development plans prioritize quality of life, balancing economic growth with societal welfare, environmental protection, and security. Safety and security, as vital components of quality of life, are highlighted in national initiatives such as the Twelve Malaysian Plan and Crime Prevention Through Environmental Design. Crime, a pressing social issue, poses significant risks to public safety, necessitating studies to explore its relationship with various factors.

While quality of life and crime have been extensively studied, including environment safety (Zyed, Harumain, Matsunaga, Hashim, & Azmi, 2025; Abd Ghany & Naharudin, 2025), the interplay between crime, temperature, and quality of life remains underexplored. Crime trends are associated with many factors, including, but not limited to, socio-economic conditions, social inequality and unemployment rates (Hakim et al., 2022). Previous research on quality of life has employed various indicators, such as health status (Tang et al., 2020), socioeconomic factors (Huguet et al., 2008), subjective well-being (Kinderman et al., 2011; Norman et al., 2000), and environmental conditions (Mouratidis, 2020). However, in urban geography and studies, the connection between temperature, crime, and quality of life has received limited attention (Kitchen & Williams, 2010).

This study seeks to address the research gap by examining how temperature variations influence property crime rates and their implications for urban quality of life, focusing on Malaysian cities where temperature differences are relatively small but environmentally significant. While Malaysia experiences minimal seasonal fluctuation, even modest increases in heat intensity, from 36°C to 40°C were expected to affect human comfort, health, and behaviour. To utilize a machine learning–based predictive framework enables this study to detect and model such subtle temperature and crime interactions with greater precision than conventional statistical methods. This approach contributes new empirical insights from a tropical urban context, extending international discussions that predominantly emphasize temperate regions.

RESEARCH BACKGROUND

Impact of Property Crime on Quality of Life

The fear of crime is a global issue affecting nearly every city. Both crime and the fear of crime are serious issues that must be addressed as the contribute to a

decreased quality of life (Sciences & Shamsuddin, 2013). Crime has psychological and physical impacts on everyone involved, including the victims, reducing their overall quality of life. This uneasiness in society is far from ideal for the social development of urban dwellers (Farhan Kamarulzaman, 2020). Ishak & Bani (2017) investigated the relationship between crime and the quality of urban geography and urban studies. However, few studies (Corcoran & Zahnow, 2021; Ghani, 2017; Kitchen & Williams, 2010; Lynch et al., 2020; Soh, 2012; Trujillo & Howley, 2021) have examined the relationship between crime and quality of life.

The effect of crime on citizens' daily lives are numerous. Most of the costs incurred from criminal activities are direct and have immediate impact. Fear of crime, lower life satisfaction, psychological issues, lower quality of life, and non-monetary cost are all examples of indirect costs with long-lasting impact From a theoretical perspective, understanding the dynamics of criminal activity is important because it sheds light on criminals' maximizing behaviour (Lersch & Hart, 2020).

Research on the fear of crime suggests it harms quality of life and psychological well-being (Ishak & Bani, 2017). Studies link crime, including its relationship with temperature, to widespread social concerns, emphasizing its impact on societal productivity and quality of life. Efforts to combat crime often divert time that could be more productively used to enhance well-being. Crime remains a global challenge with significant implications for urban quality of life (Ishak & Bani, 2017).

Domain of Quality of Life

The quality of life is classified into six (6) domains as seen in Table 1. Three (3) out of six (6) dimensions were chosen to be applied in this study, namely a) physical environmental, b) psychological, and c) social. Quality of life measures different elements. Measuring the quality of life from a physical environment aspect emphasizes elements that provide security, such as safety at home, in the neighbourhood areas, and the city.

Meanwhile, the measurement of quality of life for the psychological aspect emphasizes feelings of a fear, stress, and happiness. Therefore, to assess the influence of local criminal activity on people's quality of life, it is necessary to evaluate the respondents' psychological state. Next, the researcher focuses on the environmental aspects, which concentrate on weather elements such as temperature, based on the influence of temperature on criminal activity. Here, the researcher would assess how people perceive the impact of temperature on their quality of life in the context of criminal activity.

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Table 1: The quality of life domains

Domain	References
Physical Environmental	(Bracy et al., 2014; Ghani, 2017; Mihinjac & Saville, 2019; Mohit, 2013b; Serag El Din, Shalaby, Farouh, & Elariane, 2013; Soh, 2012)
Mobility	(Bracy et al., 2014; Serag El Din et al., 2013)
Social	(Ghani, 2017; Mohit, 2013b; Soh, 2012)
Psychological	(Kitchen & Williams, 2010; Lersch & Hart, 2020; Mohit, 2013b; Serag El Din et al., 2013; Trujillo & Howley, 2021)
Economic	(Ghani, 2017; Serag El Din et al., 2013)
Political	(Ghani, 2017; Mohit, 2013a; Serag El Din et al., 2013; Soh, 2012)

Finally, the researcher looks at the social aspects to examine the relationship of people with their social activities based on the level of security around them. This section reviews the objective measures suggested in the literature for each identified quality of life domain category. The primary goal of this review is to find the related dimensions and criteria of each domain addressed in this research, from which preferable candidate indicators would be suggested for this study.

The Relationship Between Quality of Life and Crime and Temperature Changes

Understanding the relationship between crime, temperature, and quality of life requires thorough analysis. External factors like weather significantly influence behaviour, with studies highlighting how temperature fosters aggression and diminishes self-control (Ranson, 2014). Research on the weather-crime link began in the 1960s, revealing a notable impact of temperature on criminal behaviour. Scholars stress the importance of examining weather factors, as evidence shows a correlation between higher temperatures and increased crime rates, particularly violent offences. This highlights the critical role of temperature in explaining seasonal variations in violent crime (Jung et al., 2020).

Temperature significantly influences human behaviour, including the tendency to engage in criminal activity. Environmental factors such as temperature, rainfall, and wind conditions affect outdoor human activity, thereby influencing the likelihood of crimes such as assault and property theft. Research indicates that “pleasant” weather conditions may increase the opportunity for property crimes, whereas “unpleasant” weather tends to deter such activities (Horrocks & Menclova, 2011). Despite research on crime, temperature, and quality of life, significant gaps remain in understanding their combined impact on human well-being and life satisfaction (Ghani, 2017; Soh, 2012). Scholars have suggested that climate change may exacerbate aggression and violent

behaviour, highlights the need for further empirical investigation to clarify these dynamics and their broader societal implications (Habibullah, 2017).

Machine Learning in Quality of Life Prediction

As data accumulation grows exponentially, machine learning has become essential for intelligent analysis, outperforming traditional methods in handling complex information (Kim et al., 2019). In crime-prediction research, machine learning uses data-mining techniques to identify hidden patterns within large datasets, thereby assisting law-enforcement agencies in managing criminal incidents (Malathi & Baboo, 2011). Predictive models leverage variables such as time, weather, and location, and employ algorithms like K-Nearest Neighbours (K-NN) and decision trees to forecast criminal behaviour effectively (Bharati & Rak, 2018; Kim et al., 2019a; Wu, 2019). This study further explores the potential of machine learning by employing additional algorithms that have not yet been widely applied in temperature-related crime prediction.

RESEARCH METHODOLOGY

The research employs a quantitative methodology that integrates primary data collected through surveys with secondary data obtained from agencies, industries, and archival sources to gather and analyze relevant information for achieving its objectives (Sekaran & Bougie, 2016). Primary data was gathered through questionnaires, captures public perceptions of quality of life in relation to crime.

Temperature data were collected alongside the questionnaire survey to examine its potential influence on the study's key focus areas. Secondary data were sourced from the Royal Malaysia Police (RMP), encompassing ten years (2011–2020) of crime records. This crime data, drawn from monthly and yearly reports, is categorized into six offence types: theft, vehicle theft, motorcycle theft, lorry/van/truck theft, snatch theft, and burglary (PDRM, 2021).

Site Selection

The site selection process for this study involved several vital steps. The crime index from 2011 to 2020 was initially gathered from the RMP. Table 2 highlights Selangor, Kuala Lumpur, and Johor as regions with the highest crime rates in Malaysia. These three states represent highly urbanized areas where criminal behaviour tends to increase alongside rapid development and population density. The concentration of crimes in these regions highlight the need to examine the interaction between environmental stressors such as temperature and urban heat and social behaviour. This finding further justifies the study's focus on urban settings, where small variations in temperature can have amplified effects on human comfort, behaviour, and consequently, property crime incidence.

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Table 2: The crime index statistics in Malaysia from 2011 to 2020

State	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Johor	20970	19068	17105	15082	13480	12941	11307	10338	9870	7350
Kedah	10667	10100	8636	8028	7817	7440	6759	6221	5615	4131
Kelantan	6199	6053	5737	5603	5031	4548	4520	3987	3545	2531
Kuala Lumpur	25002	23022	22319	18293	15946	16989	13482	12127	11172	8301
Melaka	4830	4764	4186	3675	2948	3664	3097	2800	2561	1794
Negeri Sembilan	6050	6563	5993	5495	4787	4474	3973	3673	3327	2431
Pahang	5994	5619	5257	5085	4257	3777	3607	3584	3271	2331
Perak	9869	8545	7429	6860	6228	5841	5326	5128	4912	3388
Perlis	1113	974	831	814	741	655	603	563	527	493
Pulau Pinang	9758	8399	7936	7491	6697	6116	5551	5017	5218	3853
Sabah	-	3489	5772	5210	5176	5367	6236	6151	5745	3799
Sarawak	-	6202	9191	7556	7230	6826	6381	5830	6023	5850
Selangor	44302	40629	43060	36165	32547	31222	26069	21420	19800	17272
Terengganu	3841	3505	3610	3213	2659	2494	2257	1823	1870	2099
Total	148595	146932	147062	128570	115544	112354	99168	88662	83456	63524

Source: Royal Malaysia Police, (2021)

Crime is divided into six types: theft, vehicle theft, motorcycle theft, lorry/van/truck theft, snatch, and burglary. Details of the index crime categories are shown in Table 3.

Table 3: Property crime data in Johor, Kuala Lumpur, and Selangor

State	Year	Theft	Vehicle Theft	Motorcycle Theft	Lorry/Van/Truck Theft	Snatch	Burglary
Johor	2011	3811	2006	7571	479	76	2598
	2012	2910	1738	7731	590	38	2219
	2013	2322	2188	6754	776	28	1798
	2014	2216	1686	6052	552	40	1603
	2015	1934	1592	5595	473	33	1440
	2016	2073	1443	4686	400	44	1475
	2017	2032	1097	4104	274	11	1211
	2018	2021	1035	3881	278	4	1239
	2019	1908	981	3471	219	4	1364
	2020	1403	802	2347	141	0	1273
Kuala Lumpur	2011	4497	3326	5692	664	951	3480
	2012	3910	3359	5693	549	384	2838
	2013	3391	3281	5459	688	214	2506
	2014	3133	2481	4469	548	593	2118
	2015	2995	2229	4015	524	604	1907
	2016	3595	2104	3864	495	1288	1867
	2017	3121	1548	3328	291	7	1188
	2018	3118	1482	3030	253	3	1104
	2019	2729	1423	2763	254	2	1087
	2020	2057	1000	2200	147	0	949

Selangor	2011	5941	6389	12957	1653	799	8422
	2012	4437	5792	13285	1757	725	6337
	2013	5147	5832	12653	2049	984	7742
	2014	4675	4723	10688	1648	845	6184
	2015	4157	3932	9794	1326	950	5805
	2016	4793	3309	8890	1140	983	5497
	2017	3951	2586	7945	844	140	4133
	2018	3638	2358	6510	654	87	3515
	2019	3514	2204	5503	595	3	3679
	2020	3753	1544	4337	374	0	3025

Source: Royal Malaysia Police, (2022)

Despite Selangor exhibiting the highest property crime statistics, Kuala Lumpur was ultimately chosen due to its second-highest crime rate in Malaysia, logistical ease in data collection, and the constraints faced in unsuccessfully accessing data from Police Headquarters Petaling Jaya, Selangor. Table 4 shows Brickfields, Cheras, Dang Wangi, Sentul, and Wangsa Maju for the property crime statistics in Kuala Lumpur.

Table 4: Statistic of property crime in Kuala Lumpur district from 2011 to 2021

Year	Brickfields	Cheras	Dang Wangi	Sentul	Wangsa Maju	Total
2011	4574	4965	2952	5740	0	**18231**
2012	3958	3737	3202	5507	0	**16404**
2013	3133	3374	3031	5668	0	**15206**
2014	2458	2525	2679	3533	1854	**13049**
2015	2304	2126	2587	2783	2228	**12028**
2016	2145	2041	3311	2698	2755	**12950**
2017	1441	1470	2254	2063	2019	**9247**
2018	1497	1370	2162	1850	1916	**8795**
2019	1492	1258	1649	2005	1631	**8035**
2020	1212	1030	1364	1407	1220	**6233**
2021	752	806	1034	1162	881	**4635**
Total	**24966**	**24702**	**26225**	**34416**	**14504**	**124813**

Source: Royal Malaysia Police, (2022)

Further analysis of crime data within Kuala Lumpur pinpointed Sentul as the area with the highest crime rate, as shown in Table 4. Sentul was situated within the administrative division of Mukim Batu, which was characterized by its division into Sentul West and Sentul East. It features various residential types, focusing on landed residences for this study. The site selection process culminated in the Taman Dato' Senu as the study area, driven by statistical evidence indicating its heightened crime rates compared to neighbouring areas and its composition of one-storey and two-storey landed housing, particularly terrace houses, which lacked security measures (refer Figure 1).

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This study used the random systematic sampling method to determine the selection of residents with the 317-sample size. In this preliminary study, 317 samples were reached to cover all subgroups of the target population (Han et al.,2018). The questionnaire was used to collect the data that comprises of quality of life, domains. The section of questionnaire was developed based on the three constructs of the quality of life: physical environment, psychological, and social. Each construct was measured using a five-point Likert scale (1 = strongly disagree, 5 = strongly agree), with estimates derived from the average scores of their indicators.

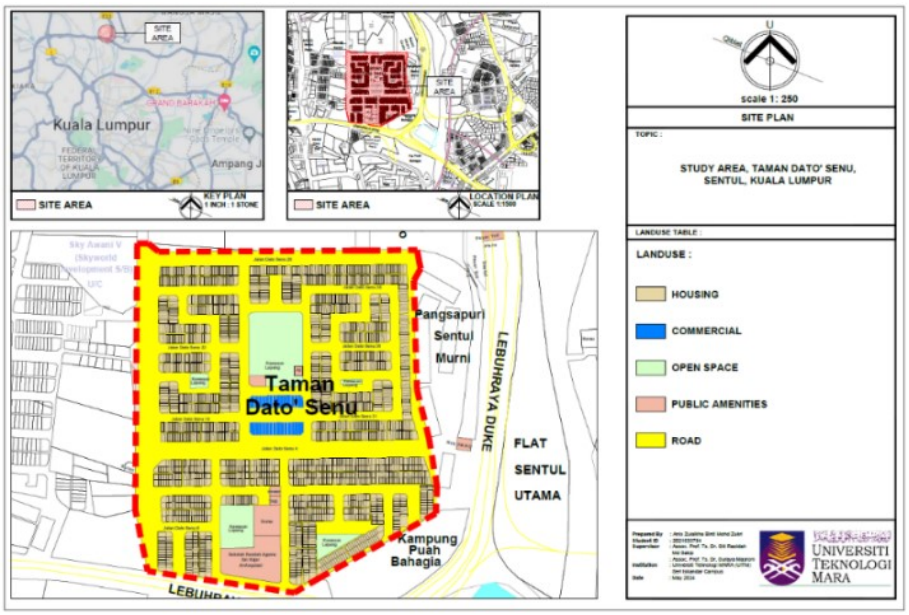


Figure 1: Study area in Taman Dato' Senu, Sentul, Kuala Lumpur

The questionnaire was conducted face-to-face with residents of Taman Dato' Senu, Sentul, Kuala Lumpur, ensuring clarity and adherence to survey instructions. Of 317 questionnaires distributed, 254 valid responses were collected, achieving an 80% response rate. Temperature data in degrees Celsius (°C) was recorded on each form using a smartphone during the survey process.

DATA ANALYSIS AND RESULT

Correlation Analysis

The Pearson correlation coefficient results in Table 5 shows the relationship between property crime and temperature changes towards quality of life.

Table 5: Pearson correlation coefficient result

	Property crime	**Quality of life**	**Temperature**
Property crime		0.726**	0.097
Quality of life	0.726**		0.057
Temperature	0.097	0.057	

**Correlation is significant at the 0.01 level (2-tailed)

Based on the Table 5, the analysis shows a Pearson correlation coefficient (r=0.726) between property crime and quality of life, with a (p=*0.01),* indicating that this relationship is statistically significant. This means that property crime rate has a noticeable impact on quality of life, affecting factors like the physical environment, psychological, and social. Meanwhile, the relationship between the variable temperature, quality of life and property crime is not statistically significant with p value above 0.005. The analysis highlights a significant correlation between property crime and quality of life. In contrast, the influence of temperature on quality of life appears to be minimal and not statistically significant. The Pearson correlation result in Table 6 shows the relationships between property crime and the three quality of life domains (physical environment, psychological, and social).

Table 6: Pearson correlation coefficient result

	Property crime	**Physical Environment domain**	**Psychological domain**	**Social domain**
Property crime		0.998**	0.351**	0.140*
Physical Environment domain	0.998**		0.349**	0.148*
Psychological domain	0.351**	0.349**		0.003
Social domain	0.140*	0.148*	0.003	

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

The analysis of correlation coefficients shows relationships between property crime and different domains of quality of life. Firstly, the exceptionally strong positive correlation between property crime and the physical domain (r=0.998, p<0.01) indicates that as property crime increase, there is a substantial deterioration in the quality of life of the physical environment.

Additionally, a moderate positive correlation is observed between property crime and the psychological domain (r=0.351, p<0.01). This indicates that higher property crime is associated with an increase in psychological distress among the community members. The people would get more chances for fear and stress if property crime increase due to concern about their safety. Furthermore,

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a statistically significant but it shows slightly as the correlation is found between property crime and social domain ($r=0.140$, $p<0.05$). This indicates that while higher property crime may impact social patterns within the community.

Machine Learning

This research presents two distinct sets of results. Firstly, Table 7 outlines the performance outcomes of machine learning in predicting the quality of life. This table can compare each machine learning algorithm's performance using the two feature selections. Secondly, Figure 2 presents an in-depth presentation and discussion of how machine learning algorithms are influenced by two independent variables: property crime and temperature. The analysis of these results provides a comprehensive understanding of the interplay between machine learning, quality of life prediction, and the impact of property crime and temperature as independent variables.

Table 7: The performances of result

Algorithm	RMSE (+/- std dev)	R^ (+/- std dev)	Time to Complete (s)
Feature Selection 1			
Generalized Linear Model	0.345(+/-0.056)	0.612(+/-0.205)	9
Random Forest	0.32 (+/-0.067)	0.626(+/- 0.261)	1
Decision Tree	0.327(+/-0.038)	0.654(+/-0.211)	5
Gradient Boosted Trees	0.367(+/-0.069)	0.568(+/-0.238)	84
Support Vector Machine	0.339(+/-0.064)	0.666(+/-0.294)	76
Feature Selection 2			
Generalized Linear Model	0.345(+/-0.056)	0.612(+/-0.205)	0.838
Random Forest	0.32 (+/-0.039)	0.613(+/- 0.307)	0.243
Decision Tree	0.344(+/-0.038)	0.538(+/-0.332)	4
Gradient Boosted Trees	0.384(+/-0.067)	0.472(+/-0.365)	87
Support Vector Machine	4.363(+/-0.025)	0.684(+/-0.094)	44

Although temperature exhibits a low correlation according to the Pearson test when considered outside machine learning algorithms, its utility in enhancing predictive abilities becomes apparent within specific algorithms. Despite the initial low correlation value, temperature contributes valuable insights to specific algorithms, leading to improved predictive accuracy. This shows how detailed and complicated its impact can be in the context of machine

learning. Even factors that may seem unrelated can be essential and improve prediction results. Regarding predictive accuracy, the root means square error (RMSE) measures how close the model's predictions are to the actual values. Lower RMSE values indicate better predictive performance. Among the algorithms, the Decision Tree exhibited the lowest RMSE of 0.32 (+/- 0.067), followed closely by Random Forest with an RMSE of 0.327 (+/- 0.038). These algorithms demonstrated more accurate predictions compared to the other models.

The coefficient of determination (R^2) measures how well the model's predictions match the data. A higher R^2 value indicates better alignment between predictions and actual values. In this case, Support Vector Machine led with the highest R^2 of 0.666 (+/- 0.294), indicating that it captured a substantial portion of the variance in the data. Considering the combination of these metrics, particularly the RMSE and R^2, the Support Vector Machine emerges as the best-performing algorithm in predicting quality of life. The higher R^2 and competitive RMSE indicate robust predictive capabilities and accurate results. Support Vector Machine outperformed other algorithms in this study primarily due to its strength in handling non-linear relationships between temperature variables and property crime rates. Unlike linear models such as Generalized Linear Model, which assume a direct linear correlation, Support Vector Machine can map complex data relationships through kernel functions, allowing it to capture subtle interactions that may exist between climatic variations (small temperature differences between 36°C and 40°C) and crime patterns.

However, practical considerations such as computational time should also be considered when selecting the most suitable algorithm for a specific use case. Support Vector Machine took longer than Generalized Linear Model, Random Forest, and Decision Tree. Nevertheless, the time taken is considerably acceptable, less than a minute with feature selection 2.

Furthermore, it is interesting to gain insight into the contributions of each attribute that influences machine learning performance. Figure 1 presents the weights of the contributions calculated based on Pearson Correlation. These contributions collectively inform the predictive model with each machine learning algorithms.

Based on Figure 2 illustrate the comprehensive framework guides researcher through a series of sequential of steps, commencing from the establishment of initial research goals to the thoughtful selection of a machine learning tailored for predicting quality of life. The process is initiated by undertaking systematic literature review and correlation analysis, followed by feature selection using various machine learning algorithms for subsequent phases.

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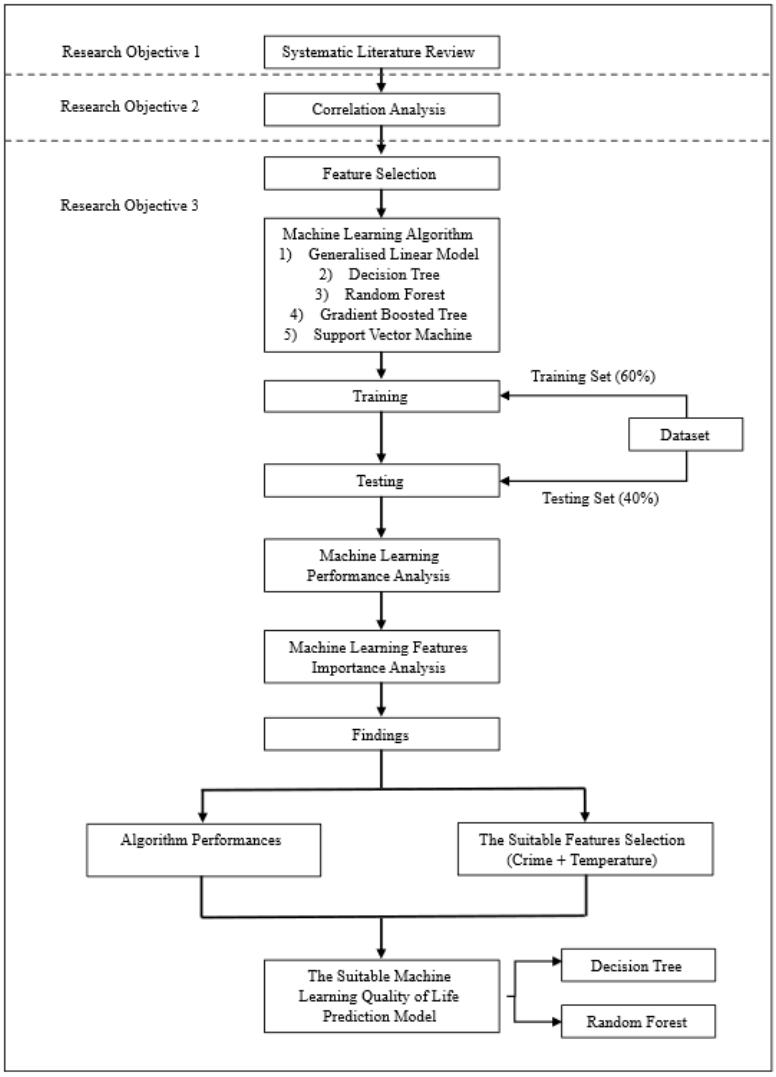


Figure 2: The suitable machine learning quality of life prediction model framework

A crucial of the framework is the feature selection phase, where a diverse array of machine learning algorithms is utilized. The selected algorithms assume a central role in the ensuing "Training" phase, where the "Training Set (60%)" dataset is utilized to refine and optimize the chosen features. Subsequently, a critical "Testing" phase ensues, subjecting the features to evaluation using the "Test Set (40%)" dataset.

The outcome of this thorough testing analysis results in two essential analyses: the "Machine learning Performance Analysis" and the "Feature Importance Analysis". These analyses serve as vital pathway leading to the subsequent phase of formulating "Findings". Within the findings, the framework incorporatesa thoughtful evaluation of "Algorithm Performances", concluding in the identification of "The Suitable Features Selection". This insight serves as the keystone for the final section of the framework, wherein researcher thoroughly select a suitable machine learning model for predicting quality of life.

DISCUSSION AND CONCLUSION

This study finds no significant relationship between property crime and temperature, aligning with prior research showing temperature impacts violent crime but not property crime. Scholars like Corcoran & Zahnow (2021) suggest that property crime is less influenced by environmental factors, emphasizing the need to explore alternative variables such as socioeconomic conditions, urban density, and opportunity structures. Malaysia's tropical climate, with relatively stable temperatures, may explain the lack of temperature's impact on crime compared to regions with extreme seasonal changes.

Despite this, the study contributes by linking property crime to quality of life across physical, psychological, and social domains, highlighting how fear of crime and perceptions of safety influence well-being. Using machine learning techniques like Decision Tree and Random Forest, the study advances traditional methods, uncovering complex relationships between temperature, crime, and quality of life.

Future research should explore other environmental factors, urban design, and socioeconomic inequalities, and conduct comparative studies across diverse climates. Advanced computational tools, such as machine learning, offer potential for better predictive models, informing policies that enhance safety, security, and quality of life, while supporting Sustainable Development Goals related to urban sustainability and social equity.

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FEAR OF CRIME IN PUBLIC SPACE: PHYSICAL AND SOCIAL ENVIRONMENTAL CONDITIONS

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Abstract

Fear of crime in urban public space affects the well-being of residents and has detrimental effect on individuals' behaviour. Thus, this study examines the effect of physical and social environment conditions on fear of crime in Malaysia. Data was collected for nine variables related to fear of crime from sample of 540 adults selected from housing estates every state in Malaysia. Binomial logistic regression analysis technique was used in identifying the odds of fear of crime among the individual attributes for the different dimensions (physical and social environmental conditions). Findings from the study revealed that the odds of fear of crime in deteriorated physical environment condition is three times higher among respondents that are married (Exp(B) = 3.766, $p<0.05$), two times higher among Malays (Exp(B) = 2.185, $p<0.05$) compared to other racial groups, and the older adults (Exp(B) = 2.201, $p<0.05$).

Keywords: Fear of Crime, Physical Environment, Social Environment, Public Space, Malaysia.

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INTRODUCTION

Public spaces play important role in human connections and public activities in urban centres (Roy and Bailey, 2021). No other urban environment echoes the meaning of city life better than the public space. Whatever the nature maybe - a garden, park, open space, a mall, public buildings, lobbies, foot path, train platform or a street corner, a public space is where people move around, interact with each other and at times become crime victim (Ceccato and Nalla, 2020). Costamagna et al. (2019) noted that public space is a place that is usable and accessible by everyone and that such a space could be outdoors or indoors. Due to the important role public spaces play in urban centres, scholars over the years, have continued to discuss about it (Mehta, 2014; Di Masso, 2015; Costamagna et al. 2019). Public space is defined as an arena for social relations that impacts the psychological wellbeing of individuals in terms of comfort, tranquillity, and sense of security (Carmona et al., 2003; Gallacher, 2005).

Public space can act as a crime generator that creates sense of insecurity and opportunities for crime in certain places and at certain times (Putra et.al. 2023). One of the main concerns regarding public spaces is safety. Safety affects accessibility and use of a public space (Ceccato and Nalla, 2020). Clarke and Eck, (2007) noted that public spaces are often risky, because of disproportionately high crime rates in them compared to the surrounding areas. Thus, discussion about safety in public spaces is not only an essential issue for academic scrutiny or research, but also for long-term sustainability of cities and economic development (UN-Habitat, 2019). How urban centres are designed and planned has influence on an individual's safety (Ceccato, 2016).

Crime literature in public space is replete with studies that have identified several factors that influence fear of crime among residents. Some of the studies identified physical environment conditions (e.g Austin et al. 2002; Freedman and Owens 2011; Md Sakip et al. 2013; Vernez Moudon et al. 2018; Roy and Bailey, 2021), while others identified social environment conditions (Hillborn 2009; Groff and McCord 2011; Gholamhosseini et al., 2018). Fear of crime in urban public space is a complex environmental, social-cultural, physiological and psychological phenomenon that is inadequately understood within the urban planning profession (Ratnayake, 2013). The complexity in understanding fear of crime in public space is partly explained by confluence of the various factors highlighted above.

In Malaysia, studies have been conducted to examine crime in urban public spaces (e.g measures that local authority could implement to reduce crime rate in Malaysia (Shamsudin, 2008); Cause and effect of urbanization on crime in Malaysia (Che Soh, 2012), Public perception of crime (Ali, 2014); Factors that influence fear of violent crime in Selangor (Mohd Arshad et.al. 2018); Fear of crime in residential areas (Md Sakip et.al. 2018); Relationship between fear of crime and self-rated health (Abdullah et.al. 2019); Contextual and multifactorial

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influence on perception of safety from crime (Abdul Ghani et.al. 2021). Although these studies examined crime in urban public space in one form on the other, there is none that incorporated individual attributes of residents, physical and social environmental conditions in one study to examine fear of crime. A recent study conducted by Abdul Ghani et.al. (2021) examined fear of crime in Malaysian public space looking only at the neighbourhood conditions (physical environment) and social conditions (e.g. experience of victimisation, crime information, law enforcement). Although this study highlighted some of the effects of physical and social environmental conditions in residents' perception of safety in public space in Malaysia, there is need for further study that incorporates the individual attributes (socio-demographic attributes) to further deepen the understanding on antecedents of fear of crime. Therefore, the current study aims at examining the influence of deteriorated physical and social environment conditions on fear of crime in Malaysia.

FEAR AND CRIME

Due to the fact that physical and emotional reactions to crime are unique to each individual, the concept of fear of crime has been defined differently by researchers. The varied definitions of fear of crime, Pain (2001) argues, act as a limitation in comparative studies. Thus, empirical results from studies on fear of crime are highly contrasting, given that, in some instances these studies do not consider the same underlying construct (Hale, 1996; Lorenc et al., 2012). In this regard, fear of crime according to De Donder, (2009) and Semmens, (2007) suffers from conceptual confusion and researchers need to develop a better, more unified conceptual understanding or framework. The best conceptualization of fear of crime are those definitions that appreciate the way in which fear of crime constantly acts as constraint to activities in daily life of people (Yates and Ceccato, 2020). Gordon and Riger (1989) defined fear of crime as a 'sense that one must always be on guard, vigilant and alert'. Three words that stood out in this definition are 'guard', 'vigilant' and 'alert'. In other words, when an individual has a sense of insecurity in an environment, it makes that individual to be on guard, alert, and vigilant because anything untoward can happen. Irvin-Erickson et.al. (2020a) opined that an individual's perception of the built and social environment in a neighbourhood could affect his/her cognition of risk of victimization and trigger feelings of insecurity and worry, which may all together be expressed as fear of crime.

Social disorder theories of fear of crime posit that disorderly events and signs of chaos in communities create fear of crime. One of such theories is 'Broken Windows Theory' (Wilson & Kelling, 1982), which posits that feelings of social and physical deterioration in an environment could increase an individual's sense of vulnerability, which then leads to higher fear of crime, reduced social control and an increase in crime rate. Extant literature on the

propositions of social disorder theories on perceived social and physical incivilities and fear of crime are well documented (Lorenc et al., 2012; Loukaitou-Sideris, 2014). For example, neglect in the immediate neighbourhood and other physical signs such as vacant plot, abandoned and vandalized buildings, and graffiti have been linked with increased level of fear of crime. Also, social environment problems such as presence of disorganized or disorderly individuals (e.g. drunkards or those under influence of drugs, beggars on the streets, homeless individuals, people with mental disorder) have also been associated with increased fear of crime (Innes, 2017; Farrall, et.al. 2009; Waters, et.al. 2007; Vrij & Winkel, 1991; Cozens, et.al. 2003; Hale, 1996). Valentine, (1990) argues that socially integrated neighbourhoods engender self-help support and networks, which helps in alleviating an individual's fear of crime, as the individual feel more confident in his/her ability to handle potential risks. It is presumed that individuals who show high levels of fear of crime live in neighbourhoods with evidence of physical incivilities and limited social cohesion. The extent of fear of crime and consequences are not evenly distributed (Burgess, 2002; Yates and Ceccato, 2020: Stjernborg and Bamzar, 2020). For example, studies have found that older adults and females experience higher levels of fear of crime (Haislmaier, et.al 2018; De Donder et. al., 2012; Ortega and Myles 1987).

METHOD

Data for study was obtained through survey of adults in Shah Alam city. The selection of the study area stems from its location and position as an industrial hub with high economic activities and the human population. Due to the high level of population growth, the city acts as an attraction for both skilled and unskilled labour from different backgrounds, the majority of whom are young adults. The level of crime in Malaysia has a decreasing rate and is generally moderate. However, there are some areas that record higher crime rates which are known as Blackspot areas by Local Authorities and District Police Headquarters. These areas have a criminal record in the past.

Based on the local cultural setting, the survey questionnaire was designed in bilingual (Malay and English) drawing from the following fear of crime indicators: (1) deterioration in physical environment (2) deterioration in social environment. The respondents were asked to rate their perception about each fear of the crime indicator on a five (5) point Likert scale ranging from 1 = Not worried to 5 = Very worried. Using stratified and random sampling techniques, a total of 540 respondents were sampled.

Dependent variable

In the field of criminology, the operationalization and conceptualization of fear of crime has been a subject of debate among scholars. The debate centres on the broad measurements of fear of crime as both cognition and felling and the

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inability of researchers to discern the two concepts (Irvin-Erickson et.al,2020b). In the current study, we measured fear of crime by asking respondents at the time of the survey, how worried they are about the deterioration of physical environment, deterioration of social environment. The respondents rated their level of worry on a scale ranging from 1 = Not worried to 5 = Very worried. We generated a dichotomous variable by grouping the responses 1,2,3 as Not worried and 4, 5 grouped as Very worried using SPSS software. Thus, the dependent variable (fear of crime) is treated in the logistic regression models as dichotomous whereby, very worried = 1, otherwise (Not worried) = 0.

Independent variables

The set of independent variables used in the logistic regression analysis to test variations in level of fear of crime are: (1) gender measured as dummy variable whereby male = 1 otherwise 0, (2) race is measured as dummy variable whereby Malay = 1 otherwise 0, (3) marital status is measured as dummy whereby 1 = married otherwise 0, (4) occupation is measured as nominal variable comprising of five categories, (5) age, (6) income and (7) educational qualifications are measured as interval variables (scale).

ANAYSIS & FINDINGS

More than half (57.6%) of the participants in the survey are female, while the rest are male. About 63% are within the age category20-39 years, while 14.6% are within the category of 40-49 years, 11.5% are within the category of 50-59 years and 10.9% are above 60 years. Based on this breakdown, it could be said that majority of participants are young adults. In terms of racial composition, results in Table 1 indicate that the dominant racial group in the sample is the Malay (72.8%), followed by Chinese (16.9%), Indians (9.6%) and others (0.7%). More than half (55.2%) of the respondents obtained University degrees, 40.4% had only secondary education, 4.1% primary education, while 0.4% had no western education. Majority (73%) practice Islamic religion, while the rest (27%) practice other religions (Christian (15%), Buddhis (4.8%), Hindu (2.8%) Others (2.8%). In terms of marital status, Table 1 indicates that 47.6% are married while 40.9% are unmarried (single), 7.8% are divorced or separated, 3.7% are widow/widower. About 40.6% are employed in the private sector, while 20.2% are self-employed, 15.6% are employed in the public sector, 14.8% are unemployed and 8.9% are retirees. About 37.4% earned RM2000 monthly, 24.4% earned between RM2001-4000, 16.1% earned between RM4001 – 6000, 15% earned between RM6001 –8000, 3.7% earned between RM9001 – 10,000 and 3.3% earned above RM 10,000.

Table 1: Socio-Demographic Attributes of Respondents

Gender	**Frequency**	**%**	**Religion**	**Frequency**	**%**
Male	229	42.40	Islam	394	73.00
Female	311	57.60	Christian	81	15.00
Total	**540**	**100.00**	Buddha	26	4.80
Age			Hindu	24	4.40
20-29	217	40.20	Others	15	2.80
30-39	123	22.80	**Total**	**540**	**100.00**
40-49	79	14.60	**Marital Status**		
50-59	62	11.50	Single	221	40.90
60 and above	59	10.90	Married	257	47.60
Total	**540**	**100.00**	Divorced	42	7.80
Race			Widow/widower	20	3.70
Malay	393	72.80	**Total**	**540**	**100.00**
Chinese	91	16.90	**Occupation**		
India	52	9.60	Private sector	219	40.60
Others	4	.70	Public sector	84	15.60
Total	**540**	**100.00**	Self employed	109	20.20
Education			Retired	48	8.90
University	298	55.20	Unemployed	80	14.80
Secondary School	218	40.40	**Total**	**540**	**100.00**
Primary School	22	4.10	**Monthly Income**		
Never attended	2	.40	RM2000	202	37.40
Total	**540**	**100.00**	RM2001 – RM4000	132	24.40
			RM4001 – RM6000	87	16.10
			RM6001 – RM8000	81	15.00
			RM9001 – RM10,000	20	3.70
			Above RM 10,000	18	3.30
			Total	**540**	**100.00**

The binary logistic regression analysis test was conducted to estimate the relationship between the fear of crime categories (deterioration in physical environment, deterioration in social environment and the socio-demographic attributes of respondents. We chose binary logistic regression because our dependent variables have been dimensioned as dichotomous variable whereby Very worried = 1, otherwise 0. Looking at the goodness of the fit results in fear of crime due to deterioration in physical environment (i.e. abandoned housing in the neighbourhood), (Table 2). the chi-square statistic along with pseudo R-square show that the full model is an improvement over the intercept only model (chi-square = 102.613, $p<0.05$, Negalgarke R-square = 0.38), bushy/green areas (chi-square = 94.858, $p<0.05$, Negalgarke R-square = 0.30), unkempt

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environment littered with garbage (chi-square =112.205, $p<0.05$, Negalgarke R-square = 0.47).

Results in Table 2 indicate that racial background, marital status, and income are significant individual factors that help explain variation in fear of crime as a result of deterioration in physical environment (i.e. abandoned buildings in the neighbourhood). Again, results show that gender and age are significant individual factors that explain variation in fear of crime due to bushy areas in the neighbourhood. Lastly, three individual factors namely gender, age and income explain variation in fear of crime due to unkempt environment littered with dirt in the neighbourhood.

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Table 2 Binomial Logistic Regression Results on Deteriorated Physical Environment

I am worried when walking in an abandoned housing area					I am worried when walking along bushy areas in the neighbourhood				I am worried when I come across an unkempt area (ie dirt)			
Individual attributes	**SE**	***Wald***	***p-value***	**Exp(B) (odd ratio)**	**SE**	***Wald***	***p-value***	**Exp(B) (odd ratio)**	**SE**	***Wald***	***p-value***	**Exp(B) (odd ratio)**
Race	.350	3.830	.040*	2.185	.554	.080	.777	1.170	.589	1.140	.286	1.875
Gender	.237	.037	.847	1.047	.488	3.210	.013*	2.796	.413	3.173	.015*	2.089
Age	.128	1.206	.272	1.151	.295	1.385	.025*	2.201	.241	1.984	.031*	1.705
Marital	.241	5.566	.018*	3.766	.573	2.331	.127	2.400	.407	.098	.754	1.136
Education	.221	.281	.596	.890	.496	.989	.320	1.638	.426	.830	.362	1.474
Occupation	.076	1.278	.258	.918	.156	.072	.788	1.043	.132	.369	.543	.923
Income	.100	4.646	.031*	2.807	.248	1.097	.295	1.296	.180	1.132	.036*	2.936
Chi-Square = 102.613 p<0.05 Nagelkerke R-square = 0.38					**Chi-Square =94.858 p<0.05 Nagelkerke R-square = 0.30**				**Chi-Square =112.205 p<0.05 Nagelkerke R-square = 0.47**			

Table 3 Binomial Logistic Regression Results on Deteriorated Social Environment (Perceived incivility)

I am worried when I come across people who have no place to live (homeless) in the neigbourhood					I am worried when I come across drunk people (drunkards) in the neighbourhood				I am worried when I see a stranger loitering or hanging around in the neighbourhood			
Individual attributes	**SE**	***Wald***	***p-value***	**Exp(B) (odd ratio)**	**SE**	***Wald***	***p-value***	**Exp(B) (odd ratio)**	**SE**	***Wald***	***p-value***	**Exp(B) (odd ratio)**
Race	.330	4.685	.030*	2.042	.420	.069	.793	1.116	.646	.309	.045*	1.533
Gender	.222	2.972	.085	1.467	.261	5.216	.022*	2.813	.512	.836	.361	1.796
Age	.114	.437	.508	1.078	.135	.210	.647	1.064	.271	.068	.794	.932
Marital	.197	.549	.459	1.157	.226	.056	.024*	2.148	.597	3.182	.021*	2.902
Education	.201	6.766	.019*	2.493	.241	.001	.975	.993	.467	.516	.038*	1.915
Occupation	.075	.009	.925	1.007	.086	.444	.505	.944	.164	.075	.784	.956
Income	.099	.153	.012*	2.962	.127	1.591	.207	1.174	.243	.078	.780	1.070
Chi-Square = 97.892 p<0.05 Nagelkerke R Square = 0.32					**Chi-Square = 104.277 P<0.05 Nagelkerke R Square = 0.47**				**Chi-Square = 118.724 P<0.05 Nagelkerke R Square = 0.49**			

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For fear of crime due to deterioration in social environment, three (3) variables were used in assessing the residents' perception. The goodness of fit results of the binary logistic regression in Table 3, indicate that the chi-square statistics along with pseudo R-square of the model is significant at .05 (homeless people in neighbourhood) (Chi-Square = 97.892, $p<0.05$, Nagelkerke R Square = 0.32, drunkards in the neighbourhood (Chi-Square = 104.277, $P<0.05$, Nagelkerke R Square = 0.47), presence of strangers loitering/hanging around in the neighbourhood (Chi-Square = 118.724, $P<0.05$, Nagelkerke R Square = 0.49).

Results show that three (3) individual attributes: race, educational qualification, and income explain variation in fear of crime due to deterioration in social environment (homeless people in neighbourhood), while two individual attributes (gender and marital status) significantly explain variation in fear of crime (presence of drunkards in neighbourhood) and three individual attributes (race, marital status and educational qualification) significantly explain variation in fear of crime due to people loitering/hanging around in neighbourhood.

DISCUSSION

Results from the binomial logistic regression show that racial background, marital status, and income are the individual attributes that help explain variation in fear of crime due to physical deterioration of physical environment (i.e. abandoned buildings) in the study area. Among those who fear most, results indicate that racial background, marital status and income level increases their odds of fear of crime. The dominant racial group in Malaysia are the Malays, thus race was coded as dummy whereby Malay = 1 otherwise 0 in the data analysis. Based on the results in Table 2, the odds of fear of crime due to abandoned buildings in the neighbourhood is higher among Malays than the other racial groups ($Exp(B) = 2.185$, $p<0.05$). In other words, the odds of fear of crime among Malays is two times higher than other racial groups in the study area. Yates and Ceccato (2020) observed that perceived social distance between different racial groups in a neighbourhood could explain variation in fear of crime.

Again, results from the study indicate that being married tends to increase the odds of fear of crime due to physical deterioration (i.e. abandoned buildings in the neighbourhood). ($Exp(B) = 3.766$, $p<0.05$). This aligns with Warr (1985) notion of 'altruistic fear' which asserts that married people with children report higher level of fear of crime compared to the unmarried (single) who have no children. The married people with children fear not only for their own safety, but also for their children's safety (Warr,1985). Marriage comes with a sense of responsibility to one's spouse and children, thus it is not surprising that the level of fear of crime is higher among the married in the study area. In this study, the odds of fear of crime among married respondents due to abandoned buildings in the neighbourhood is three times higher than unmarried.

Again, results in Table 1 indicate that the odds of fear of crime due to bushy areas in the neighbourhood is higher among women (Exp(B) = 2.796, $p<0.05$) and the older adult (Exp(B) = 2.201, $p<0.05$). As shown by the results, the odds of fear of crime from bushy environment among women is about three times higher than their male counterpart and two times higher for older adults. Vegetation is very important in safety perspectives (Bogacka, 2020). Areas with thick vegetation limits or hinders visibility, which can act as hiding places for criminals, and in turn brews fear of crime among residents (Michael & Hull, 1994). This finding resonates earlier studies that have reported that women express higher level of fear of crime than men (Tjaden & Thoennes, 2006; Macassa et al., 2018). This in part is attributed to their fear of sexual harassment or violence (Yates and Ceccato, 2020). Peake, (2020) observed that the gender dimension of public space is rarely the focus of urban planning, and it is yet to be integrated into urban planning. Therefore, there is a disconnect between what women experience in their use and access to public spaces and what urban planners envision (Roy and Bailey, 2021). Again, gender and age were significant in explaining variation in fear of crime due to unkempt environment (i.e. neighbourhood littered with garbage). Results indicate that the odds of fear of crime among female respondents (Exp(B) = 2.089, $p<0.05$) is two (2) times higher than their male counterpart and also two times higher among older respondents (i.e. those above 50 years) compared to other age categories (Exp(B) = 2.201, $p<0.05$). Meaning that fear of crime due to unkempt environment is higher among women and the older adults. With regard to specifics of place, Scharf et.al. (2003) opined that older adults have a strong relation to their neighbourhood environment. They are particularly vulnerable, and more likely than others to express fear in deprived or deteriorated neighbourhoods (Smith, 2009; Stjernborg and Bamzar, 2020). In terms of fear of crime due to deterioration in social environment (ie presence of homeless people in the neigbourhood), results show that race, educational qualification and income are the individual attributes that significantly explain variation in fear of crime. The dominant racial group in the study area is the Malay. City center has witnessed rapid growth in human population over the years due to high level of industrial activities. Most of the unskilled labourers from neighbouring countries who have come in search of 'greener pasture', sometimes find it difficult to rent an apartment due to the high cost. The resultant effect is that some sleep-in open places at night. Hunter, et.al. (2002) observed that rapid changes in environment due to high population inflow in the form migration of people, have an impact on residents' sense of safety. In their study in India, Roy and Bailey (2021), found that one of the major factors that made participants feel unsafe is cultural differences. This is attributed to lack of awareness about other people's culture and values which results in decrease acceptability of strangers in the neighbourhood and the sense of insecurity.

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Again, results indicate that fear of crime due to social problems (i.e. presence of drunkards and strangers loitering in neighbourhood) is higher among female (Exp(B) =2.813, $p<0.05$), those that are married (Exp(B) = 2.148, $p<0.05$), respondents with high-income (Exp(B) = 2.962, $p<0.05$), and higher educational qualifications (Exp(B) = 2.493, $p<0.05$). Based on these results, it could be said that the odds of fear of crime as a result of the aforementioned social problems in city center is two (2) times higher among women, respondents with higher educational qualifications and high income and the married. Previous studies have linked social environmental problems such as the presence of disorderly individuals (homeless individuals, drunkards/drug addicts, beggars) and unkempt neighbourhood environment (presence of litter) to higher level of fear of crime (Innes & Jones, 2006; Waters, et.al. 2007; Farral et.al. 2009; Irvin-Erickson, et.al. 2020a). Findings from the study lend support to these earlier studies. Perception of safety is influenced by space and people living therein (Roy and Bailey, 2021). Studies have reported that women feel unsafe in the presence of strangers, labourers, drug addicts, beggars and gamblers (Dhillon & Bakaya, 2014; Machielse, 2015; Chhetri, 2015). It is not suprsing in this study that fear of crime is gendered. Vera-Gray and Kelly (2020) observed that gender difference is by far the most consistent findings in fear of crime literature.

The discussion above demonstrates how deterioration in physical and social environment in a public space, shapes the perception of different segment of the society on fear of crime. Fear of crime and its consequences are not evenly distributed, thus the findings from the study may align or contradict previous studies. Several environmental and social factors affect the safety of public space, yet, it is the people's safety perception that plays an important role in making places seem safe or unsafe (Costamagna, et.al. 2019). What this suggests is that, aside the environmental and social factors, safety perception could be influenced by individual attributes or traits. In this study, we examined how the individual attributes (socio-demographic characteristics) of the participants influenced their level of fear of crime with respect to the deterioration in their immediate physical and social environment. Findings from the study, demonstrates that fear of crime is varied among the different segment of the society (socio-demographic groups), which is influenced by the interplay of socio-environmental factors,

CONCLUSION

This article has shown that fear of crime in a public space is influenced by both physical and social environmental condition, the mass media and individual attributes of the population. A neighbourhood may show some attributes that breed or attract crime in terms of deterioration in physical and social environment, however, the importance of socio-demographic attributes in the discourse of fear of crime cannot be overlooked. This is based on the fact that an individual's safety perception (fear of crime) may not necessarily be as a result

of presence of crime but a function of personality or beahvioural traits. Findings from the study revealed that gender, marital status, race, income and educational qualifications are the major individual attributes that influenced fear of crime viz-a-viz the three dimensions adopted in the conceptualization (i.e. deteriorated physical environment, social environment and mass media dimensions). From the results of the study, we found that women, the older adults and those that earned high income are more worried than other groups when walking along bushy areas and unkempt environment littered with garbage and dirt (deterioration in physical environment). In other words, the odds of fear of crime due to bushy and unkempt environment is higher among these groups in the study area. In terms of deterioration in social environment, results further showed that Malays, those with higher income and educational qualifications are more worried when they see homeless people in the neighbourhood, while women and the married are more worried when they come across drunkards or drug addicts in the neigbhourhood. Meaning that the odds of fear of crime due to deterioration in social environment is higher among these group (women, the married, those with higher educational qualifications and income). On how mass media affect the perception of different segment of the society on fear of crime, findings from the study revealed that older adults, the married, and those with higher educational qualifications are more worried than other groups when they hear news about crime from mass media or hear stories about crime from friends who have been victim. The findings from this study have shown that fear of crime is not to be understood as a permanent or fixed trait that is inherent in a particular demographic group, but rather something that any individual can express to a varying degree depending on the mass media, physical and social environmental condition which the individual is exposed to at a given point in time. Therefore, a holistic approach that encompasses an understanding of the physical and social environmental conditions in urban public spaces and individual characteristics of the population, are necessary in understanding the problem of fear of crime in Malaysia.

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CHARACTERISTICS AND PATTERNS OF WORKER MOBILITY FROM PERI-URBAN AREAS TO BANDA ACEH CITY

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Abstract

Daily mobility from peri-urban areas to Banda Aceh City contributes significantly to increased urban traffic volumes. This study aims to identify the characteristics and patterns of worker mobility from the peri-urban districts of Darul Imarah, Darussalam, and Ingin Jaya to Banda Aceh. Employing a quantitative approach, the research utilises questionnaire data and applies the Origin-Destination matrix technique to analyse movement patterns. The findings reveal that 89% of respondents are employed in the formal sector, with 62% commuting using private vehicles. Mobility frequency does not consistently correlate linearly with distance, as the destination's function also plays a key role. The observed mobility pattern is polycentric, distributed across all districts of Banda Aceh, with a high concentration towards both the old and new city centre areas – specifically Banda Raya, Baiturrahman, and Syiah Kuala – which function as administrative and public service hubs.

Keywords: Mobility Characteristic, Mobility Pattern, Origin Destination, Peri-urban, Polycentric

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INTRODUCTION

The rehabilitation and reconstruction efforts following the 2004 tsunami marked a pivotal point in the development trajectory of Banda Aceh. Two decades later, the city has experienced significant densification driven by population growth and the expansion of built-up areas, which now cover nearly the entire city. This urban growth has resulted in a marked decline in available land, with only 190.3 hectares remaining for development as of 2021, while land prices continue to escalate (Zahara et al., 2021). The expansion of built-up areas has extended both northwards and southwards within Banda Aceh, and has also spilled into the neighbouring Aceh Besar Regency, which shares a direct boundary with the city. This development pattern signifies ongoing urban expansion into adjacent areas (Al-Fath & Marsoyo, 2023). The growth of Banda Aceh has significantly influenced land use on the urban fringe. These fringe zones – referred to as peri-urban areas – are not defined by administrative boundaries but by the emergence of built-up land driven by urban sprawl and the formation of new activity centres (Giyarsih, 2010). This phenomenon is evident in several districts within Aceh Besar Regency, such as Darussalam, Ingin Jaya, and Darul Imarah.

As peri-urban areas, these three districts maintain strong economic, social, infrastructural, and transportation linkages with Banda Aceh. Their proximity to the city, in contrast to the more distant administrative centre of Aceh Besar, reinforces these connections. A critical aspect of this relationship is the economic dependence of the peri-urban areas on Banda Aceh, particularly in terms of employment opportunities. This dependency fuels daily commuting from the districts of Darussalam, Ingin Jaya, and Darul Imarah into the city (Al-Fath & Marsoyo, 2023; Fadhly, 2019; Helmi et al., 2019).

The emergence of sub-service centres contributes to the development of surrounding residential areas, resulting in increased traffic volumes. The high level of dependence of peri-urban residents on urban core activities drives significant daily movement. This increase in private vehicle use and commuting intensity can exacerbate transportation issues, including rising traffic volumes and congestion in both Banda Aceh and Aceh Besar (MG. Brilliant et al., 2024). These challenges underscore the need for proactive solutions. However, existing transportation systems often fall short in addressing Indonesia's complex mobility issues (Maulana & Yudhistira, 2020). One method for anticipating and managing these issues involves analysing movement patterns using the Origin-Destination (O-D) matrix technique.

Unlike the majority of mobility studies in Indonesia, which predominantly examine cities in Java, dominantly large metropolitan areas such as Jakarta, Surabaya, and Bandung, this research focuses on Banda Aceh - a medium-sized, post-disaster city exhibiting distinctive peri-urban development characteristics. By directing attention to a non-Java urban context that remains

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underrepresented in existing scholarship, this study offers a meaningful contribution by addressing a notable gap in the literature and providing empirical evidence on mobility patterns within a less-examined urban system. This study aims to examine the characteristics and mobility patterns of workers commuting from peri-urban areas into Banda Aceh. Understanding these patterns is crucial, as they reflect the extent of interdependence and interaction between peri-urban zones and the urban core. This knowledge is fundamental for formulating inclusive economic policies aimed at reducing overreliance on the city centre (Aulia, 2020). Moreover, such analysis provides essential insights to support the planning and development of public transport systems and road infrastructure.

LITERATURE REVIEW

Peri-Urban

According to Yunus (2008), peri-urban areas occupy transitional zones situated between distinctly different environments – urban settings on one side and rural landscapes on the other. The global phenomenon of urbanization has contributed to the emergence and expansion of these peri-urban areas. Often functioning as reservoirs of labour, these areas supply workers to urban centres, particularly in the industrial, service, and informal sectors. However, peri-urban areas typically lag behind urban centres in terms of infrastructure and public services, such as water supply, sanitation, healthcare, and education (Simon, 2008; Tacoli, 2006)

The relationship between peri-urban areas and cities is characterized by strong interdependencies, particularly in economic activity, infrastructure provision, and population mobility. Studies in several major Indonesian cities – such as Bandung, Surabaya, and Jakarta – highlight these dynamics (Santoso et al., 2019; Somantri, 2022; Winarso et al., 2015). Residents of peri-urban areas often seek employment in city centres due to the availability of better job opportunities and higher wages (Sari & Santoso, 2017). However, this high volume of daily mobility from suburban to urban areas can give rise to various negative externalities, including increased population density, traffic congestion, and air pollution. To address these issues, strategic planning and development of peri-urban areas are essential, particularly to improve infrastructure and reduce over-reliance on city centres (Somantri, 2022).

Characteristics and Patterns of Movement

Population mobility is primarily shaped by socio-economic routines, such as typical working hours, shop operating times, school schedules, public entertainment, and social events. Movement patterns can generally be categorised into daily, weekly, and seasonal types. The characteristics of mobility include various attributes frequently utilised in research, such as the purpose of movement, distance travelled, time of travel, and frequency of movement (Tamin,

2000; Usman, 2020). However, key variables often emphasised in mobility studies include the purpose of movement, mode of transport, and frequency of movement (Permatasari & Hudalah, 2013; Sari & Santoso, 2017).

Movement patterns can be illustrated using an Origin-Destination (O-D) matrix, a two-dimensional matrix that captures the volume of movements between zonal locations within a specific area. This tool aids in explaining the spatial interrelation between origin and destination areas (Tamin, 2000, 2008). The matrix typically includes data on the frequency of daily and weekly movements from origin points to destination points. Such information is essential for the effective planning, design, and management of transportation systems that are responsive to the actual needs and travel behaviours of the population (Ramli et al., 2020; Zhao et al., 2024). Therefore, the use of the O-D matrix is both appropriate and essential for the purposes of this study.

METHODOLOGY

This study employs two primary variables: mobility characteristics and mobility patterns. The indicators used to assess mobility characteristics are the purpose of travel (limited to work-related purposes) and the mode of transportation. For mobility patterns, the variable is measured using the frequency of movement as the primary indicator. Data was collected through questionnaires distributed both online and via door-to-door surveys to individuals working in Banda Aceh but residing in three peri-urban districts within Aceh Besar Regency: Darul Imarah, Darussalam, and Ingin Jaya, on August 2023 (Figure 1). These districts were selected due to their strong connectivity to Banda Aceh and the availability of adequate respondent databases. A stratified random sampling technique was employed. The sample size was calculated using the Slovin formula with a 10% margin of error and then proportionally distributed based on the worker population in each district. A minimum target of 30 respondents was set for each district to ensure adequate representation. In total, the study gathered responses from 50 individuals in Darul Imarah, 30 in Darussalam, and 35 in Ingin Jaya. This research adhered to ethical guidelines for human subject studies. Informed consent was obtained from all respondents, and participation was voluntary and anonymous.

The research employs a quantitative approach, using descriptive statistical analysis to examine mobility characteristics and Origin-Destination (O-D) matrix techniques to analyse mobility patterns. The O-D matrix is a two-dimensional framework in which rows represent origin zones and columns represent destination zones. Each cell within the matrix indicates the volume of movement from the origin to the destination, measured by the frequency of trips per week. In this study, the origins are the peri-urban districts of Darul Imarah, Darussalam, and Ingin Jaya, while the destinations are the nine districts of Banda

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Aceh: Baiturrahman, Meuraxa, Lueng Bata, Banda Raya, Kuta Alam, Syiah Kuala, Kuta Raja, Jaya Baru, and Ulee Kareng.

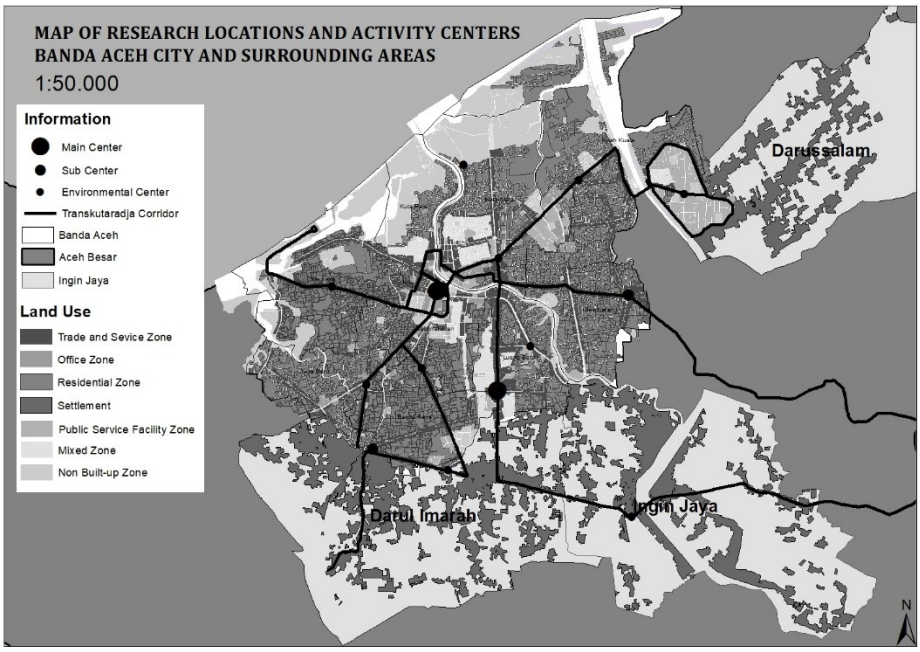


Figure 1: Research Location Map

RESULT AND DISCUSSION

Questionnaires distributed to 115 respondents revealed that the majority were middle-class individuals, earning between Rp.2,500,000 – Rp.3,500,000 per month. The characteristics of worker mobility are identified based on the purpose of travel and the mode of transportation used (Table 1 and Table 2).

Table 1: Purpose of Travel Among Respondents

District	Number and Percentage of Respondents by Travel Purpose			
	Formal Sector		Non Formal Sector	
Darul Imarah	44	88%	6	12%
Darussalam	29	97%	1	3%
Ingin Jaya	30	86%	5	14%
Total	103	89%	12	11%

Source: Authors, 2024

Table 1 presents the distribution of travel destinations according to the employment sectors of respondents from each district. The formal sector includes destinations such as government offices, private companies, clinics or hospitals,

and educational institutions. The findings show that the vast majority of respondents (over 85%) across all three districts commute to formal sector workplaces in Banda Aceh. In contrast, only a small proportion of workers travel for non-formal employment, with 12% from Darul Imarah, 3% from Darussalam, and 14% from Ingin Jaya engaging in such mobility.

These patterns suggest that Banda Aceh serves as a key employment hub, offering diverse opportunities largely concentrated in public service and institutional facilities. A contributing factor to this trend is the limited availability of suitable employment within Aceh Besar, where job offerings often do not align with the qualification or expectations of the workforce (Simah Bengi & Jamal, 2017).

Table 2: Transportation Mode Used by Respondents

District	Transportation Mode							
	Walking		Private Vehicle		Public Transport		Online Transport	
Darul Imarah	0	0%	15	30%	19	38%	16	32%
Darussalam	0	0%	26	87%	4	13%	0	0%
Ingin Jaya	1	3%	33	94%	0	0%	1	3%
Total	1	1%	74	62%	23	20%	17	15%

Source: Authors, 2024

Table 2 illustrates the modes of transportation used by respondents, revealing that private vehicles – specifically motorcycles and cars – are the predominant means of commuting across all districts. Overall, 64% of respondents commute to work using private vehicles. When examined by district, private vehicle use is particularly high among respondents from Ingin Jaya and Darussalam, where more than 85% rely on this mode for commuting. In contrast, respondents from Darul Imarah display more varied transportation preferences. Approximately 30% commute using private vehicles, while an equal proportion utilise public transportation and online ride-hailing services.

The preference for private vehicles is influenced by factors such as convenience, flexibility, and comfort (Affandi & Parikesit, 2022). Furthermore, the availability and accessibility of public transport also significantly impact modal choices (Widjaya, 2024). Currently, Banda Aceh's public transportation is represented by the Trans Koetaraja Bus, which has been operational since 2016. However, its coverage in peri-urban areas remains limited, reaching only parts of Darul Imarah and Ingin Jaya (as depicted in Figure 1). Notably, public transportation usage in Darul Imarah stands at 38%, surpassing both private and online transport options. This is attributed to the bus route passing through several residential areas in the district, thereby facilitating greater accessibility. Conversely, none of the respondents from Ingin Jaya reported using the Trans

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Koetaraja Bus. Although the route passes through this district (as shown in Figure 1), the residential density along the route is relatively low, possibly limiting its utility. Meanwhile, 13% of respondents from Darussalam reported using the bus service, despite the route only extending to the district's border, indicating a willingness to walk or connect via other means to access the service (Figure 1).

Online transportation services are most frequently used by respondents from Darul Imarah. Nevertheless, when aggregated across all respondents, online transport accounts for just 15% of total usage – less than public transportation at 20%. The latter figure reflects a latent interest among peri-urban residents in using public transit options, particularly the Trans Koetaraja Bus. In response to this growing interest, the Aceh Provincial Transportation Department plans to introduce new routes, including one connecting Darussalam to Pasar Lam Ateuk (Dinas Perhubungan Aceh, 2025). This expansion aims to improve the accessibility and attractiveness of public transportation, particularly for residents of Darussalam, thereby enhancing overall connectivity between the peri-urban areas and Banda Aceh City.

Table 3: Origin-Destination Matrix (Trips per Week)

Origin/ District	**Destination Zone/District**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
Darul Imarah	28	5	35	66	40	28	12	13	13	240
Darussalam	45	19	18	5	15	48	0	0	16	166
Ingin Jaya	43	20	18	36	20	10	11	17	21	196
Total	116	44	71	107	75	86	23	30	50	602

Notes: The code for the zone (district) is as follows:

1 = Baiturrahman	2 = Meuraxa	3 = Lueng Bata
4 = Banda Raya	5 = Kuta Alam	6 = Syiah Kuala
7 = Kuta Raja	8 = Jaya Baru	9 = Ulee Kareng

Source: Authors, 2024

The mobility pattern was analysed using an Origin-Destination (O-D) matrix and subsequently described in spatial form. The commuting flows from the origin zones – Darul Imarah, Darussalam, and Ingin Jaya – to the various zones within Banda Aceh City are presented in Table 3. The data reveal that the highest number of weekly work trips is directed towards Baiturrahman (116 trips), followed by Banda Raya (107 trips), and Syiah Kuala (86 trips). As illustrated in Figure 1, these three destination zones are situated adjacent to their respective origin zones, between Darussalam and Syiah Kuala, as well as Darul Imarah and Banda Raya. These areas serve as central nodes within Banda Aceh, functioning as administrative, governmental, and public service centres at both the provincial and city levels.

In contrast, the Kutaraja and Jaya Baru districts record the fewest work-related trips, with only 23 and 50 trips per week, respectively. Although these zones form part of Banda Aceh's urban core, they are largely residential in character and host relatively fewer public facilities associated with the formal employment sector. The dominance of formal-sector employment among respondents not only shapes their travel destinations but also influences their preference for private vehicles, reflecting the limited coverage of public transport services in peri-urban areas.

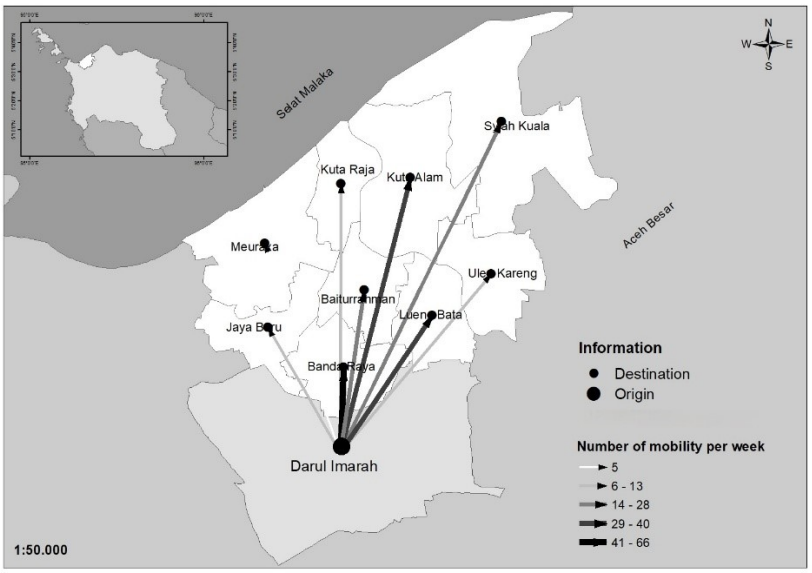


Figure 2: Spatial Distribution of Mobility Frequency from Darul Imarah District
Source: Authors, 2024

The spatial distribution of worker movements from Darul Imarah district, as shown in Figure 2, demonstrates that all districts in Banda Aceh function as employment destinations. The highest number of trips – 66 per week – is directed toward Banda Raya. According to the Banda Aceh Spatial Plan 2009 – 2029, Banda Raya is designated as a new urban development zone, serving as a hub for sports facilities, terminal infrastructure, trade and services, and warehousing (Qanun Rencana Tata Ruang Wilayah Kota Banda Aceh Tahun 2009- 2029, 2009). However, for respondents in this study, institutional and office buildings remain the dominant destinations, particularly for those employed in the formal sector. Another major destination is Kuta Alam district, recording 40 trips per week. As the administrative centre for various government offices (Figure 1), it naturally attracts a high volume of formal sector workers.

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Lueng Bata district, which recorded 35 trips per week, is also emerging as a new urban centre with functions similar to Banda Raya.

In terms of spatial proximity, Banda Raya directly borders Darul Imarah, indicating a strong relationship between available residential land in Darul Imarah and employment opportunities in Banda Raya. This adjacency likely contributes to the high commuting frequencies between the two areas. By contrast, other nearby districts such as Jaya Baru and Meuraxa generate relatively fewer trips – between five and 13 per week. Although Kuta Alam is a key employment centre, its greater distance from workers' residences may affect commuting patterns. It is important to note that this study does not examine the underlying motivations behind the selection of residential and workplace locations. Therefore, mobility patterns from Darul Imarah district are not solely attributable to distance. While Handy et al (2005) suggest that workers tend to choose residential locations that minimise commuting time, this tendency is not clearly reflected in the current findings.

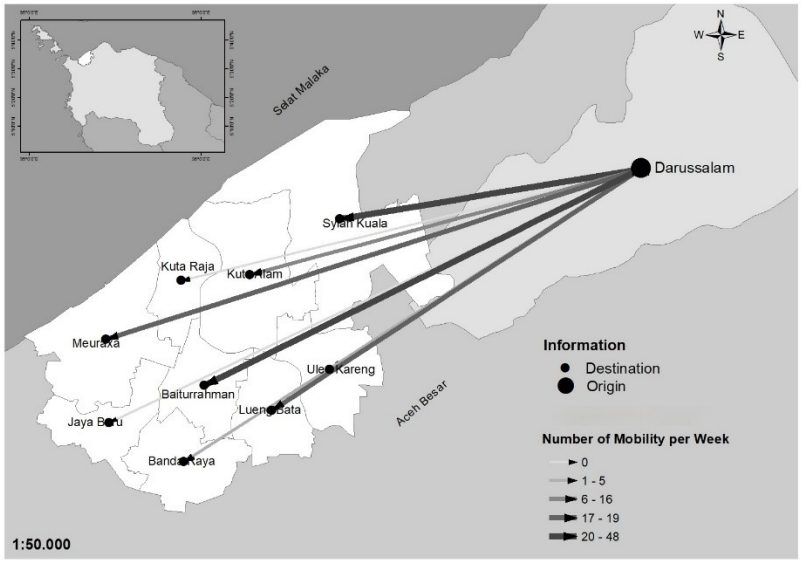


Figure 3: Spatial Distribution of Mobility Frequency from Darussalam District
Source: Authors, 2024

Based on Table 2 and Figure 3, the highest number of worker movements from Darussalam district is directed toward Syiah Kuala and Baiturrahman, with 48 and 45 trips per week, respectively. According to Qanun Rencana Tata Ruang Wilayah Kota Banda Aceh Tahun 2009- 2029 (2009), Syiah Kuala, adjacent to Darussalam, is designated as a higher education hub and currently hosts two state universities. Most formal sector workers from

Darussalam are employed as teachers or lecturers, making Syiah Kuala a primary commuting destination. Meanwhile, Baiturrahman district serves as the historic city centre and functions as a key node for regional trade and government administration (Qanun RTRW Kota Banda Aceh Tahun 2009-2029, 2009).

Conversely, worker movements toward Kuta Raja, Jaya Baru, and Banda Raya are minimal, with frequencies ranging from 0 to 5 trips per week. Although these districts – located approximately 15 kilometres from Darussalam – are designated urban development areas in the city's spatial plan (Qanun RTRW Kota Banda Aceh Tahun 2009- 2029, 2009), they attract relatively few commuters from Darussalam.

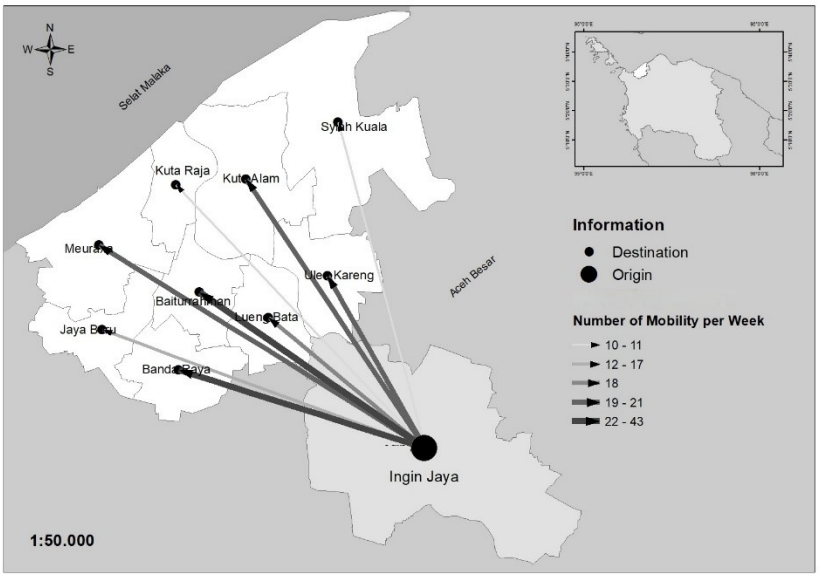


Figure 4: Spatial Distribution of Mobility Frequency from Ingin Jaya District
Source: Authors, 2024

Based on Table 2 and Figure 4, worker movements from Ingin Jaya are relatively well distributed across all districts in Banda Aceh. The primary destinations are Baiturrahman and Banda Raya. Baiturrahman functions as the historic city centre, while Banda Raya is designated as part of the new city centre development, serving as a hub for trade, services, and warehousing (Qanun Rencana Tata Ruang Wilayah Kota Banda Aceh Tahun 2009- 2029, 2009). These characteristics make both districts key destinations for formal sector workers residing in Ingin Jaya. The relatively short distance of approximately 5 –10 kilometres enhances their accessibility and attractiveness as commuting targets.

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Conversely, the lowest number of worker movements – around 10 trips per week – are directed toward Kuta Raja and Syiah Kuala. Both are part of Banda Aceh's old city centre development area. Kuta Raja functions as a centre for trade and administrative offices, while Syiah Kuala is designated as the city's higher education hub.

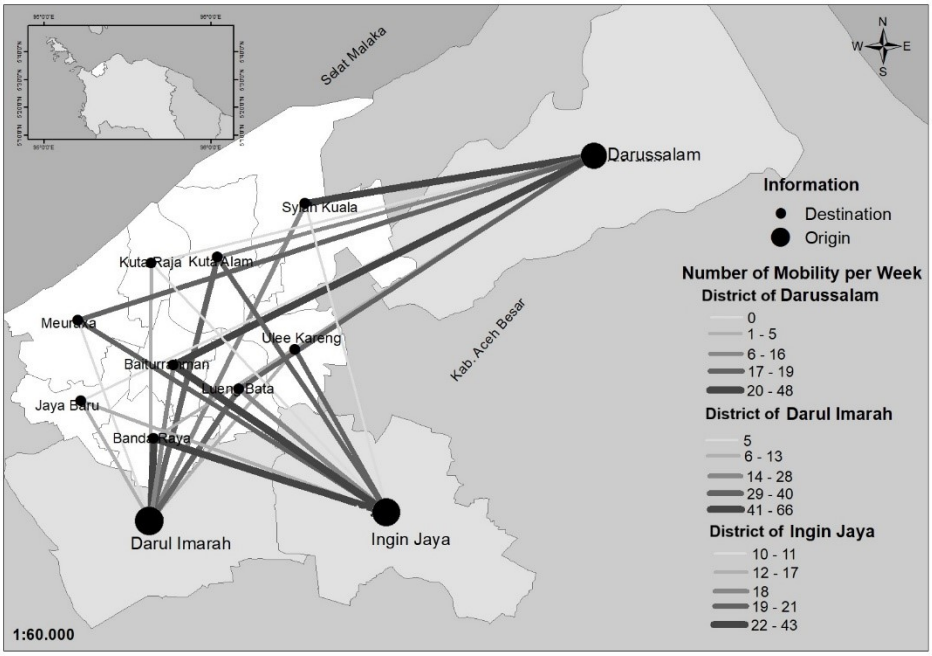


Figure 5: Spatial Distribution of Mobility Frequency from the Districts

The mobility patterns of workers commuting to Banda Aceh City are predominantly shaped by employment in the formal sector, including government institutions, private enterprises, and educational institutions. This trend is largely influenced by Banda Aceh's status as the provincial capital and its role as a hub for administrative, healthcare, and educational services. Consequently, the city's development as a central functional area may lead to the expansion of built-up zones for public facilities, potentially displacing residential functions to peripheral areas. As Banda Aceh continues to develop, commuter flows from peri-urban areas are likely to intensify – not only from the three districts studied here but also from others in Aceh Besar Regency, such as Krueng Barona Jaya and Baitussalam. To manage this expansion sustainably, coordinated efforts between Banda Aceh City and Aceh Besar Regency are necessary. Strategic urban policies and strengthened regional partnerships should be implemented to mitigate the negative effects (Rizkiya et al., 2023).

The prevalence of formal sector employment among respondents also influences their commuting behaviour and transport mode choices. Approximately 62% of workers rely on private vehicles, a preference that is shaped by factors such as vehicle ownership and the availability or lack of public transportation (Widjaya, 2024). The Trans Koetaraja Bus, for example, services densely populated residential areas in the Darul Imarah district, contributing to higher public transport usage in that locale. However, the system does not yet comprehensively cover all peri-urban areas, limiting its overall impact. Although designed as an environmentally friendly commuting option (Purwoko et al., 2022), the bus service has yet to adequately support the mobility needs of all workers. Commuting behaviour is further shaped by variables such as distance, travel duration, and transportation availability. While both private and public transport enable mobility, most workers in this study own and use private vehicles for their daily commutes. Since commuting is inherently linked to non-residential activities, the spatial distribution of land use within the city significantly influences travel behaviour (Tamin, 2000). Therefore, a transportation planning framework that prioritises the community by actively considering local needs and movement patterns in infrastructure development could help establish a more inclusive and sustainable mobility system for both rural and peri-urban populations (Khalisha et al., 2025). Additionally, factors such as age, life cycle stage, economic circumstances, and lifestyle should serve as key considerations in policy design, especially in efforts to promote the long-term sustainability of public transport systems (Sugito et al., 2024).

Figure 5 illustrates that the most frequented destinations are Baiturrahman, Banda Raya, and Syiah Kuala districts. Their high trip volumes are attributable to their functions as centres for government and public services – primary destinations for formal sector workers. Interestingly, the volume of trips does not correlate linearly with distance. High-frequency commutes occur across both long and short distances, such as the relatively distant journey from Darussalam to Baiturrahman.

This indicates that pull factors, such as employment opportunities in the public sector, play a more decisive role in travel behaviour than distance alone. Helmi et al (2019) similarly found that in Darussalam factors including age, household employment structure, and vehicle ownership influence travel frequency. The designation of these districts as centres for government and public services acts as a strong attractor for population movement, regardless of travel distance. Recognising this dynamic is crucial for informing transportation and spatial planning efforts aimed at accommodating existing mobility patterns.

The mobility patterns of workers from peri-urban areas to Banda Aceh City are not only determined by distance but also by the spatial orientation of their destinations. These patterns reveal a dispersed or polycentric distribution of

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work trips across all districts, with varying frequencies. This is consistent with the usage patterns of online transportation services in Banda Aceh, which show trip concentrations at multiple key points (Rizkiya et al., 2024). Tondobala (2015) highlights that in a polycentric model, population density and economic activity are distributed across several service zones rather than concentrated in a single urban centre. Similarly, Permatasari & Hudalah (2013), in their study on the daily mobility of industrial workers in Cikarang, Bekasi, found that commuting patterns have shifted from core urban centres towards emerging employment nodes in suburban areas.

The polycentric structure of worker mobility reflects Bandar Aceh's ongoing spatial expansion. This presents opportunities to enhance public transport usage among peri-urban commuters. Expanding the coverage of the Bus Trans Koetaraja network could serve as a strategic approach to improve transportation infrastructure, particularly for residents of Aceh Besar commuting to the city.

CONCLUSION

The commuting patterns of workers travelling to Banda Aceh City are predominantly driven by employment in the formal sector, reflecting the city's role as the provincial capital and a hub for government and public services. Private vehicles remain the primary mode of transport, while usage of the Trans Koetaraja Bus is concentrated among workers from the Darul Imarah – likely due to its routes serving higher-density residential areas. The findings indicate a clear polycentric mobility pattern, with trips dispersed across multiple districts rather than concentrated in a single urban core. The frequency of these movements does not show a clear or linear relationship with distance, suggesting that the choice of residential location is not necessarily determined by proximity to the workplace. These findings underscore the need to improve public transport infrastructure, particularly through the expansion of the Trans Koetaraja Bus network to better serve peri-urban residential areas. Such improvements are necessary for promoting sustainable urban mobility and accommodating the evolving spatial dynamics of the Banda Aceh metropolitan region. However, the findings should be interpreted cautiously due to the relatively small sample size (115 respondents) and the study's reliance on descriptive statistics, which may limit broader generalizability. Further research with larger samples and more advanced analytical methods is recommended

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ESTABLISHING BASELINE CONDITIONS FOR A SUCCESSFUL IMPLEMENTATION OF LAND READJUSTMENT (LR) IN MALAYSIA

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Abstract

Land readjustment (LR) shows potential to address the challenges of urban development amid rapid urbanisation. Unlike eminent domain or expropriation which involves the compulsory acquisition of property for public use or its reallocation to third parties for municipal objectives, land readjustment offers an alternative mechanism for restructuring land. Notably, LR is recognised as an innovative form of land pooling and can help in solving urban restructuring problems particularly in underdeveloped countries. In Malaysia, although LR was approved as a land development method in 1999, its practical implementation remains absent. Thus, this study aims to establish the baseline conditions necessary for successful LR initiatives in Malaysia. The study is based on a survey of 37 urban planners who are directly involved in land development projects. As a result, nine of the baseline conditions significantly impact the successful implementation of urban land readjustment, with the landowner's participation as an essential aspect. Conversely, suitable topography and land distribution play a less impactful role. Findings from this study provide a foundational understanding of the baseline conditions crucial for planning and executing successful LR projects that are valuable for policymakers, urban planners, developers and community stakeholders in shaping sustainable urban landscapes through land readjustment strategies. As the first empirical study of LR baseline conditions in Malaysia, it complements international LR literature by highlighting local context considerations.

Keywords: Urban Development, Land Readjustment, Development Tool, Public Infrastructure

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INTRODUCTION

Urbanisation is a global trend and cities in Malaysia are experiencing rapid growth and development. However, this rapid urban growth brings significant challenges, including traffic congestion, inadequate infrastructure, and housing shortages (Rosni et al., 2016)Traditional methods of urban planning, such as eminent domain and expropriation, often involve the compulsory acquisition of private property, which can lead to resistance and social conflict. In contrast, Land Readjustment (LR) offers a voluntary and cooperative approach to land consolidation enabling the reorganisation of land parcels and infrastructure without the need for compulsory acquisition. LR is known for its innovative potential and serves as an effective strategy to address the challenges of urban redevelopment, especially in underdeveloped areas ((Kresse & van der Krabben, 2021); Needham & Hong, 2007).

Land readjustment (LR) is a tool that facilitates the reorganisation of land for urban development by consolidating adjacent unplanned land into a unified layout with designated streets, open spaces and building plots (Lai et al., 2022). Some building plots can be sold to cover the necessary costs while the remaining plots are redistributed among the original landowners. LR offers an inclusive approach to urban land management which includes land acquisition, site preparation, subdivision, and the provision of planned urban spaces (Van der Krabben, Tiwari, et al., 2020).

In this method, the government oversees the planning of roads, infrastructure, and public facilities, ensuring that each landowner receives a smaller, yet more valuable, fully developed plot of land (Sorensen, 2000; Alterman, 2007; Turk & Korthals Altes, 2011;De Souza, 2018. As a self-financing mechanism, LR benefits the government by enabling urban improvements without the need for expropriation, while improving living conditions and increasing the value of land for landowners (Needham & Hong, 2007; Byahut, 2014).

Although LR has been widely and successfully implemented in several European and Asian Countries (Ballaney et al., 2022; Mugisha et al., 2024), its application in Malaysia remains unexplored despite its potential for urban development. Key challenges that hinder the implementation of LR in Malaysia include funding constraints, limited public participation and the absence of specific legal frameworks for LR (Che Pin et al., 2024). Thus, this study aims to establish the baseline conditions needed to implement LR initiatives in Malaysia. By offering the first empirical analysis explicitly focused on the Malaysian context, it addresses a gap in the national LR literature. It complements international research by focusing on local stakeholder perspectives which helps distinguish Malaysia's unique context such as its institutional arrangements and legal structure.

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LITERATURE REVIEW

Baseline Conditions for Land Readjustment

Establishing the baseline conditions is a crucial step in starting a land readjustment project as it provides a starting point based on existing conditions and factors. However, it is essential to note that the necessary conditions for a successful implementation of land readjustment may vary depending on factors such as the specific type of project, its objectives, and the context in which it is being carried out, as pointed out by Vitikainen in 2004. By identifying current challenges and opportunities, baseline conditions inform strategic planning, set realistic goals and enable effective monitoring and evaluation of ULR initiatives. In Malaysia, where LR was approved in 1999 but has yet to be implemented, establishing these conditions is important to ensure the success and sustainability of LR projects.

Existence of Land Fragmentation

According to FAO (2002), land fragmentation is a crucial factor in implementing land readjustment. Furthermore, researchers such as Van Dijk (2007), Bullard (2007), Long (2014), and Demetriou (2014) acknowledged that land fragmentation is a significant issue in unplanned neighbourhoods.

Willingness to Participate

Van Dijk (2007) posits that the success of land readjustment hinges on the willingness of stakeholders to participate, as it affects private properties. In this regard, the exchange of land among owners becomes necessary and cannot be overlooked, although there is no compulsion for the landowners to participate in the program (Louwsma et al., 2017)).

Furthermore, UN-Habitat introduced the Participatory and Inclusive Land Readjustment (PILaR) approach in 2014 and 2016. PILaR is designed to help national governments and local authorities address urbanisation challenges, such as urban sprawl and slums, using a rights-based approach that prioritises participation, inclusiveness, and the coordination of private and public sector roles and responsibilities (Lemmen & Bennett, 2015). PILaR strongly emphasises securing property rights for owners through active participation during land acquisition (Uisso & Tanrıvermiş, 2024).

Reliable Land Information

Demetriou et al. (2013) contend that a dependable land information system is vital when stakeholders are willing to participate in land readjustment without coercion. This system provides a comprehensive inventory of ownership and use rights, including platforms for verifying claims, among other functions (Sonnenberg, 2002). To achieve this, an effective land information system is

required that details the various rights, boundaries, and proposed developments in the area (Jansen et al., 2010).

When developing an LR model suitable for such contexts, it is imperative to draw on experiences from cadastral practices. In recent years, extensive efforts have been made to modernise cadastral systems including renewed cadastral surveying, updated cadastral records and integration of modern technologies into existing data sets.

For instance, the introduction of GIS and other technologies can provide consistent and precise data for planning, partitioning, and redistribution of land, thereby enabling the efficient implementation of land readjustment (Demetriou, See, & Stillwell, 2013).

Existence of Land Banks

Land banks play a crucial role in facilitating land readjustment, as they provide a means for stakeholders to acquire, manage, redistribute and lease land to improve its allocation. According to Damen (2004), land banks aid in the acquisition and management of land for this purpose. Similarly, Jansen et al. (2010) argue that land banks offer opportunities for expanding and shaping land for infrastructure development, while Hartvigsen (2014) suggests that they increase land mobility by providing flexible pathways for land readjustment, thus facilitating the reallocation process.

In essence, land banks are managed by the state through laws to successfully acquire, hold, and reallocate land for future infrastructure provision (Van den Berg, Revilla, Menken, et al., 2005).

Enabling Legal Frameworks

The success of Urban Land Readjustment (ULR) projects hinges on a robust legal framework and its practical implementation. These legal mechanisms play a crucial role in ensuring that the processes of land acquisition, redistribution, and urban development are conducted transparently, fairly, and in compliance with local and national regulations (Mahandhar, 2019).

Jensen et al. (2010) categorised land readjustment into two broad categories: legal and institutional requirements, which involve legislation and regulations that empower state institutions for implementation, as well as all other baseline conditions. Bullard (2007) contends that legislation is necessary to address land fragmentation and prevent its recurrence, while Thapa and Niroula (2008) argue that without preventive mechanisms, land fragmentation becomes a recurring cycle. Thus, the regulation of laws on inheritance, land sizes and disjointed land is critical in preventing land fragmentation (Thapa & Niroula, 2008).

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Meanwhile, in Germany, LR (Umlegung) is embedded in the national planning code (Baugesetzbuch), requiring alignment with approved land-use plans (UCLG, 2016). This law has certainly made LR mandatory in new developments and ensured consistent implementation. The clear rules on how to convert underdeveloped land into buildable plots prevent conflicts and provide predictability for all stakeholders (Mansour, 2024).

Favourable Landownership Structure

The ownership structure of land also plays a crucial role in facilitating the reallocation of land. According to Lemmen, Jansen, and Rosman (2012) and Abubakari, Van der Molen, Bennet, et al. (2016), land tenure can either facilitate or impede readjustment. Therefore, private owners and users of land need to participate in readjustment without any element of compulsion.

In this regard, the structure of land ownership is critical. Multiple co-ownership of land limits the ability to exchange land without the consent of the other owners, making it less attractive compared to individual ownership, where the owner can decide to exchange the land or not at any point in time (Demetriou, Stillwell, & See, 2012). Therefore, a favourable land ownership structure that allows for individual ownership can facilitate land readjustment processes.

Availability of Technical Expertise

Technical expertise and adequate infrastructure are crucial for the successful implementation of land readjustment. It is a technical task that requires professionals with the ability and capacity to perform the duties of reorganising, restructuring and redistributing the land to an acceptable quality by all parties involved. Therefore, there is a need for land use planners, surveyors, land valuation experts, administrators and environmental managers who have specialist knowledge to be provided with the appropriate infrastructure to implement land readjustment successfully (Van Dijk, 2007). These professionals must possess the necessary skills and tools to handle the technical aspects of land readjustment (Uisso & Tanrıvermiş, 2024).

Moreover, countries need to adopt and modify the examples of countries that have successfully implemented land readjustment to meet their land and infrastructural needs. This highlights the importance of technical expertise and adequate infrastructure in the successful implementation of land readjustment.

Financial Viability/ Cost Recovery

LR's self-financing nature depends on mechanisms to capture land value increases. Cost recovery model such as selling a portion of the land or retaining land for future sale are crucial. For instance, German LR law allows

municipalities to retain up to 30% of consolidated land to fund infrastructure(Zhao & Choy, 2019).

Uisso and Tanrivermis (2024) affirm that land readjustment is beneficial in countries where government funding is limited as it results in gains in property value that are distributed and shared among various parties making it a self-financing method. The redistributed serviced plots, although smaller in size have greater economic value ensuring that landowners are compensated through increased asset worth rather than monetary payments ((Müller-jökel, 2004)

Land Readjustment in Malaysia

The Land Readjustment System (LRS) was introduced in Malaysia in 1987 through a series of studies and research conducted by PLAN Malaysia (formerly known as the Department of Town and Country Planning of Peninsular Malaysia) in collaboration with experts from the Japan International Corporation Agency (JICA). However, the services of JICA experts ended in December 2003.

In 1995, a feasibility study on the introduction of LRS in Malaysia was conducted by JICA and PLAN Malaysia, which concluded that the LRS could be implemented in Malaysia. On June 23, 1999, a Cabinet Meeting decided that the LRS would be one of Malaysia's land development methods. The Steering Committee for the Implementation Plan Study, chaired by the Secretary General of the Ministry of Housing and Local Government (KPKT) on August 25, 2006, agreed to expand the planning and implementation of projects using the LRS to other areas across the country.

In Malaysia, two sites were identified as locations for two pilot projects namely Kampung Pulau Meranti, Sepang, and Kampung Skudai Kiri, Johor. However, no land readjustment projects have been completed yet. This is due to various challenges encountered during the implementation phase including disagreements among landowners regarding the project and a lack of government funding (JPBD, 2014). The complexities arising from landowner conflicts and financial constrains have hindered the implementation of land readjustment efforts in Malaysian context.

RESEARCH METHODOLOGY

A preliminary study was conducted due to a small set of surveys undertaken as (Fraser et al., 2018) explained in their pilot testing research. The research approach for this study consisted of three steps: (1) a literature review to identify potential baseline conditions, (2) a practitioner survey to gather perceptions on these conditions and (3) statistical analysis of the survey data. The rationale for this deductive approach was based on the generalisability of the finding (Bougie & Sekaran, 2020). The survey questionnaire included two distinct sections: (1)

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demographics and (2) perceptions on the baseline conditions for ULR implementation.

Survey Administration

The survey was conducted via email. Purposive sampling was used to gather necessary data from the targeted population, which consists of planners directly involved in urban land development and likely familiar with LR issues. Among the 80 questionnaires distributed to the targeted population, 37 were valid, resulting in a 46% response rate. Since the primary purpose of a preliminary study is not hypothesis testing, the sample size is often not calculated (In, 2017). Browne (1995) recommended over 30 samples per group as a magic number for the scholar to apply to a pilot study. Therefore, a sample of 37 was deemed sufficient for this exploratory study. However, the findings from this sample should be interpreted as preliminary and further research with a larger sample can be conducted to enhance the results.

Additionally, all respondents participated voluntarily and were informed about the purpose of the study. Informed consent was obtained from the respondents prior to data collection. Respondents were assured of confidentiality and their responses were anonymised in the analysis.

DATA ANALYSIS

Quantitative data were analysed using IBM SPSS Statistics (SPSS) version 27.0. The SPSS procedure included two techniques: (1) descriptive statistics with measures of central tendency and frequency analysis and (2) parametric tests namely, one-sample t-tests. The baseline conditions were ranked based on frequency analysis, which used values derived from central tendencies such as the standard deviation and mean scores.

On the other hand, one (single) – sample t-test of the mean was performed to assess the significance of the baseline conditions influencing successful implementation of urban land readjustment. Instead of assuming mean values above 3.0 to be essential or critical, it was considered appropriate to conduct statistical tests, such as a t-test to determine whether the mean values differed significantly from 3.0 or even 3.5 (to agree on a five-point scale). Previous studies have used a cut-off point of 3.5 for a five-point scale in a one-sample t-test analysis. According to Kavishe et al. (2019), the value of '3' represents mid-point of the identified variables, equivalent to 50% success and resulting in equidistance.

Respondent's Characteristics

The characteristics of the survey respondents are displayed in Table 1. An analysis of the table shows that the majority of the survey respondents (59.5%)

were the planners from PLANMalaysia, while the remainder were from state aand local authorities. Based on working experience, 51.4% of the respondents have over 10 years of working experience.

Table 1: Frequency distribution of organisation and working experiences (n=37)

Variables	Freq.	Per cent
Organisation		
State Authority	5	13.5
Local Authority	10	27
PLANMalaysia	22	59.5
Working Experience		
1-5 years	7	18.9
6-10 years	11	29.7
11-20 years	19	51.4

Source: Authors' research, 2023

RESULTS

This section presents the findings of a quantitative research study that aimed to establish baseline conditions for implementing land readjustment in Malaysia. The practitioners were requested to rate the importance of nine baseline conditions that could influence the successful implementation of LR in Malaysia using a five-point Likert scale. The perceptions of the practitioners are shown in Table 2 below:

Ranking of the Baseline Condition

The baseline conditions that influence the successful implementation of ULR were ranked in descending order, as presented in Table 2. One sample t-test was conducted to determine whether these baseline conditions significantly affected the successful implementation of ULR.

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Table 2: Ranking of baseline conditions

Baseline Conditions	Mean	SD	*t*	*p*
Existence of Legal Structure	4.35	0.79	6.560	.000
Participation of Landowner	4.30	0.81	5.973	.000
Cost Recovery / Self-financing	4.19	0.81	5.169	.000
Favourable land ownership structure	4.14	0.92	4.209	.000
Sharing of the Project Benefits and Costs	4.14	0.82	4.700	.000
Suitable Topography and land distribution	4.08	0.83	4.262	.000
Availability of technical experts	4.05	0.85	3.974	.000
Establishment of an Implementing Body (IB)	4.00	0.85	3.579	.001
Quality of Cadastral Map	3.95	0.85	3.119	.003

Source: Authors' research, 2023

Generally, the importance ratings of all nine baseline conditions were higher than 3.0. All the factors were statistically significant ($p < .05$), indicating their positive effects on the success of LR implementation. The results also show that seven out of the nine determinants had a mean score above four, signifying their relatively high importance in affecting the success of LR implementation. As shown in Table 3, most respondents believed that the existence of a Legal Structure, participation by the landowner, and self-financing are the three most important baseline factors affecting the successful implementation of ULR.

In addition, the literature confirms these baseline conditions, mentioning four legal issues including a lack of legislation, legal backup, or regulatory framework (Mittal, 2014), a complicated legal system (Turk, 2005), land ownership structure (Turk, 2005, 2008), and enhanced protection of property rights (Alterman, 2007), as among the most challenging regulatory issues in the Land Readjustment literature.

Furthermore, an efficient financing mechanism must be considered to cover upfront costs. Other alternatives could be considered such as borrowing from financial institutions. (Che Pin et al., 2024; Mugisha et al., 2023).

DISCUSSION AND CONCLUSION

This study establishes the baseline conditions essential for successful LR implementation in Malaysia. The top-ranked factors include a clear legal structure, landowner participation and financing mechanisms provide a foundational understanding necessary for planning and executing practical LR projects.

For instance, the implementation of LR requires the active participation of all stakeholders, including landowners, government agencies and private developers. Transparent communication and consultation processes should be established to address concerns, build trust and encourage voluntary participation. Strategies such as public education campaigns and community meetings may help foster support for LR projects. Active engagements also ensure that local communities understand the benefits and long-term impacts of LR initiatives.

Moreover, a clearly defined legal framework is essential for the successful implementation of LR. For instance, the rights of landowners and the role of government agencies must be clearly outlined in the legislation. Legal provisions similar to Germany's planning code, which mandates LR in conjunction with approved development plans (BauGB Sections 45-84), could be adapted (UCLG,2016) in the Malaysian context.

Additionally, promoting financial viability through self-financing models should be encouraged to reduce dependence on government funding. This can be achieved through land value capture where a portion of the increased land value resulting from the infrastructure improvements is reinvested into the project. For example, municipalities retaining a portion of reconfigured land as has been done in Germany or charging for the value increase less than 30%.

These recommendations align with international experiences. For example, Japan's and South Korea's postwar LR programmes achieve significant urban redevelopment by gaining support from landowners and using value capture mechanisms. The Gangnam LR project demonstrated how capturing land value uplift can finance infrastructure without heavy subsidies (Kim, 2023). Similarly, Germany's longstanding LR (Umlegung) has been practised since 1902, with over 80% of new building plots in some regions developed via LR. German law ensures owners keep a parcel and municipalities capture added value through land readjustment (Muñoz Gielen & Mualam, 2019). These cases highlight the importance of the conditions outlined in this study, which include a strong legal framework, public participation, and self-financing through land value capture. By taking into the Malaysian context, this study provides a baseline that Malaysian planners and policymakers can use to prepare for LR projects. The identified conditions particularly legal and participatory factors are consistent with successful LR regions elsewhere.

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In conclusion, while LR presents a viable alternative for land development in Malaysia, specific enhancements are required to facilitate its successful implementation. Strengthening the legal framework, promoting public participation and adopting suitable financial models are essential so that LR can be effectively applied in various regions and adapted to their specific needs. Future research should further investigate these factors for example using multivariate or regression analysis could examine how baseline conditions interact and predict the successful implementation of LR.

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BOURDIEU'S SOCIAL CAPITAL AND THE FORMATION OF SENSE OF PLACE: A SYSTEMATIC LITERATURE REVIEW

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Abstract

Urban environment is losing its character due to unregulated development which poses challenges to maintaining its symbolic meanings, memories, and identities that are substantial for the urban community. A key factor in sustaining urban character includes fostering a sense of place of an urban community. Sense of place refers to individuals' subjective and emotional attachment to their environment, encompassing physical, social, and symbolic dimensions. Previous studies reported that sense of place is closely connected to social capital. Despite this, the positioning role of social capital towards sense of place is hardly researched and analysed systematically. This paper aims to explore the trend of studies on the relationship between social capital and sense of place through a systematic literature review using Scopus and Web of Science database. Result shows the expanding trend of this topic, however, is limited in the context of Malaysia urban area. This study contributes to the knowledge of the potential role of social capital to enhance sense of place which contributes to the sustainability of urban characters in Malaysia context.

Keywords: Bourdieu, Social Capital, Sense of Place, Urban Character, Urban Area

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INTRODUCTION

An urban area is a geographical space with continued urban settlement and higher population density than the surrounding (Mela, 2014). There is an urban character for every urban area which comprises of tangible and intangible elements, including architectural styles, massing, urban layout, and people's usage and interaction with the built environment (Cox, 2022). These elements also shape urban identity, alongside the formation of interaction between historical evolution, natural, social, and built environments (Oktay, 2006). This interaction is closely related to the sense of place in the urban area. The sense of place in an urban community is influential towards the sustainability of the urban character (Erfani, 2020). Sense of place refers to the emotional, symbolic, and spiritual affective bond between people and specific locations (Zlender & Gemin, 2020) embedded in the feelings, emotions, and behaviour towards the environment (Ujang & Zakariya, 2015). Erfani (2020) defined the sense of place as a multidimensional construct with three variables: place attachment, place identity, and place satisfaction. Sense of place has also been coined as the emotional and internal relation between people and their environment (Mohammad-Moradi et al., 2020), including the elements of attitude, emotion, affect, feeling, value and consciousness (Fan et al., 2024). These various definitions elucidate the sense of a place as having symbolic meanings to an individual. Westerholt et al. (2022) mentioned the importance of the structural age of a neighbourhood building and the symbolic meanings that the urban community attaches to the feature of urban character. However, factors such as rapid and unplanned development, degradation of environmental attributes, precarious livelihoods, and resource pressures are impacting the urban character (Mpanje et al., 2018).

According to Ziyaee (2018), in the modern era, there is a noticeable challenge to sustaining urban ideas which have meanings, memories, and identities for the urban community. The impact of urbanisation through the standard structures of manmade objects influenced the cultural and natural features that further diminished the urban character (Kaymaz, 2013). This enables the loss of meaningful places due to the change in material environment, which also affects the sense of place in the urban community (Westerholt et al., 2022). Alongside this impact, urbanisation also impacts interpersonal ties (Goode, 1970 c.f. Hofferth and Iceland, 1998) within the people or locals living in urban areas. Interpersonal ties are very important for urban communities as the ties reflected through trust and social networks can help lower crime figures, improve health, increase educational achievement, and improve economic growth (Ijla, 2012). In urban areas such as cities, the physical proximity between one another enables an opportunity for a speedy transition from anonymity into intimacy (Lofland, 1973 c.f. Felder, 2020). This underlying invisible network of relationships through the tie forms social capital. Pierre Bourdieu (1986) understands social capital as the

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individual's resource of ties (relationships) that are also impacted by the presence of cultural and economic capital. According to Claridge (2018), the ties can be represented as internal ties, which refer to the bonding relationships within the organisation, while the external tie is the bonding relationship across and between organisations. The organisation refers to the affiliated relationship between the community, for example, residential-community association, neighbourhood-community association, and so on. This study posits that social capital values can influence the sense of place formation, which sustains the urban characters. Sustaining urban character is important for preserving urban identity and fostering community engagement. Therefore, understanding the relationship between social capital and a sense of place is critical. This paper aims to explore the trend of studies on the relationship between social capital and sense of place particularly through Bourdieu's framework. This contributes to a new application of how Bourdieu's social capital can be applied in the context of Malaysian urban planning. Bourdieu's social capital framework has been applied in various field of studies and has been largely regarded as significant. In addition to that, the impact of this study will also be to provide a foresight knowledge into the possible role of social capital in the formation of a sense of place to ensure the sustainability of urban characters in Malaysia. This knowledge contributes to the Malaysian government's policy-making in urban planning, improving public participation and collaboration, and building community-based resilience shield against climate change in urban areas.

LITERATURE REVIEW

The deterioration of urban character is increasingly linked to the decline of social cohesion within urban communities. As cities expand and modernise, traditional social structures often weaken, leading to fragmented communities, reduced interactions, and a diminished sense of collective identity (Putnam, 2000; Robles et al., 2021). This lack of social cohesion manifests in various forms, including weakened community bonds, loss of cultural identity, declining public spaces, increased social isolation, and heightened socio-economic segregation. Without strong social networks and shared experiences, urban environments lose their distinct character, transforming into impersonal and disconnected spaces (Jacobs, 1961; Beatley & Newman, 2013). In an urban context, strong social capital facilitates active community engagement, shared responsibilities, and a deep-rooted sense of belonging. A well-connected urban community fosters mutual trust and cooperation, strengthening local identity and contributing to urban character sustainability (Putnam, 2000; Stratford, 2016). The concept of social capital can be traced back to three notable authors: Bourdieu (1986), Coleman (1988), and Putnam (2000). Bourdieu (1986) defined social capital as the aggregate of the actual or potential resources linked to possessing a durable

network of relationships with mutual recognition. His idea of social capital is closely linked with his famous Theory of Field pertaining to the field of interaction between social agents through different capital as a resource. Coleman (1988) coined social capital as the less tangible form of relationships between persons. This is similar to Putnam (2000), who refers to social capital as the connections among individuals that form the social network for a cohesive society. The word formed 'individual' connection is also contained in Fukuyama's (2001) interpretations of social capital alongside formed cooperative virtues. Social capital formation within an individual may stem from the parental community ties, which develop over time through networks in different field settings, such as friendship, work colleagues, and many more. (Hofferth and Iceland, 1998). Social capital has been proven to be a critical indicator for any issue established in community-based studies. In the urban setting study, Mpanje et al. (2018) extracted social capital into three attributes: bonding, bridging, and linking. The bonding social capital refers to shared identity and personal relations, which can be measured by two components: quantity and quality of relationships. It can be reflected in strong community relationships and interactions (Rami et al., 2023). Bridging social capital is defined by the relations with distant people with quality and quantitative Meso-level connections. The linking social capital relates to the relations with external parties and is measured through the quality and structure of linkages and institutions. This encapsulation of social capital relates to Bourdieu's (1986) conceptualisation. Bourdieu (1986) emphasised the application of mutual names in forming social capital and that it is a resource that depends on other capitals. Figure 1 visually represents Bourdieu's (1986) definition of social capital.

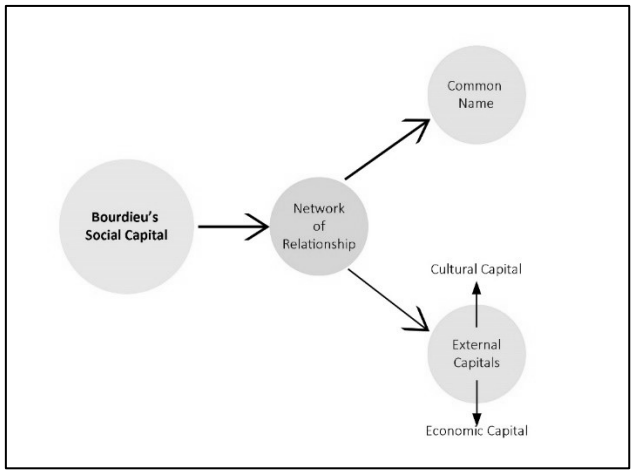


Figure 1: Bourdieu's Social Capital Operationalisation
Source: Authors

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From the figure, social capital is formed through the network of relationships (ties) influenced by the common name and the external capitals: cultural and economic capitals. This relationship stems from Bourdieu's theory of field, in which he theorised about the dynamic interaction of each capital in a field (Grenfell, 2014). Capital accumulation depends on the type of field to which the person belongs, and its formation depends on the external capital; cultural capital refers to the cultural resource of an individual reflected in three dimensions: embodied, institutionalised, and objectified. The economic capital is the monetary resource that allows the accumulation of the two capitals: social and cultural capital. This study adopted Bourdieu's (1986) conceptualisation of social capital due to this theoretical basis to better investigate its relationship towards the sense of place.

Bourdieu (1986) stressed the dynamic property of social capital that can be reduced or expanded depending on the size of the network of connections an individual can mobilise and the volume of other capitals. This is different with, Coleman (1988) who sees social capital as goal oriented which the actors have a clear instrumental purpose on the utilisation of social capital (Tzanakis, 2013). For Putnam (2000), social capital is the organisation's features through networks, norms, and trust that encourage collaboration and collective action for shared benefits. This conceptualisation is more inclined towards a group of people, for example, community through the civic engagement (Tzanakis, 2013) and is not dependence on the other possessed capitals. These three authors have different notions of concept in terms of how the social capital is derived. The context of urban area is dynamic and evolving through the change of society (common name) through migration of individuals from one place to another. This in turns will impact the network of relationship between individuals. It is imperative to understand that the social capital possessed by the individual may be reduced or increased (Bourdieu, 1986) through this impact. Hence, the measurement of social capital in urban area context, shall consider these dynamic changes, of capital resources and the presence of other capitals as Bourdieu (1986) posited.

According to Noordin and Ngah (2018), future Malaysia policies shall be directed at social capital development in tandem with urban planning. Community social capital can change the direction of urban planning, thereby impacting the community itself (Zhai & Ng, 2013). Social capital, represented by networks, norms, and trust passed down among long-term acquaintances, plays a significant role in community development (Tong et al., 2021). A study by Cramm et al. (2013) found that the social capital of individuals and neighbourhoods is significant towards community well-being. Besides, social capital is also important to community resilience (Aldrich & Meyer, 2015) alongside becoming a resource for mobilising community development (Kim, 2018). It also plays a role in collective action for tourism (Pramanik et al., 2019)

due to the strong bond through religious activities, family relationships, and lineage descent which help to become a catalyst towards the strength and sustainability of the community identity (Syaharuddin et al., 2021). Social capital under the dimensions of social awareness, participation and collective action, group membership, social trust, and social involvement influence rural community households' liveability during environmental crises (Savari et al., 2023). The role of social capital in any community has been proven to have a positive influence. According to Muzayanah et al. (2020), in urban areas, the formation of social capital is often influenced by the character of the urban area itself. Urban built environment influences social capital formation at actual and perceived levels through street connectivity, walkability, and incivilities (Wood et al., 2012). The placement of these physical urban planning elements also contextualises the social capital level. Said AlGhassani et al. (2024) reported that urban physical factors such as the availability of facilities, for example, grocery stores, health centres, mosques, and schools, could foster social cohesion (social capital) among the community in Muscat, Oman. The finding concurs with Muzayanah et al. (2020), who found that street connectivity of urban form has a positive association with bridging trust in social capital in Indonesia. However, they also revealed that, in Indonesian high-residential density areas, the level of social capital in the community is low. In China, there is evidence that strong ties are associated with rural migrants in urban areas more than urban residents, which may be influenced by the income disparity between each type of community (Lu, 2013). In Malaysia, the social capital level may differ depending on the locality, surrounding developments, and the period of the developed urban area (Hamdan et al., 2014). The built environment of the developed urban area may contribute towards the formation of a sense of place. The association of sense of place with social capital includes the increased level of sense of place is proportional to an increased level of social capital (Putra et al., 2023; Forouzangohar, 2022) and the role of social capital that promotes community engagement and consequently the sense of place (Zhu, 2022).

METHODOLOGY

This study explores the trend surrounding the research on social capital and sense of place in an urban area context. To achieve this, a systematic literature review was conducted. This systematic literature review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol to ensure the study's replicability. This approach enables authors to ensure transparency in their systematic reviews while evaluating a broad range of literature (Liberati et al., 2009). Keywords such as "Social Capital Sense of Place", and "Social Capital Urban Area Malaysia" were prompted. Through PRISMA, studies from original

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searches were included in the systematic review on the condition of meeting the following inclusion criteria:

- Field of Studies
  This study focuses on exploring the role of social capital towards a sense of place in urban areas. The urban area is defined by the spatial concentration of people organized around non-agricultural activities (Weeks, 2010). The field context is urban area because the presence of social capital is strong with built environment urban factors such as street connectivity, walkability, availability of facilities and many more (Said AlGhassani et al., 2024; Wood et al., 2012).
- Publication period
  The publication sources from 2005 to 2025 are selected to identify the trend from 20 years back.
- Study Design
  This study considers including conceptual and empirical studies to establish an understanding of the topic of social capital and sense of place.
- Language
  Only English-language sources were included, common in systematic reviews due to the practical challenges of translation and the need for replicability (Voorberg et al., 2015).
- Publication Quality
  This study maintains the quality standard for systematic review studies through this inclusion criteria: peer-reviewed research papers (review articles and research articles) in scholarly journals of Scopus and Web of Science (Wos).
- Title Scope
  A specific title with social capital and sense of place is included to ensure clarity and accurate exploration of the topic. The publication title with 'place attachment' was also chosen to broaden the scope as the term represents a close link with a sense of place (Erfani, 2020).

Figure 2 shows the flow diagram of the record selection:

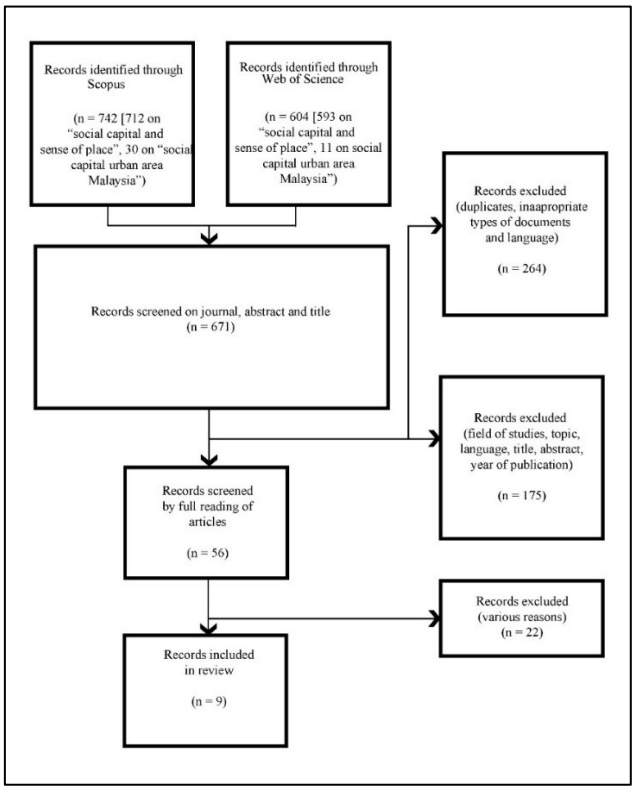


Figure 2: Flow diagram of the record selection
Source: Authors

RESULT

Nine (9) records of publication are included in the final review. The Scopus and Web of Science databases screening showed a limited number of studies specific to social capital and sense of place and social capital in urban areas of Malaysia. Table 1 shows the details of reviewed publications.

Table 1: Summary of Final Reviewed Publications

No	Authors (Year)	Journal Extracted	Title of Paper	Methodology	Samples	Geographical Location	Main Findings/Outcome
Publications keywords: Social Capital and Sense of Place							
1	Jorgensen (2010)	Journal of Economic and Human Geography	Subjective mapping methodologies for incorporating spatial variation in	Conceptual Paper	Conceptual Paper	-	Sense of Place comprises the networks of relationships constituting the social environment

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No	Authors (Year)	Journal Extracted	Title of Paper	Methodology	Samples	Geographical Location	Main Findings/Outcome
		(WOS & Scopus Database)	research on social capital and sense of place				within a spatial setting as well as social relationships with the physical environment (both natural and built)
2	Acedo, Painho, and Casteleyn (2017)	Transactions in GIS (WOS & Scopus Database)	Place and city: Operationalizing sense of place and social capital in the urban context	Conceptual Paper	Conceptual Paper	-	Recognized the spatialization of sense of place and social capital in urban context.
3	Azizi & Shekari (2018)	Interdisciplinary Journal of Management Studies (WOS Database)	Modeling the relationship between sense of place, social capital and tourism support.	Quantitative	446 residents in Shiraz, Iran	Iran	Positive relationship between Shiraz residents' sense of place and social capital
4	Lee and Jeong (2021)	Journal of housing and the built environment (WOS Database)	Residential environmental satisfaction, social capital, and place attachment: the case of Seoul, Korea	Quantitative	750 residents of Seoul	Korea	Social capital mediates the effect on all sub-components of residential environments
5	Binder et al. (2023)	American Journal of Community Psychology (WOS Database)	"Upheaval": Unpacking the dynamic balance between place attachment and social capital in disaster recovery.	Quantitative	111 American	United States of America	Increases of place dependence were associated with the increase of social capital
6	Ahmadi et al. (2024)	Journal of housing and the built environment (WOS Database)	Analyzing the relationship between place attachment and residential satisfaction through the mediation of social capital-the case of affordable housing.	Quantitative	370 residents of Pardis, Tehran	Iran	Social capital mediates the relationship between place attachment and residential satisfaction

No	Authors (Year)	Journal Extracted	Title of Paper	Methodology	Samples	Geographical Location	Main Findings/Outcome
Publications keywords: Social Capital in urban area of Malaysia							
1	Hamdan, Yusof, and Marzukhi (2014)	Procedia-Social and Behavioral Sciences (Scopus Database)	Social Capital and Quality of Life in Urban Neighborhoods High Density Housing	Quantitative	797 households	Klang Valley, Malaysia	Variation in the level of social capital for the three neighbourhood.
2	Ahmad Marzuki et al. (2014)	Asian Social Science (Scopus Database)	Community social capital in Malaysia: A pilot study	Quantitative	41	Northern Malaysia	Dimension of social capital used demonstrated high tendency for community life setting to generate high social capital
3	Said et al. (2022)	International Journal of Environmental Research and Public Health (Scopus Database)	Income Disparity and Mental Wellbeing among Adults in Semi-Urban and Rural Areas in Malaysia: The Mediating Role of Social Capital	Secondary data	25,512 respondents in SEACO Health Survey (2013)	Johor, Malaysia	Social capital plays a role for increased interaction between community members, thus increasing mental health status

Source: Authors

The databases' literature search indicates the lack of study centred around social capital and sense of place, and social capital in the context of urban areas in Malaysia. Six articles (Jorgensen, 2010; Acedo et al., 2017; Azizi and Shekari, 2018; Lee and Jeong, 2021; Binder et al., 2023; Ahmadi et al., 2024) were identified surrounding the topic of social capital and sense of place. Out of six articles, four are empirical and two are conceptual. All four publications applied quantitative as their research approach. For the geographical location, two of the publications (Azizi & Shekari, 2018; Ahmadi et al., 2024) are in Iran, one publication (Lee & Jeong, 2021) in Korea, and another publication (Binder et al., 2023) conducted their research in the United States of America. All empirical research done by these authors proved the positive association between social capital and sense of place. Three articles (Hamdan et al., 2014; Ahmad Marzuki et al., 2014; Said et al., 2022) were found for social capital in urban areas of Malaysia. All these articles were extracted from the Scopus database. For methodology choice, two publications (Hamdan et al., 2014; Ahmad Marzuki et

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al., 2014) used quantitative methods, while the remaining publication (Said et al., 2022) used secondary data. Their geographical location, albeit in Malaysia, is scattered with Klang Valley (Hamdan et al., 2014), Northern Malaysia (Ahmad Marzuki et al., 2014) and Johor (Said et al., 2022). All research results show that social capital has a positive role in the Malaysian context.

DISCUSSION

Empirical studies on social capital and sense of place have been trending from 2018 to the present. However, it can be argued that there is still limited focus on specifying the direct relationship between social capital and a sense of place. For example, Azizi and Skehari (2018) studied the relationship between sense of place and social capital, while Lee and Jeong (2021) and Ahmadi et al. (2024) put social capital as the mediator between a sense of place relationship. According to Acedo et al. (2017), the spatialisation of the sense of place and social capital shall be recognised in both ways. This means there might be an underlying impact of social capital on the formation of a sense of place. The strong ties (social capital) are tied with memories of interaction between two individuals or groups (Smith et al., 2012) and this may influence the attachment that is rooted in the subjectivity and objectivity of the environment of the urban area (Hashemnezhad et al., 2013). The actual role of social capital in the formation of a sense of place in an urban area context is still under-researched. All studies of social capital and sense of place were conducted outside Malaysia's geographical location. Three past studies were conducted on social capital in the context of urban areas in Malaysia, although they were not linked to a sense of place. Social capital studies in Malaysia were mainly centred around organisational and economic attainment (Abdul-Hakim et al., 2010; Zal et al., 2013; Saukani, 2018; Said et al., 2022; Zahari et al., 2019; Amir Zal et al., 2020), and community establishment (Hakim et al., 2012; Jaafar, 2014; Chan et al., 2015; Md Rami et al., 2022). All the results for the studies of social capital and sense of place despite being conducted outside Malaysia's context showed significant role of social capital. This supports Acedo et al. (2017)'s proposition, that the importance of recognising the connection between social capital and sense of place in urban context and how the spatial dimension of social capital has not been highlighted by past scholars. However, it is argued that Malaysia, as a multiracial country, presents a different perspective regarding social capital's influence on the formation of a sense of place in the urban context. The varies division of racial groups in Malaysia (55.1% Malay, 24.3% Chinese, 11.9% Non-Malay, 7.4% Indian, and 1.3% other population groups in Malaysia as of 2010 (Lee & Khalid, 2016)) exemplifies the distinction between cultural inclination and dimension. Malaysia has a diverse culture with various subcultures (Ting & Ying, 2013). Different cultural dimensions a nation can exhibit are influenced by

the various subcultures (Hofstede, 1983). This underlines the gap between a study of social capital and a sense of place in the urban areas of Malaysia. There is a also a lack of studies that adopted Bourdieu's framework of social capital. Bourdieu's (1986) stated that social capital involves two variables forming social capital: common name and two capitals (cultural and economic capitals). The dynamic role of cultural capital has been highlighted by Savage et al. (2018) in Belgium and the United Kingdom. Bourdieu's (1988) forces-field theory analogy underlined that the interaction of cultural and economic capitals is the result of individual distinction (Grenfell, 2014). Social capital has been understood as an independent capital by scholars (Coleman, 1988; Putnam, 2000), which is different from Bourdieu's (1986) sense of reasoning. Bourdieu (1986) made it clear that "social capital is never completely independent" (p. 21). He proposed that accrued social capital also depends on the amount of cultural and economic capital that influences the transformation of all circumstantial relationships into lasting connections. Through this adoption of Bourdieu's social capital framework, the underlying connection of influence it exerts on a sense of place in Malaysia's urban area context will provide interesting findings and an understanding of how these two elements will contribute to urban character sustainability.

CONCLUSION

Social capital is a concept that has been researched in a multidisciplinary scope. As it represents a robust concept of the relationship between persons/people, its relevancy can be considered in the field of urban environment. This paper reviewed past studies surrounding social capital and sense of place in urban areas of Malaysia to find a knowledge gap in this topic. The lack of studies of Bourdieu's social capital relationship towards a sense of place formation in Malaysia's urban areas provides a future direction for this study to be conducted empirically. The value lies under the Bourdieu operationalisation of social capital, which can influence the formation of a sense of place and the sustainability of urban character is evidenced through reviews of past studies. The adoption of Bourdieu's social capital framework could provide a unique perspective on how the network of relationship stems through common name and external capitals are interrelated with the sense of place. This contributes to a new knowledge in Malaysian urban planning field. In practical sense, this study is significant specifically for enhancing Malaysia's urban planning policy, which shall be focused on the public's participation and collaboration in sustaining urban areas from unplanned development, climate change, and deterioration. The limitation of this study includes the limited search database that only includes articles from Scopus and Web of Science databases. This was to ensure the inclusion of peer-reviewed publications to review. However, this may limit the

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broad, expanding articles published on this topic and may affect the comprehensiveness of the findings. Despite this limitation, the Scopus and Web of Science database is reliable and all the publications under these databases underwent peer-review process, thus proving their quality and robustness. Forward research on this topic is recommended to explore the relationship empirically through quantitative methodology by primary data utilisation, which may provide better generalised findings.

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EXPLORING THE KEY FACTORS DRIVING THE ADOPTION OF BIOPHILIC DESIGN IN AFFORDABLE ENVIRONMENTS: PERSPECTIVES FROM EXPERTS AND DESIGNERS

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Abstract

Financial constraints and developers' and designers' ignorance of the advantages of biophilic design, among other creative and sustainable design approaches, frequently impede its implementation. This study aims to evaluate the factors that influence the implementation of biophilic design in a low-cost context through the views of experts and designers. Biophilic design, which integrates elements of nature into the built environment, is increasingly recognised as essential for enhancing user well-being. In this context, this study is significant because it supports efforts to promote sustainable and environmentally friendly design, especially in developments that are limited by financial resources. The main objective of this study is to identify and analyse the factors that influence the implementation of biophilic design in low-cost settings. This study involves nine experts who are within the fields of architecture, green technology, sustainable design, and interior design. A qualitative approach was employed through in-depth interviews, utilising thematic analysis to identify themes related to biophilic design, including designers' awareness and knowledge regarding its implementation in low-cost settings. Although this study provides valuable insights, it has several limitations, including a small sample size and a restricted geographic focus. The main findings show that awareness of the benefits of biophilic design, support from authorities, and financial constraints are the main factors influencing its implementation. While the implementation of biophilic design in low-cost housing and the opinions of professionals like architects and designers are still understudied, prior research has concentrated more on commercial buildings and user perspectives. This study closes this gap by evaluating important aspects of low-cost housing from an expert perspective while accounting for design, policy, and cost. The implications of this study highlight the necessity of enhancing awareness and education regarding biophilic design, as well as advocating for policies that foster innovation in a cost-effective manner. Consequently, this study not only sheds light on the challenges encountered in the implementation of biophilic design but also presents recommendations to encourage more sustainable practices within the framework of sustainable development.

Keywords: Biophilic design, Low-Cost settings, Influencing factors, Residents' well-being, Sustainable development

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INTRODUCTION

Biophilic design refers to an architectural approach that incorporates natural elements into built environments to strengthen human connections with nature. In a context where development is increasingly constrained by financial resources, the implementation of biophilic design in low-cost settings is becoming more pertinent. Although many studies show the benefits of biophilic design in improving the well-being and quality of life of users, there are certain constraints that prevent its implementation in low-cost settings. In this study, the term "Low-Cost Settings" refers to affordable housing such as the People's Housing Project (PPR) and the Malaysian Civil Servants Housing (PPAM), which are created for low and middle-income groups (B40 and M40) in urban areas in Malaysia.

Financial constraints are often a major obstacle to adopting innovative and sustainable design strategies. In addition, the lack of awareness and understanding of the advantages of biophilic design among developers and designers also contributes to this issue. Therefore, this study aims to investigate the factors that influence the implementation of biophilic design in a low-cost context through the views of experts and designers.

Through a qualitative approach, this study will gather insights from industry experts and experienced designers, such as professionals with technical and practical competence, in assessing the use of biophilic design, especially in the context of affordable housing; this includes architects and interior designers. Their opinions are crucial in ensuring that the ideas created are workable, compliant with the law, and affordable. Through analysing the findings obtained, this study hopes to provide a deeper insight into the challenges and opportunities that exist in the implementation of biophilic design in low-cost settings. Biophilic design is increasingly recognised for improving psychological well-being.

Although biophilic design has been widely discussed within the broader sustainability and green building literature, its application in affordable housing remains limited. Previous studies concentrate primarily on energy performance and environmental efficiency, with minimal attention to psychological outcomes such as stress recovery. This study advances existing knowledge by repositioning biophilic design as a human-centred, low-cost strategy that addresses the mental well-being of residents. By analysing residents' preferences, demographic influences, affordability constraints and expert insights, this research develops a comprehensive guidance model that fills a significant gap in current sustainable housing research

However, previous studies have focused on commercial buildings while implementation in low-cost settings has been underexplored. In addition, the views of experts such as architects and designers who are directly involved in the implementation of design have received little attention because existing studies

have focused more on the user perspective. This study fills the gap by assessing key factors from an expert perspective in the context of affordable housing, taking into account costs, policies and design strategies. Finally, the results of this study are expected to contribute to the development of more effective policies and strategies to promote biophilic design in low-cost settings, while improving community well-being.

LITERATURE REVIEW

Definition and Concept of Biophilic Design

Biophilic Design refers to an architectural approach that integrates natural elements into the built environment to strengthen the relationship between humans and nature (Kellert, 2008). This concept is rooted in the idea that interaction with nature can emphasise the emotional attachment(Wilson, 2018) improve psychological well-being, reduce stress, and increase productivity (Browning et al., 2014). In the context of sustainable development, biophilic design also supports efforts to create more comfortable, pleasant, and healthy spaces. There is the importance of biophilic implementation in design, which contributes to the well-being of the population, increased productivity, ecosystem diversity and sustainable development.

Studies show that within minutes, exposure to biophilic design elements in an indoor environment can significantly reduce stress and anxiety, and physiological effects are immediately observed(Yin et al., 2020). Studies show that elements of nature, such as natural light, plants, and views outside, can improve mood, reduce stress, and improve mental health. Factors like thermal conditions, lighting, noise, layout, and biophilic design affect office workers' stress levels, highlighting the need for stress-free workspaces (Awada et al., 2023) .Plants offer emotional and mental health benefits, reducing anxiety, improving attention, boosting memory retention, and increasing happiness (Hall & Knuth, 2019). These findings affirm that biophilic design contributes meaningfully to mental restoration and stress recovery in built environments.

Benefits of Biophilic Design in a Low-Cost Settings

Two benefits from biophilic design in a low-cost setting are a response to the well-being of users and society, and economic and social benefits in low-cost projects. Biophilic design incorporates natural elements into buildings, enhancing mental and physical well-being. It reduces stress and anxiety, creating a more pleasant environment that promotes better mental health; integrating plants and sunlight can lower physical health issues such as high blood pressure and encourage physical activity. Such spaces also boost creativity and productivity, especially at work, fostering social interaction and strengthening community

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bonds. Ultimately, biophilic design improves quality of life, making people feel more connected and at ease in their surroundings (Kellert & Calabrese, 2015)

Biophilic design enhances user well-being and offers significant economic benefits for development projects. Several buildings in Malaysia use a biophilic approach that includes natural elements such as natural lighting, green spaces, and natural ventilation to reduce energy consumption, an example is the Pertubuhan Arkitek Malaysia (PAM) building. Ibrahim et al. (2021), through studies, prove that the use of biophilic elements in buildings can reduce operating costs and, at the same time, increase employee productivity. Notably, incorporating natural elements reduces operating costs through lower lighting and heating needs, while increasing property values and attracting buyers. This design approach is appealing for sustainable projects, often drawing investment and incentives from authorities. Additionally, using local materials supports the local economy, creates jobs, and boosts small businesses. Over time, biophilic design fosters a better living environment within an urban sprawl, enhances the area's appeal, and raises community awareness about environmental preservation. (Browning et al., 2014)

Factors Influencing the Implementation of Biophilic Design

Awareness and Knowledge Gap (Designer and Developer)

Factors influencing the implementation of biophilic design include: developer and designer awareness and knowledge, cost and budget, access to information, government support, and perceptions of health and well-being benefits. Awareness and knowledge of biophilic design among developers and designers is essential to integrate natural elements in their projects. Lack of knowledge on how to implement this design with a limited budget causes this concept to be often overlooked in the construction industry (Clark-Havron, 2023). This is probably due to the lack of knowledge about biophilic design practices, where it is known as a new design practice and the lack of accessibility of information related to this practice. There is a misconception that biophilic design requires high costs, which causes hesitation in its implementation. Sadick et al. (2023b) in their study stated that architects and building sustainability consultants influenced design decisions, yet very limited studies were found on their point of view about the direct nature integration (DNI) adoption barriers. This statement has been denied by Lei et al. (2022), whereby their study states that designers were well versed with this design approach and have adapted biophilic design attributes in design practices. Moreover, raising awareness through training and seminars can help developers and designers understand the benefits of biophilic design, including improved mental and physical well-being, and encourage them to prioritise spaces that support human relationships with nature. Awareness in making decisions to integrate biophilic design elements into buildings provides

many benefits, especially to green technology supporters, property owners, building designers and architects (Bartczak et al., 2013). If the information and knowledge about this practice and its implementation are more widespread and understood, this practice will be easier for the public to access (Clark-Havron, 2023).

Financial and Resource Constraints

Cost remains one of the primary barriers to adopting biophilic design in low-cost projects. Tight budgets, expensive organic materials, and maintenance costs deter the developers (Nguyen, 2023; Shamsi et al., 2023). Even though early integration can reduce costs in the long run, the perception of inefficiency persists. Studies by Larsson and Krishnaraj, (2023) indicate that while biophilic homes offer long-term benefits, they are often perceived as unaffordable. Government incentives and clearer communication of long-term savings could improve adoption. However, integrating biophilic elements during the pre-construction phase can provide benefits such as seamless installation, aesthetic value at no additional cost, and reduced labour and material costs. Most biophilic elements require high costs due to the involvement in the maintenance of natural elements, other than expensive organic materials (Shamsi et al., 2023). These facts are supported by (Larsson & Krishnaraj, 2023) through their study, which shows that biophilic design can give many benefits to residents and society that have been found to be severely unaffordable. In conclusion, biophilic design can benefit residents and communities, but is often considered inefficient. Sharp price increases force developers to find alternatives that may sacrifice quality. Lack of government incentives and understanding of the benefits of biophilic design make its implementation difficult. Structured incentives can increase developers' confidence to integrate biophilic design while considering profitability (Saka et al., 2021). Financial risk due to the uncertainty of demand for space that integrates biophilic elements puts pressure on developers. Although government incentives aim to stimulate growth (Bramayusa & Adi, 2024), a lack of consumer confidence in the price of biophilic homes makes sales difficult. Developers need to convince buyers of the long-term benefits of this design, especially in maintenance costs. Summatively, the government has an important role in dealing with financial problems for the implementation of this design.

Authorities Support

Government policies and incentives play an important role in promoting biophilic design by providing guidelines and financial incentives such as tax deductions. Although there are financial risks due to demand uncertainty, government policies can mitigate these challenges. Studies show that financial incentives and legal obligations are common ways to support green infrastructure (Liberalesso

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et al., 2020). Javed et al. (2020) identified high costs and a lack of experienced contractors as risks in green building projects, suggesting financial incentives. Tambe et al. (2023) suggested incentives in the building permit approval process to increase resource efficiency, while Deborah Aanuoluwa Soyombo (2024) suggested mandatory building codes, financial incentives, and procurement policies as effective means for encouraging sustainable practices. Malaysia is making progress in the development of green roofs, but much remains to be done to promote their widespread adoption. Overall, government intervention is important to drive sustainable construction practices and improve an environmentally friendly built environment. Authorities' support through incentives, policies, and guidelines will not be effective without public awareness. Community environmental awareness is still low due to a lack of formal education (Wiradimadja et al., 2023). Education programs can raise awareness and encourage sustainable practices (Tadesse, 2024), emphasising the importance of government support and private sector collaboration. In Malaysia, in 2018, there was a positive relationship between awareness levels and the efficiency of green building practices, highlighting the importance of education and government support (Sabar et al., 2018). This shows that environmental awareness is on a good path to be developed over time.

Experts' Insight: Challenges and Opportunities

Biophilic design offers benefits but faces challenges in a low-cost context, including high material costs, limited space, lack of awareness, and obstacles from regulations and planning policies. Other obstacles such as green retrofits and housing market issues, also make implementation difficult (Adabre et al., 2020). The use of renewable materials to reduce embodied emissions often requires increased investment costs (Schneider-Marin & Arendt, 2024). However, new incentives and policies are needed to overcome economic barriers and promote sustainable construction practices (Schneider-Marin & Arendt, 2024). The implementation of biophilic design faces challenges in limited spaces, especially in dense cities. In Dubai, residents showed high acceptance of green strategies such as balcony control and rooftop gardens (Shakhshir & Sheta, 2023). In Australia, low-cost biophilic design increases biodiversity (de Souza et al., 2023). Researchers suggest creating shared spaces in various building typologies to promote healthy living (Tracada & Sorensen Allacci, 2023). There is a lack of awareness about biophilic design and green buildings among developers and architects. Studies in Turkey revealed that technical knowledge about pro-environmental practices in the business domain is a stronger predictor of pro-environmental behaviour than general environmental awareness (Acar & Yalçın, 2019). In Pakistan, the most critical barrier to green building adoption was identified as a lack of awareness about its importance and advantages (Azeem et

al., 2020). Researchers suggest seminars, mandatory green building codes, and financial incentives to increase awareness (Azeem et al., 2020; Sabar et al., 2018). There are opportunities to leverage innovations in environmentally friendly materials, education, and community collaboration to reduce the cost of biophilic design. Government policies need to be revised to support the implementation of these designs, which can bring great benefits to society if the challenges can be overcome.

Table 1 summarises key findings from previous studies related to the challenges and opportunities. This synthesis highlights several gaps, which this study aims to address.

Table 1: Summary of Key Findings from Previous Studies

Author(s)	Challenges Identified	Opportunities / Recommendations
(Adabre et al., 2020)	High material cost, limited space, lack of awareness, policy barriers	Recognition of green retrofits and design incentives is needed
(Schneider-Marin & Arendt, 2024).	Renewable materials increase initial investment cost	Propose new policies and incentives to address economic barriers
(Shakhshir & Sheta, 2023)	Limited urban space in dense cities	Residents support green strategies like rooftop gardens and balconies
(de Souza et al., 2023)	Low-cost implementation may be seen as limiting	Can enhance urban biodiversity through biophilic strategies
(Tracada & Sorensen Allacci, 2023).	Challenges in promoting health through shared space	Promote shared biophilic spaces in varied building types
(Acar & Yalçın, 2019)	Lack of technical knowledge on environmental practices	Technical knowledge is key to promoting sustainable behavior
(Azeem et al., 2020).	Lack of awareness on green building benefits	Suggest seminars, mandatory codes, and incentives
(Azeem et al., 2020; Sabar et al., 2018)	Low public awareness of green design practices	Improving awareness boosts implementation efficiency

Strategies for Improving Implementation

Increasing awareness and education about biophilic design is essential for its widespread implementation. Education and training programs, including courses for architects and the public, need to be expanded (Adua et al., 2024); only 10% of colleges teach passive heating and cooling systems. Interdisciplinary collaboration and public awareness campaigns through social media and community events are also important to convey biophilic benefits (A. O et al., 2023), including their effects on mental and physical health. Higher awareness will increase the demand for projects that integrate biophilic elements, making the implementation of this concept more relevant and effective.

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Implications for the Future of Biophilic Design

The future of biophilic design carries important implications for architecture, urban planning, and well-being. With increasing awareness of environmental and health impacts, integrating natural elements into the built environment can enhance human connection with nature, improve mental health, and increase productivity. Advances in technology and sustainable materials will facilitate innovative designs that are aesthetically appealing and environmentally friendly. Additionally, in the face of ongoing urbanisation, biophilic design can help overcome issues such as urban heat and loss of biodiversity, creating healthier and more sustainable communities.

While biophilic design has been widely recognised for its psychological, environmental, and economic benefits, its application in low-cost housing settings remains underexplored. Existing studies have predominantly focused on commercial or high-end residential contexts, often neglecting the realities and constraints of budget-limited environments. Moreover, limited attention has been given to expert perspectives, particularly those of designers, architects, and built environment professionals who play a key role in the feasibility of implementation. This study addresses these gaps by assessing the factors that influence biophilic design adoption in low-cost housing through the lens of experts, aiming to inform more inclusive and practical design strategies.

RESEARCH METHODOLOGY

Semi-Structured Interview

This study employed a qualitative approach using semi-structured interviews that were conducted online, each lasting 45 to 60 minutes. Nine (9) architectural experts with backgrounds in green, sustainable, and biophilic design were interviewed. Questions were developed through a literature review, allowing flexibility for in-depth discussion. This method is effective for keeping the conversation focused while enabling the interviewer to guide the discussion as needed (Islam & Aldaihani, 2021). Key points for the questions are outlined below:

Table 2: Questions Procedures and Guide

Procedures	Questions Guide
Introduction Questions	Knowledge and awareness about biophilic design in building design
Focus Questions	Factors that affect the effectiveness of the application of biophilic design in the interior design of housing Key design strategies and challenges in the implementation of biophilic design in low-cost setting

Procedures	Questions Guide
Concluding Questions	Open question about future recommendation for biophilic design widely used in the field of design in Malaysia.

In conclusion, the primary objective of this interview session is to support the goals of this study, which are to explore the strategies and challenges encountered by design practitioners in Malaysia regarding the implementation of biophilic design. Additionally, the session aims to identify the key factors that influence the effectiveness of biophilic design in practice.

Expert Selection

Since biophilic design is a relatively new design approach in Malaysia, no expert in this field has been identified in Malaysia. In the absence of experts who are directly labelled under biophilic design, this study selected professionals such as architects, interior designers, and sustainability consultants who actively incorporate nature-based design principles into their work. Their expertise was deemed relevant based on their direct involvement in low-cost housing development and environmental design decisions (Welch & Patton, 1992). Therefore, this interview takes the approach of interviewing experts in the field of green building design and sustainable design, since biophilic design is identified as one of the design approaches that is closely related to this design approach. Meanwhile, interior designers and architects were interviewed since they are the key people who prepare the design brief for each project, which is formed through understanding the end user's needs and experience in the field of construction. Practitioners are close to the end user, and biophilic design is a design approach that touches the heart of the end user, and is not just a standard practice. Interdisciplinary knowledge is required to form biophilic design guidelines, where information and in-depth knowledge about biophilic design is obtained to link design strategies with the benefits (Zhong et al., 2022). According to Creswell and Creswell, (2018) conducting approximately 3 to 10 interviews is sufficient for phenomenological research.

Despite its restricted geographical focus, this study offers useful theoretical and technical viewpoints by concentrating on professional insights from various disciplines. The expert opinions add to a greater understanding of biophilic design concepts, which helps inform future practical applications and advances, even though it excludes input from all stakeholders, such as the inhabitants or users.

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Table 3: Interviewee Key Profiles

Item	R1	R2	R3	R4	R5	R6	R7	R8	R9
Interviewee Position	Managing Director /Green Design Expert	Architect /Interior Designer	Architect	Project Manager / Sustainability Architect	Architect/ Head of Department	Architect	Principle Architect/ Managing Director	Architect	Architect Ecologist Planner
Professional title	Ts	n/a	n/a	n/a	Ar	n/a	Ar	n/a	Dr Ar
Organisation	Consultant	Consultant	Consultant	Consultant	Developer	Consultant	Consultant	Developer	Consultant
Experience In industry (Years)	>10	>10	>15	>10	>10	>10	>30	>10	>40
Experience in biophilic/ sustainable/ green design	Sustainability Green	n/a	Sustainability Green	Sustainability	Sustainability	n/a	Sustainability Green	Sustainability Green	Sustainability Green

This research complied with institutional ethical standards. Approval was granted by the UiTM Research Ethics Committee according to CH Good Clinical Practice Guidelines, Malaysian Good Clinical Practice Guidelines, and the Declaration of Helsinki. Participants were fully informed of the study purpose, procedures, confidentiality measures, and their right to withdraw at any time. All participants provided written informed consent before taking part in the survey and interviews.

DATA ANALYSIS

Data analysis for in-depth interviews has several procedures. Based on Creswell and Creswell, (2018), before reaching the data analysis stages, it starts with data collection, data recording, data analysis, interpretation, validity, reliability and writing a qualitative report. Figure 1 shows the data analysis procedures:

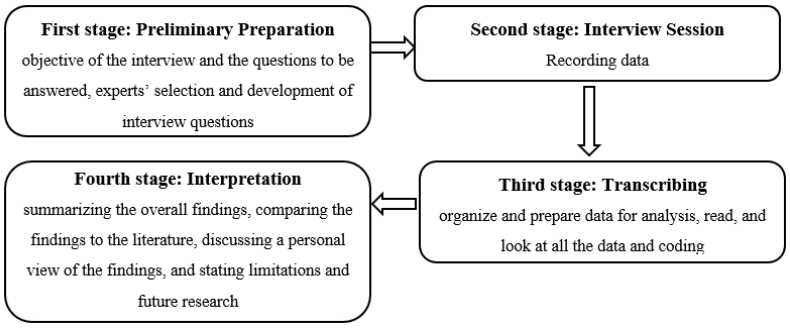


Figure 1: Data Analysis Procedures

Data Collection
Data were collected through semi-structured interviews with experts in the fields of architecture, design, and planning. Purposive sampling was used to ensure that the expertise of the respondents was relevant to the research topic. Interview questions focused on the challenges and opportunities in implementing biophilic design.

Data Recording
With the consent of the interviewees, all interviews were audio recorded, accompanied by field notes. After that, these recordings were thoroughly transcribed for study.

Data Analysis
Data were analysed using thematic analysis methods. Transcripts were reviewed and read repeatedly, coded, and key themes were identified based on expert views.

Data Interpretation
Results are interpreted by contrasting new themes with those of earlier research, especially those pertaining to affordable housing.

Validity and Reliability
Cross-checking findings with existing literature

RESULTS AND DISCUSSION
Based on interviews with nine experts, the key challenges include: (1) awareness and knowledge among developers and designers, (2) financial and resource constraints, and (3) support from authorities through guidelines and policies.

Challenge 1: Developer and Designer knowledge and awareness
Referring to the content analysis of the interview session conducted, all 9 experts believe that biophilic design is known and realised by experts involved in green design, however, their opinions regarding the understanding of developers and designers are different according to their respective approaches.

The lack of knowledge about biophilic design may be because it is still new in Malaysia, causing a gap in understanding between designers and end users. – ***R1, R6***

The fact that designers lack of knowledge to implement this design approach is due to them not being able to balance between design strategies and design

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requirements. This is because at the worldwide level and Malaysia itself, it has its own design and cost standards – ***R2***

As a designer, we only applied biophilic design concept by client request. If not, we will go with a standard design, due to cost implementation even, we clearly aware of the advantages of biophilic design – ***R3***

The consultant's role is to convince the developer in the use of this design approach. Awareness is also necessary from the top down. developers well versed with this concept, but in the end, everything turned to dollars and cents. but it is picking up. they are exploring biophilic design and passive design. That is a high-rise building, but it going to be a long journey in Malaysia – ***R4***

The issue is not about developer and designer lack of knowledge or awareness, an issue is there is no enforcement from the government, so this design approach not compulsory ***– R5***

For me, it is not about new design approach, designers have practiced similar designs all this time. it is something very natural. It is something natural that humans need. Now, it has a name – ***R7***

It is about the awareness and the issues. It is not about the adaptation – ***R8***

Certainly, designer need to consider and aware about beneficial influences of vegetation on humans – ***R9***

Literature highlights some of the main reasons why biophilic design is less used, whereby the main reason being the developers' and designers' lack of knowledge. The main concern is a lack of knowledge about the implementation of biophilic design with a limited budget (Clark-Havron, 2023). New design practice and the lack of accessibility of information related to this practice are also highlighted as factors. It appears that both the literature and the findings converge on similar concerns regarding the issues at hand. Several new challenges are highlighted, particularly the relationship between the government's role and the developer's role in promoting the expansion of this approach; this aspect is currently gaining traction in Malaysia.

Challenge 2: Financial and Resource Constraints

Based on the content analysis of the interview session, the second question is more focused on the challenges of implementing biophilic design in low-cost

settings. Every interviewee expressed almost the same opinion that financial constraint is the main influence concerning implementation.

...we need to balance all of this in terms of the capital expenditure and the operating expenditure. the challenge is to find the balance, between design and cost because of financial constraint – ***R1***

Cost constraint is the main subject, but if we can strategize this design into nice to have, must have and which can be implemented later, cost is not the main constraint. The main constraint is the design requirement and the residents' understanding of the biophilic itself – ***R2***

Green or biophilic implementation itself is indeed costly, and it has not yet been used for low-cost houses in Malaysia, however, it goes back to the design strategy itself despite the high cost of implementation – ***R3***
In the Malaysian industry, particularly in green building design, the focus is often on active design, while passive design is frequently overlooked. However, it is essential to prioritize passive design first. If biophilic design is considered at the beginning of the design stage, it does not necessarily lead to high implementation costs – ***R4***

In the context of low cost, you will not be able to get all the elements in one housing unit due to the high cost of implementation and maintenance – ***R5***

The cost of construction and the cost of the house is beyond our control as a designer, but we can control the design strategy from causing the cost to skyrocket – ***R6***

To provide comfortable home units at the same time low cost, government must do not mind to invest their money. We cannot balance between implementation costs and including all the benefits of biophilic at one time – ***R7***

....it is not about cost. It is how you design your space; you just integrate it as part of your design – ***R8, R9***

Most of interviewees agree that as a designer, seeing cost as an obstacle is unnecessary. The effectiveness of implementation is based on the design strategy for the implementation of biophilic elements in housing (R2, R3, R6, R8, R9). Apart from that, a focus on passive design is necessary to make this adaptation design approach a success method to not lead to high-cost implementation (R4). Apart from the cost, there is an interviewer who

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highlighted the role of government in providing investment for this design to be used well in Malaysia (R7). Designers consider cost to be the main issue, but this can be overcome through a design strategy. Moreover, the government plays a role in providing incentives related to the implementation of green and biophilic design strategies. Implementation at the start of the design phase to prevent cost increases (R1) and classifying the biophilic characteristics as common or unusual for low-cost implementation (R2) are two of the design solutions that are recommended. Furthermore, according to R8 and R9, the way the space is constructed is a design strategy, and this parameter can be broken down in the design without raising the price.

Challenge 3: Authorities Support and Initiatives

Referring to the content analysis of the last question, all the interviewees agreed that the government's support in providing incentives can help this approach to be widely used in Malaysia.

For first group of biophilic design such as natural lighting, view of nature and natural ventilation, government already enforced it in policies and guidelines namely GBI. that one is all green building parameters – ***R1***

If the government can enforce the universal design act, they also need to look at biophilic design, where the benefits are broader ***– R2***

Designers will only adapt the minimum requirements enforced by government and authorities, so focused guideline is required ***– R3***

Enforcement by government indeed with a focus on passive design first. Also, the government now offers some sort of green building initiatives, namely tax allowance, so that buyers are more confident to invest their money to buy green housing units ***– R4***

Government giving incentives to developers during MCO, lead to reducing development charges, and developer can tolerate with affordable housing scheme. Government should impose green technology incentives so that win-win situation between government and buyer can be develop ***– R5***

Government should enforce biophilic design through green building index so that we as a designer can adopt this design approach without any cost barrier – ***R6***

Despites of incentives, government should initiate more affordable housing scheme, and need to manage it well to give an opportunity especially B40 income

level persons. Government also needs to give an education to public about this scheme – ***R7***

Authority supports comes along with design strategies itself even there is no guidelines for biophilic design. We called it design principle – ***R8***

In line with the literature review, the analysis shows that the government or authorities play an important role in encouraging biophilic design to be widely implemented in Malaysia. Among the recommendations are improving policies, creating a guideline focusing on biophilic design and incentives for buyers (Liberalesso et al., 2020). Another highlighted factor is public awareness, whereby the government needs to educate buyers to promote the implementation of biophilic design.

The literature and findings of this study converge on a key issue, i.e., the lack of knowledge among developers and designers regarding the implementation of biophilic design, particularly in low-cost housing contexts. A significant concern identified is the perception that biophilic design is too costly to implement within a limited budget (Clark-Havron, 2023). This is echoed by the designers in the study, who acknowledge cost as a barrier but suggest that it can be mitigated through strategic design solutions. By integrating biophilic elements early in the design phase, such as classifying features as either common or uncommon for low-cost projects, designers can minimise additional expenses. Additionally, according to experts (R8 and R9), the construction approach itself can be a flexible design strategy that does not necessarily increase costs, indicating that thoughtful planning can address financial constraints without compromising biophilic principles.

In line with the literature, the study highlights the importance of the government's role in promoting biophilic design. Policy improvements and the creation of biophilic design guidelines, along with incentives for developers and buyers, are crucial in encouraging wider adoption in Malaysia (Liberalesso et al., 2020). Public awareness is another critical factor, as government initiatives that are aimed at educating buyers and stakeholders about the benefits of biophilic design can help drive its acceptance and implementation. These combined efforts, through better policy, design strategies, and public engagement, can support the integration of biophilic design in affordable housing, making it a more feasible and attractive option for both developers and residents.

The study outlines the key factors that hinder the adoption of biophilic design in low-cost housing, with the primary issue being the ignorance of developers and designers regarding how to implement it economically. Designers believe that early design integration and calculated decisions, including categorising biophilic features as common or uncommon, will address cost-

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related challenges. The government plays a crucial role in promoting biophilic design by proposing policy changes, establishing biophilic design guidelines, and providing incentives for developers and buyers. Additionally, campaigns aimed at raising public awareness are essential for further promoting biophilic design.

By highlighting how economic considerations, which are frequently viewed as the main obstacle, can be resolved through thoughtful design decisions, the study offers fresh perspectives on the viability of integrating biophilic design in affordable housing. This includes including biophilic features early in the design process and categorising them as typical or more cost-effective choices for low-cost housing. Furthermore, the study emphasises how important it is for the government to support biophilic design through incentives, policies, and public awareness campaigns. This will help to create an environment that is conducive to incorporating biophilic principles into affordable housing projects. Despite these findings, there is a significant gap in practical knowledge regarding how biophilic design can be applied specifically in low-cost housing in the Malaysian context. Although the study indicates that biophilic design has the potential to enhance well-being, little is known about how people interact with biophilic design elements in low-cost housing, especially regarding the advantages and difficulties they perceive. Additionally, although design solutions are suggested, there are not many thorough case studies or actual instances of low-cost biophilic housing projects that have been successful. To improve implementation tactics and guarantee wider adoption in the future, there is a deficit in both real-world applications and residents' input.

CONCLUSION

This study identified several factors influencing the implementation of biophilic design in Malaysia's construction sector, focusing on three main challenges: knowledge and awareness among developers and designers, financial constraints, and the need for governmental support and initiatives. Biophilic design is relatively new in Malaysia, which has led to hesitance among developers and designers who view it as costly. To foster collaboration between these two groups, it is crucial to strengthen their relationship, thereby ensuring that biophilic design can be implemented in a cost-effective manner. Designers often view cost as a significant barrier; however, effective design strategies can mitigate this issue. The government can play a crucial role by providing incentives for green and biophilic design implementation, making it more financially viable. By allocating funding for developments that incorporate green technologies, the government can facilitate the creation of comfortable housing that ensures mental health. Additionally, improving policies and establishing guidelines focused on biophilic design can encourage its implementation. The government should also promote public awareness and education regarding

affordable housing schemes, helping the public to understand the advantages of biophilic design. In conclusion, the successful implementation of biophilic design in low-cost housing requires collaboration among the government, the designers, and the public.

This study recognizes various methodological constraints. First, the expert and designer sample was relatively small (n=9), which limits the ability to generalize the findings across the broader professional population. Although the participants provided in-depth and informed perspectives, their views may not fully capture the diversity of opinions among practitioners in other regions or sectors of the built environment industry. Second, the study's limited geographic scope further limited the results' external validity. As a result, the particular professional and local context in which the study was carried out should be taken into account when interpreting the results. To improve the model's generalizability, future studies using a broader and more geographically diverse pool of experts and designers are advised.

This collective effort will contribute to sustainable development goals, particularly SDG 3 (Good Health and Mental Wellbeing) and SDG 11 (Sustainable Cities and Communities), and align with the KPKT's vision for sustainable, affordable housing. While this study offers valuable insights, it faces limitations such as a small sample size and a restricted geographical focus. Future research should investigate the perspectives of designers and developers regarding the implementation of design strategies in low-cost settings to effectively address cost barriers.

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AUTHOR CONTRIBUTIONS

Author 1 and 3 contributed to the conceptual framework development, provided academic guidance, and secured publication funding. *Author 2* was responsible for conducting the literature review, designing the research methodology, collecting and analyzing the data, and drafting the manuscript. All authors reviewed and approved the final version of the article.

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TOWARDS SAFER CITIES: UNRAVELLING SAFETY PERCEPTIONS IN MALAYSIAN COMMUNITIES ACROSS 46 LOCAL AUTHORITIES

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Abstract

Urbanization has significantly impacted public safety, making it a major concern in Malaysia. To address this, the Safe City Program was introduced in 2004, playing a vital role in reducing crime and enhancing community security. Over the past 20 years, Malaysia's crime index has declined by 3.0%, reflecting the program's effectiveness. This study evaluates the program's impact on Malaysians' perceived safety through a demographic survey. A total of 10,076 respondents from 46 Local Authority areas across 13 states and three Federal Territories participated. ANOVA and post-hoc analysis revealed that individuals who are married, earn over RM10,000, are in their 40s, Malay or Muslim, highly educated, and residing in Terengganu, Kelantan, Putrajaya, or bungalow-style homes feel the safest. The findings highlight the Safe City Program's success in fostering security and well-being among Malaysians.

Keywords: Safe Cities, Safety Perception, Fear of Crime, Crime, Public Safety

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INTRODUCTION

The Safe City Program (SCP), led by PLAN Malaysia in collaboration with local authorities, was introduced in 2004 following a Ministerial Council directive. By 2005, it had been disseminated to 38 local authorities in Peninsular Malaysia. From 2006 to 2008, the Federal Department of Town and Country Planning monitored its implementation, setting guidelines for CCTV specifications, bollards, railings, and crime prevention lighting (Jabatan Perancangan Bandar dan Desa Semenanjung Malaysia, 2010). In 2009, the Government Transformation Programme (GTP) launched the National Key Result Areas (NKRA), prioritizing crime reduction. This led to the NKRA LAB, focusing on street crime reduction through SCP and Crime Prevention through Environmental Design (CPTED) under clause NKPI 1.2.1. During GTP 1.0 (2010–2012), SCP was further expanded, with 151 local authorities adopting its measures (Jabatan Perancangan Bandar dan Desa Semenanjung Malaysia, 2010).

In 2011, the Cabinet Ministers and the National Council for Local Government endorsed the CPTED Implementation Guide, integrating it into the Ministry of Housing and Local Government (MHLG) Secretary General's Circular No. 3 for planning approvals at one-stop centers (OSC). The Safe City Monitoring System was implemented in 35 local authorities and 215 police stations, reinforcing commitment to urban and rural safety. According to Jabatan Perancangan Bandar dan Desa Semenanjung Malaysia (2010), 496 CCTV cameras were installed across 25 local authorities, strengthening the Performance Management and Delivery Unit (Pemandu) Basic Services Sector (PBS) under GTP 2.0 (2013–2015, NKRA Reducing Crime). Additionally, initiatives such as blackspot whitening, CPTED enhancements for housebreaking prevention, car park safety audits, and an expanded Safe City Monitoring System further improved crime prevention efforts.

From 2020 to 2025, the government allocated RM40 million to enhance blackspot whitening efforts, reinforcing its commitment to crime reduction through the Safe City Program (Jabatan Perancangan Bandar dan Desa Semenanjung Malaysia, 2010). This study evaluates the program's success by analyzing Perceived Safety across 46 local authorities in Malaysia. Unlike previous studies, this research offers a nationwide assessment of safety perception with direct reference to the Safe City Program, addressing a critical gap in understanding public safety in Malaysia. However, most previous evaluations of the Safe City Program have been localised, focusing on single cities such as Putrajaya, Shah Alam, Kuala Lumpur and other selected urban centres. These local case studies provide useful insights but do not allow comparison across different socio-demographic groups, geographic settings, and housing environments involved in the program. As perceptions of safety are shaped not only by crime statistics but also by neighbourhood conditions, social

cohesion, personal security experiences, and lifestyle patterns, a broader and more representative national assessment is needed to understand how Malaysians actually feel about safety in their everyday environments.

Therefore, the novel contribution of this study lies in providing the first nationwide empirical assessment of safety perceptions involving 10,076 respondents across 46 Local Authorities. This extensive coverage enables a more equitable comparison of Perceived Safety across states, income levels, age groups, and residential forms, strengthening the evidence base for targeted safety planning, CPTED implementation, and policy adjustments under the Safe City framework. This nationwide approach provides a more comprehensive and comparative understanding of safety perception, which has not been examined at this scale in prior Safe City research.

LITERATURE REVIEW

Unveiling Malaysia's Crime Landscape

In Malaysia, crime documentation is categorized into indexed and non-indexed crimes, with indexed crimes being frequently reported and supported by sufficient evidence, serving as significant indicators of the country's crime situation (PDRM, 2008) and evaluating crime rate trends. Indexed crimes encompass two types: property and violent, with violent crimes further divided into seven categories, including murder, rape, armed robbery, unarmed robbery, and assault. Property crimes are subdivided into six categories: theft, motor vehicle theft, motorcycle theft, theft of vans/trucks/heavy machinery, snatch theft, and burglary (PDRM, 2023). Non-indexed crimes encompass criminal cases beyond those listed under indexed crime categories, with their occurrence frequency not utilized for crime trend assessment (PDRM, 2008). These crimes, including fraud, insurance fraud, forgery, counterfeit money, and breach of trust, fall under commercial crimes (YDH Tan Sri Dato' Seri Musa, 2008). Over ten years, crime indices in Malaysia allow the observation of trends to determine if the crime index is rising or falling, as illustrated in Figure 1.

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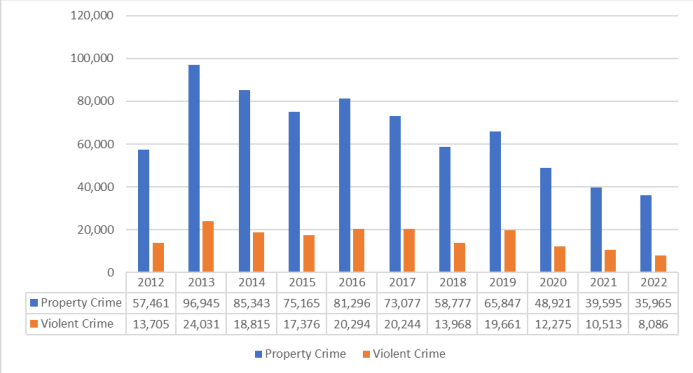


Figure 1. Indexed Crime Trends in Malaysia from 2012 to 2022
Source: PDRM (2023)

Figure 1 depicts the total number of indexed crimes over a decade, comprising 718,392 property crimes and 178,968 cases of violent crimes. Indexed crime has steadily decreased from 2012 to 2022, reflecting a consistent 10-year trend. This decline signifies the effectiveness of government and Royal Malaysia Police (RMP) initiatives in managing indexed crime cases. Meanwhile, Figure 2 illustrates index crime statistics across 46 local authorities in 14 states over the same 10-year period in Malaysia.

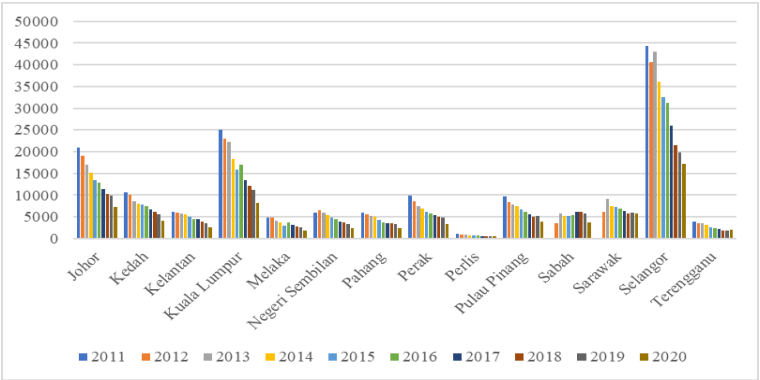


Figure 2. Crime Index Statistics in Malaysia States for the Years 2011 – 2020
Source: PDRM (2021)

Referring to Figure 1 and 2, comparing indexed crimes plays a crucial role in assessing the safety and security level of the Malaysian population. As crime decreases, people's safety levels improve. However, attention must also be given to non-indexed crimes, as they impact population safety. For example,

cybercrime has emerged as a serious issue, with 11,367 cases recorded in Kuala Lumpur from January to July 2023 alone (Metro, 2023). Additionally, crimes not investigated for legal reasons should be considered, as they reflect the level of security and efforts to combat crime among the population. Therefore, relevant authorities must continue monitoring the development of both indexed and non-indexed crimes to ensure the safety and well-being of the population are maintained and enhanced.

In the realm of crime prevention, implementing the Safe City Program aligns with the principles of Crime Prevention through Environmental Design (CPTED), which emphasizes interconnectedness and shared objectives. Specifically, the program's environmental component, alongside considerations of image and maintenance, surveillance, and supportive endeavours, collectively strives to cultivate social cohesion among community members (Lim, S. B., Kong, Y. C., Abdul Rashid, M. F., & Abdul Malek, J.,2020). This endeavour involves modifying the physical environment to facilitate meaningful interactions within the community. Positive interactions bolster neighbourhood morale and indirectly contribute to establishing natural surveillance mechanisms over residential areas, consequently mitigating crime rates (Zainudin & Abdul Malek, 2010). The emphasis on social factors is particularly evident in community surveillance initiatives, which constitute a primary prevention strategy to enhance the populace's capacity to detect and monitor criminal activities (Yahaya, 2006). This approach, often called Neighborhood Watch, entails informal collaboration among neighbours to safeguard their locality against criminal threats by assuming voluntary responsibility for the security of their homes and surroundings (Lab, 1988; Mohd Reduan, 1990). Central to the success of this strategy is the cultivation of vigilance and attentiveness, particularly within neighbourhood contexts. Consequently, community members are auxiliary eyes and ears for law enforcement agencies, emphasizing the importance of societal engagement and commitment in fortifying crime prevention efforts (Zainudin & Abdul Malek, 2010).

Environmental Factors and Perception of Safety

Gender, age, and income significantly influence fear of crime. Women generally reported higher fear levels than men, experiencing up to four times more fear when alone at home, walking at night, or in dark areas (Grabosky, 1995; Donder et al., 2005; Heinen, 2023; Navarrete-Hernandez et al., 2023). Individuals experience five times more insecurity and are three times more fearful of physical assault, primarily due to physical vulnerability and limited self-defence skills. Age also plays a role, with fear increasing as individuals grow older. Additionally, income level affects fear perception, as higher-income individuals

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can afford security systems, while lower-income groups experience double the fear when on the streets (Donder et al., 2005; Grabosky, 1995).

Strong community and neighborhood cohesion are essential for fostering safety and support, while their absence increases concerns about crime. Norcikeyonn Samuni (2021) highlights the need to strengthen community resilience and civic awareness to address these issues. In Kota Kinabalu, five key barriers hinder community participation in enhancing livability: low civic awareness, lack of knowledge, limited promotion of the Livable City program, time constraints, and absence of incentives. Additionally, a deteriorating physical environment—marked by vandalism, property damage, and uncleanliness—can signal reduced security. Areas with litter and traces of recreational activities may also be perceived as potential crime hotspots, particularly in remote locations.

A sense of safety greatly influences individual behaviour, often leading people to prefer indoor activities or take precautions like installing security devices and improving lighting (Kitchen & Schneider, 2007). These measures impact Malaysia's quality of life, highlighting the need to restore confidence in public safety. For instance, well-lit and busy areas can reduce anxiety about going out at night, though fear may persist in secluded locations (Kitchen & Schneider, 2007). A 55.8% decline in fear of crime indicates the effectiveness of Malaysia's crime prevention policies, reassuring policymakers and safety-conscious individuals. Meanwhile, Malaysia's population grew by 0.9% from 2018 to 2021 (EPU, 2022).

Exposure to crime—whether through personal experience or media—strongly influences individuals' sense of security. Media platforms, including social media (Facebook, TikTok), television, newspapers, and magazines, play a crucial role in shaping public perception. Sensationalized crime reports often amplify fear (Stephen Farrall et al., 2007; Amar et al., 2006). In Britain, tabloid readers show heightened anxiety about crime, whereas broadsheet readers exhibit less concern (Grabosky, 1995). However, fear of crime is not solely linked to victimization; other factors, such as perceived environmental risks, physical ability, age, gender, and socioeconomic status, also shape emotional responses (Navarrete-Hernandez et al., 2023).

A weak social environment in urban communities can contribute to feelings of insecurity, potentially leading to various phobias (polyphobia) among residents (Sparks et al., 2001). Phobias, characterized by persistent and irrational fears, often result in avoidance behaviours and can negatively impact psychological well-being. These fears stem from perceived social threats, creating an unhealthy state of anxiety (Malek et al., 2015). The loss of well-being and security in urban settings may heighten these fears, affecting individuals' mental health and overall quality of life.

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Crowe (2000) examines crime from a social perspective, attributing it to factors such as lack of opportunities, societal problems, and environmental deterioration or 'disorder,' which act as situational triggers for criminal behaviour (Birkbeck & Lafree, 1993). From a psychological standpoint, crime is not merely a societal issue but also a product of individual choices shaped by personal beliefs. Some individuals may resort to crime as a means of problem-solving, often influenced by underlying mental pathologies that drive dysfunctional behavior (Crowe, 2000). Additionally, from an environmental perspective, crime is shaped by actual conditions, with each criminal act motivated by different incentives.

METHODOLOGY

This study employs a quantitative approach utilizing a survey questionnaire distributed to Malaysian citizens. The questionnaire gathers demographic data and measures Perceived Safety (POS). Each construct is assessed using a five-point Likert scale, a reliable tool for evaluating respondents' perceptions. The scale consists of five response options: 1 - Very Unsafe, 2 - Unsafe, 3 - Less Safe, 4 - Safe, and 5 - Very Safe, providing a comprehensive understanding of safety perceptions. The Perceived Safety (POS) tool in this study is adapted from the British Crime Survey (BCS), also known as the Crime Survey for England and Wales (CSEW). The BCS is a well-established research tool used in the UK to measure crime rates and public safety concerns, providing critical insights for policymakers, law enforcement, and researchers. By adapting this tool to the Malaysian context, this study aims to comprehensively assess POS among Malaysian citizens.

The respondents were selected from 46 Local Authorities involved in the Safe City Program between 2017 and 2022. The study employs a stratified random sampling approach based on population distribution within Local Authority areas to ensure broad representation. The sampling process is conducted in two stages, covering 10% and 7% of the population, with at least 1% representation from each Local Authority. The sampling frame ranges from 10,403 (7%) to 14,890 (10%), ensuring a sufficient sample size in accordance with Krejcie and Morgan's sampling guidelines (See appendix 1). This approach enhances the study's validity and reliability.

Data collection was conducted through both face-to-face interactions and QR code distribution to maximize respondents' engagement. This process took place from June to July 2023, yielding responses from 10,076 participants. With a sampling frame of 10,403, the response rate reached 96.8%, while a larger sampling frame of 14,890 resulted in a response rate of 67.6%. Additionally, a pilot study involving 219 respondents was conducted to assess the validity and reliability of the research instrument. The findings align with the works of

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Radhakrishna (2007) and Bolarinwa (2015), affirming the instrument's effectiveness in measuring the study construct. Therefore, the sample size used in the pilot study was deemed sufficient to ensure the validity and reliability of the instrument.

The Perceived Safety construct (Alpha = 0.91) has yielded reliable and valid results. Each item exhibits correlations with the respective constructs exceeding 0.3, and the internal consistency values are above 0.8, which is considered satisfactory and good according to DeVellis (1991). These findings validate each item as a measure of its dimension and emphasize their practical implications in constructing the dimension for the respective construct. This, in turn, enhances our understanding of public safety, making the research's impact tangible and relevant.

RESULTS

Demographics Analysis

This research includes a diverse group of respondents based on gender, ethnicity, religion, age, marital status, education, employment sector, and household income. The gender distribution is nearly equal, with males (49.4%) and females (50.6%). Malays form the majority (73.9%), and Islam is the predominant religion (78.4%). Age-wise, 34.1% are in their twenties, and 31.6% are in their thirties, highlighting a youthful population. Marital status shows a mix, with 54.6% married and 40.9% single. Education levels are high, with 69.4% holding university or college qualifications. Employment varies, with 32.6% in the public sector and 27.9% in the private sector. Household income levels vary, with 31.5% earning between RM2001–RM4000 while 27.2% earning below RM2000, illustrating economic diversity among respondents.

The Perceived Safety Levels and Differences by Demographics

The Perceived Safety (POS) measurement assesses respondents' sense of safety in their environment during both daytime and nighttime. It evaluates their ability and frequency of leaving home based on their perceived security. This measure captures perceptions of crime risks, including theft, assault, or harassment, and considers how safe individuals feel engaging in outdoor activities. By analysing respondents' comfort levels outside their homes at different times, the POS measurement provides valuable insights into their daily security experiences. Utilizing a five-point Likert scale, it offers a detailed understanding of these perceptions. The descriptive findings of POS are presented in Table 1.

Table 1. The Level of Perceived Safety among Malaysian Citizen

No.	Perceived Safety (POS)	Scale	Frequency	Percentage
1	The Level of Safety in Residential Areas	Very Unsafe	119	1.2
		Unsafe	212	2.1
		Less Safe	1327	13.2
		Safe	**6681**	**66.3**
		Very Safe	1737	17.2
2	The level of feeling safe staying at home	Very Unsafe	58	0.6
		Unsafe	159	1.6
		Less Safe	1148	11.4
		Safe	**7032**	**69.8**
		Very Safe	1679	16.7
3	Feeling of safety when leaving home	Very Unsafe	52	0.5
		Unsafe	164	1.6
		Less Safe	1153	11.4
		Safe	**7276**	**72.2**
		Very Safe	1431	14.2
4	The frequency of leaving home at night within a week	Every day	1646	16.3
		Once or twice	**3487**	**34.6**
		3 to 4 times	2526	25.1
		5 to 6 times	1859	18.4
		Never go out	558	5.5
5	The level of feeling safe when going out at night	Very Unsafe	274	2.7
		Unsafe	448	4.4
		Less Safe	2161	21.4
		Safe	**6265**	**62.0**
		Very Safe	941	9.3
6	The level of feeling safe when alone at home during nighttime	Very Unsafe	201	2.0
		Unsafe	365	3.6
		Less Safe	2314	23.0
		Safe	**6397**	**63.5**
		Very Safe	799	7.9
7	The frequency of leaving home during daytime within a week	**Every day**	**5037**	**50.0**
		Once or twice	555	5.5
		3 to 4 times	1166	11.6
		5 to 6 times	3228	32
		Never go out	90	0.9
8	The level of feeling safe when going out during the daytime	Very Unsafe	29	0.3
		Unsafe	73	0.7
		Less Safe	821	8.1
		Safe	**7579**	**75.2**
		Very Safe	1574	15.6
9	The level of feeling safe when alone at home during daytime	Very Unsafe	29	0.3
		Unsafe	182	1.8
		Less Safe	900	8.9
		Safe	**7383**	**73.3**
		Very Safe	1582	15.7

Source: Author

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A nationwide survey across various residential areas in Malaysia indicates a strong sense of safety and well-being among Malaysians. The study found that 66.3% of respondents feel safe in their residential areas, with 69.8% expressing security in their homes. Safety perception remains high, with 73.3% feeling secure when alone at home during the day and 63.5% at night. Additionally, 62% feel safe going out at night, while 75.2% feel secure during the day. Notably, 34.6% reported going out at night once or twice a week and feeling safe while doing so.

Relationship Between Demographics and Perceived Safety

The study analysed the relationship between respondents' demographic characteristics and Perceived Safety (POS). Findings indicate a significant difference in POS based on gender ($t(10023.26) = 6.18$; $p = 0.00$), highlighting gender's crucial role in shaping safety perceptions. Men reported higher POS ($M = 27.66$, $SD = 3.59$) than women ($M = 27.23$, $SD = 3.43$). This disparity may be influenced by social factors, the physical environment, risk perception, and physical ability to defend against crime. As noted by Eva Heinen (2023), women experience higher anxiety levels than men and are twice as likely to alter their travel behavior due to safety concerns.

Additionally, this study aimed to understand the factors influencing Perceived Safety (POS) across different demographic groups. To achieve this, we conducted a One-Way Analysis of Variance (ANOVA) on various demographic factors. The results revealed significant differences between POS and Age Group ($F(4, 10071)= 3.54$, $p=0.00$), Ethnicity ($F(3, 10072)= 19.17$, $p=0.02$), Religion ($F(4, 10071)= 11.68$, $p=0.00$), Marital Status ($F(3, 10072)= 8.36$, $p=0.00$), Education Level ($F(3, 10072)= 34.59$, $p=0.00$), Employment Sector ($F(4, 10071)= 3.32$, $p=0.00$), Income Level ($F(5, 10070)= 9.51$, $p=0.00$), Residential Area ($F(45, 10030)= 29.51$, $p=0.00$), and Residence Type ($F(9, 10065)= 42.91$, $p=0.00$). Further analysis using the post-Hoc HSD test revealed significant differences in Perceived Safety (POS) across various demographic factors. Age-wise, individuals in their 40s reported the highest POS ($M=27.57$, $SD=3.33$). Ethnicity also showed variations, with Malays exhibiting the highest POS ($M=27.58$, $SD=3.31$). Marital status was another key factor, with married individuals reporting the highest POS ($M=27.49$, $SD=3.33$). Education level significantly influenced POS, with university/college graduates feeling the safest ($M=27.61$, $SD=3.50$). Employment status also played a role, where unemployed individuals reported the highest POS ($M=27.65$, $SD=3.95$). Income level showed clear differences, with those earning above RM10,000 demonstrating the highest POS ($M=28.26$, $SD=3.55$). In terms of residential factors, Putrajaya residents reported the highest POS ($M=32.92$, $SD=3.19$), while individuals living in

detached houses (bungalows) felt the safest (*M*=28.51, *SD*=3.84). These findings highlight the demographic and environmental factors influencing POS.

DISCUSSION

The findings emphasize the significant role of age in shaping Perceived Safety (POS), particularly among individuals in their 40s and 50s. Notably, those in their 40s report a higher POS than those in their 50s, suggesting that financial stability may influence safety perceptions. A small percentage of individuals in their 40s earn above RM10,000 (6%), with others earning between RM9001–RM10,000 (6%), RM6001–RM8000 (18%), and RM2001–RM4000 (29%). At this stage, many have established careers, gained professional recognition, and developed essential skills, contributing to greater confidence and well-being. This aligns with Garcia, Mangold, & Johansson (2024), who found that improved socioeconomic conditions correlate with higher perceived safety. Their research suggests that better economic stability within a neighborhood enhances individuals' sense of security, reinforcing the link between financial well-being and POS. This indicates that policies aimed at improving livelihood stability, professional development, and neighbourhood-level socio-economic support may indirectly enhance community safety perceptions. Local Authorities could leverage this insight by integrating livelihood enhancement and community capacity building into Safe City planning strategies.

Ethnicity also plays a pivotal role in safety perceptions, with Malays reporting higher POS, potentially due to their strong social ties and community connections. With 73% of respondents being Malays, cultural factors emphasizing close family and friendships may contribute to this heightened security perception. Regarding marital status, the study identified significant differences in Perceived Safety (POS) between single and married individuals, with married respondents reporting higher POS. This may be attributed to emotional support and shared life experiences that enhance feelings of security. Financial stability also plays a role, as marriage often leads to combined financial resources. The study found that 5% of married respondents earn more than RM10,000 or RM9001–RM10,000 monthly. Additionally, married individuals were more likely than single respondents to earn between RM4001–RM6000, reinforcing the link between financial stability and a stronger sense of security. These findings imply that community cohesion and family-oriented neighbourhood development may serve as soft security mechanisms. Therefore, Local Authorities could strengthen neighbourhood networking programmes, social participation platforms, and community-based surveillance systems to enhance collective efficacy and trust.

The correlation between income levels and education is significant in Perceived Safety (POS). ANOVA analysis reveals that respondents with

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university or college education report higher POS than others. Higher education provides access to stable job opportunities with benefits like health insurance and retirement plans, fostering financial and job security. Cross-tabulation analysis further supports this, showing that individuals with higher education earn greater incomes. The t-test results confirm that those earning over RM10,000 have higher POS values. A stable financial position reduces concerns about basic needs such as food, housing, and healthcare, minimizing insecurity. Additionally, financially stable individuals can invest in home security measures like alarms and CCTV, enhancing their sense of safety. This suggests that safety outcomes are not solely determined by physical security infrastructure but are also influenced by socio-economic empowerment. As such, Safe City interventions should be planned in parallel with social development strategies, including targeted upskilling, economic resilience programmes, and inclusion-based urban planning.

The research highlights a significant disparity in Perceived Safety (POS) across residential areas, influenced by the involvement of Local Authorities (PBT). Respondents in Putrajaya report higher POS, reflecting increased public confidence in security, attributed to proactive local authority efforts. This contrasts with earlier findings by Anuar, Bookhari, & Aziz (2012), which highlighted areas needing improvement. However, by 2023, enhanced safety initiatives have significantly improved public perceptions. Insights from in-depth interviews with government agencies such as PDRM, JKM, Plan Malaysia, AADK, and JIM emphasize the importance of an integrated Safe City Program (PBS). Collaboration among authorities has strengthened security measures and fostered a greater sense of safety. Community engagement is crucial for urban security. Norcikeyonn Samuni (2021) stresses that local authority-supported participation enhances community confidence and social functionality. Similarly, studies by Zainudin & Abdul Malek (2010), Talha (2008), and Wang et al. (2019) affirm that community-driven initiatives are more effective in crime prevention than environmental factors, promoting mental well-being through social cohesion and physical activity. This demonstrates that Local Authorities that actively implement visible safety improvements and foster strong inter-agency collaboration tend to achieve higher public confidence. Therefore, Local Authorities with lower POS scores may adopt benchmarking and replication of best practices from high-performing cities such as Putrajaya, particularly in street surveillance, nighttime illumination, maintenance quality, and community safety governance

The Perception of Safety (POS) varies significantly across different housing types, including cluster homes, terraced houses, urban houses, apartments, semi-detached houses, condominiums, and "Zero Lot Boundary" homes. Single-family homes (bungalows) report the highest POS, likely due to the financial stability of their residents. Higher income levels enable individuals

to afford such residences and invest in security measures like CCTV and alarms. Understanding this correlation between income and residential security can provide valuable insights for urban planning and sociological research. This supports the need for differentiated CPTED strategies tailored to different residential forms. For example, apartment-based settings may prioritize surveillance, lighting, and controlled access, while landed housing zones may emphasise perimeter visibility, neighbourhood watch coordination, and defensible space design.

Limitations and Future Research

This study is based on self-reported perceptions, which may be influenced by personal experience and media exposure rather than actual crime rates. Although the sample is large, certain groups may still be underrepresented, indicating possible non-response bias. In addition, the cross-sectional design limits the ability to observe changes in safety perception over time. Future research may employ longitudinal tracking or combine perception data with crime statistics and built environment indicators to provide a more integrated understanding of urban safety.

CONCLUSION

The findings emphasize the need for age-specific urban safety policies, given the significant impact of age on Perceptions of Safety (POS). Notably, individuals in their 40s report higher POS than those in their 50s, likely due to financial stability gained through career advancement. Income analysis shows a substantial percentage of individuals in their 40s earning above RM10,000, reflecting professional success and stability. This financial empowerment boosts confidence and well-being, reinforcing the importance of tailored urban safety policies to further support and protect this age group.

The study highlights the influence of social and cultural factors on safety perception. Ethnicity plays a key role, with Malays reporting higher Perceived Safety (POS), likely due to their strong community bonds and predominant representation. Marital status also impacts POS, as married individuals feel more secure, possibly due to emotional support and financial stability. Education is another crucial factor, with higher educational attainment linked to greater perceived security. This is attributed to better job opportunities and financial stability, reinforcing the connection between income and education. These findings emphasize the need for education-focused policies to enhance urban safety, making it a priority for policymakers and researchers.

Geographic variations in Perceived Safety (POS) are evident, with Putrajaya residents reporting higher safety levels than those in other Local Authorities (PBTs). This highlights the importance of collaborative efforts by

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local authorities in enhancing security and community well-being. Additionally, community leaders and their initiatives play a crucial role in crime prevention and urban safety. Their effectiveness highlights a key focus area for policymakers, community leaders, and NGOs in strengthening safety measures and fostering secure living environments.

The research confirms the positive impact of the Safe City Program in Malaysia. Its successful implementation has enhanced local authorities' and communities' understanding and engagement. Collaboration between the government, NGOs, and the community has significantly improved safety and well-being, demonstrating the program's effectiveness and its potential as a model for future urban safety initiatives.

ETHICAL COMPLIANCE STATEMENT

This research was conducted in accordance with institutional ethical standards. Ethical approval was granted by the Universiti Teknologi MARA Research Ethics Committee (Ref:REC/07/2023(ST/MR/168)). Participation was voluntary, and informed consent was obtained from all respondents.

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Appendix 1: Sampling Details for Respondent Numbers

NO	State	Local Authorities	Total Population	Population (1%)	Respondents	
					10%	7%
1	Johor	Majlis Bandaraya Johor Bahru	1,177,700	11,777	1,177	824
		Majlis Bandaraya Iskandar Puteri				
		Majlis Bandaraya Pasir Gudang				
2	Melaka & Negeri Sembilan	Majlis Bandaraya Melaka Bersejarah	409,400	4,094	409	286
		Majlis Perbandaran Alor Gajah	186,600	1,866	186	130
		Majlis Perbandaran Jasin	111,100	1,111	111	77
		Majlis Perbandaran Seremban	493,100	4,931	493	345
		Majlis Perbandaran Nilai				
3	Kedah, Pulau Pinang & Perlis	Majlis Bandaraya Alor Setar	270,400	2,704	270	189
		Majlis Perbandaran Kulim	245,300	2,453	245	171
		Majlis Perbandaran Sungai Petani	392,800	3,928	392	274
		Majlis Perbandaran Kubang Pasu	185,200	1,852	185	129
		Majlis Bandaraya Pulau Pinang	587,500	5,875	587	411
		Majlis Bandaraya Seberang Perai	687,100	6,871	687	480
		Majlis Perbandaran Kangar	224,600	2,246	224	157
4	Perak	Majlis Bandaraya Ipoh	653,900	6,539	653	457
		Majlis Perbandaran Manjung	173,700	1,737	173	121
		Majlis Perbandaran Taiping	197,400	1,974	197	138
		Majlis Perbandaran Teluk Intan	102,800	1,028	102	71
5	Selangor, Kuala Lumpur & Putrajaya	Majlis Bandaraya Shah Alam	1,636,800	16,368	1636	1145
		Majlis Bandaraya Subang Jaya				
		Majlis Bandaraya Petaling Jaya				
		Majlis Perbandaran Ampang Jaya	1,009,500	10,095	1,009	706

NO	State	Local Authorities	Total Population	Population (1%)	Respondents	
					10%	7%
		Majlis Perbandaran Kajang				
		Majlis Perbandaran Klang	774,500	7,745	774	542
		Majlis Perbandaran Selayang	679,500	6,795	679	475
		Dewan Bandaraya Kuala Lumpur	1,397,900	13,979	1,397	978
		Perbadanan Putrajaya	72,000	720	72	50
6	Kelantan & Terengganu	Majlis Perbandaran Kota Bharu	408,400	4,084	408	285
		Majlis Bandaraya Kuala Terengganu	167,700	1,677	167	117
		Majlis Perbandaran Kemaman	144,500	1,445	144	101
		Majlis Perbandaran Dungun	112,300	1,123	112	78
		Majlis Daerah Besut	108,900	1,089	108	76
7	Pahang	Majlis Bandaraya Kuantan	405,700	4,057	405	283
		Majlis Perbandaran Temerloh	118,600	1,186	118	83
		Majlis Daerah Maran	77,700	777	77	54
8 & 9	Sabah & Wilayah Persekutuan Labuan	Dewan Bandaraya Kota Kinabalu	301,100	3,011	301	210
		Majlis Perbandaran Sandakan	206,600	2,066	206	144
		Majlis Perbandaran Tawau	187,900	1,879	187	131
		Majlis Daerah Semporna	65,300	653	65	45
		Perbandaran Labuan	60,200	602	60	42
10 &11	Sarawak	Dewan Bandaraya Kuching Utara	478,000	4,780	478	334
		Majlis Bandaraya Kuching Selatan				
		Majlis Perbandaran Padawan				
		Majlis Bandaraya Miri	191,400	1,914	191	133
		Majlis Perbandaran Sibu	187,600	1,876	187	131
		TOTAL	**14,890,700**	**148,907**	**14,890**	**10,403**

Source: Author

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THE CHALLENGES OF IMPLEMENTING GREEN ACTIVITIES IN KINDERGARTEN TOWARDS A SUSTAINABLE ENVIRONMENT

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Abstract

This study is novel in its focus on Malaysian kindergartens, a context where sustainability education remains underexplored. By situating the challenges within Malaysia's policy frameworks such as the National Preschool Curriculum Standards and the country's sustainability agenda, the research highlights localized implications for early childhood education. Using survey data from 80 stakeholders (kindergarten owners, teachers, institutional members, and parents) in Perak, the study identifies six major barriers: institutional resistance, resource constraints, curriculum integration issues, parental engagement, cultural norms, and policy gaps. While descriptive statistics provided valuable insights, the reliance on quantitative summaries is acknowledged as a limitation and future research should incorporate inferential analysis and triangulation with qualitative data to strengthen validity. The findings underscore the need for targeted awareness campaigns, dedicated funding, curriculum reform, parental involvement, and culturally responsive pedagogy. By emphasizing localized challenges and policy implications, this study contributes to advancing sustainable practices in Malaysian kindergartens and offers practical recommendations for policymakers, educators, and communities to foster eco-consciousness among young learners.

Keywords: Sustainable environment, Green activities, Kindergarten

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INTRODUCTION

Kindergartens serve as foundational spaces for instilling environmental awareness and sustainable behaviors in children. Introducing green activities in these formative years not only cultivates eco-consciousness but also nurtures lifelong habits that contribute to sustainable living. Early childhood is a critical period for shaping attitudes and behaviors, and incorporating sustainability into kindergarten curricula can have a lasting impact on children's understanding and commitment to environmental stewardship (Davis, J. M., & Elliott, S. (2018). Despite the clear benefits, the successful implementation of green initiatives in kindergarten settings faces numerous challenges. These challenges range from institutional barriers, such as lack of administrative support and inadequate teacher training, to logistical constraints, including limited resources and funding (Hashim, S. Z., Mazlan, D., Ahzahar, N., Mizal, N., Jamaludin, N., & Rijal, N. S. (2023). Understanding these challenges is essential for developing effective strategies to promote sustainability in early childhood education (Zhang, J., & Rahman, M. N. B. (2024). The aim of this research is to thoroughly investigate the challenges associated with implementing green activities in kindergarten settings and to propose viable solutions for overcoming these obstacles. By doing so, the research seeks to advance sustainable practices in early childhood education, ensuring that children develop a strong foundation in environmental awareness and sustainable behaviors from a young age. These challenges may include institutional barriers, such as lack of support from school administration, and logistical constraints, such as limited resources and funding (Constantin, F.-V., Oprea, T.-M., Opricescu, C., & Ștefan, I. (2024). By examining the root causes of these challenges, the research seeks to understand the factors that contribute to the difficulties faced by educators and institutions in integrating green activities into the kindergarten curriculum (Somerville, M., & Williams, C. (2015). The research aims to offer practical and evidence-based solutions to address the identified challenges. These solutions may involve policy recommendations, strategies for teacher training, and suggestions for resource allocation to support the effective implementation of green initiatives (García-González, E., & Schenetti, M. (2022). Ultimately, the research is to contribute to the broader goal of sustainable education by providing insights and recommendations that can help kindergartens foster eco-consciousness and sustainable behaviors in children. By addressing the challenges and proposing solutions, the research seeks to create a more supportive environment for green activities in early childhood education. By achieving these objectives, the research hopes to pave the way for more effective and widespread adoption of sustainable practices in kindergartens, thereby promoting a culture of environmental stewardship from an early age.

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RESEARCH BACKGROUND

Learning environments can serve as active teaching tools, where the built, natural, and cultural surroundings are not passive spaces but integral to learning across disciplines such as physics, geometry, botany, and ecology (Taylor, 1993). By engaging with their environment, teachers, students, and parents learn to "read" and interact with it at multiple levels. Play, as the most natural form of childhood learning, further enhances this process by fostering cognitive, physical, and social skills through direct experiences with natural and man-made elements (Putney, 2016). Integrating authentic environmental projects into the curriculum strengthens environmental awareness and allows students to gather data, investigate solutions, and reflect on conservation successes and failures (Putney, 2016). These projects extend beyond science, connecting with social sciences and history to help children understand how communities have addressed environmental challenges over time. Such activities not only enrich classroom learning but also influence parents and communities, as children share their experiences and projects at home. In this way, green activities become transformative, embedding sustainability into education while fostering broader community engagement.

Challenges of Implementing Green Activities

Institutional Resistance and Lack of Awareness

Institutional resistance remains a major barrier, as sustainability is often treated as supplemental rather than core in early education. Administrators and policymakers may undervalue its relevance, requiring awareness campaigns, policy advocacy, and integration of green initiatives into institutional priorities (G. D. et al., 2020; Birkes Builders, 2024). The success of such initiatives also depends on teacher capacity. Insufficient guidance and weak collaboration hinder implementation (Zhang & Rahman, 2024), while forest education and nature-based learning can enrich curricula and child development (García-González & Schenetti, 2022). Professional development should therefore equip teachers with practical strategies and foster collaboration to embed sustainability effectively.

Resource Constraints and Funding Challenges

The implementation of green activities in kindergarten settings is faced with significant hurdles due to resource restrictions. Insufficient financial resources, substandard infrastructure, and a dearth of resources impede educators' capacity to create and maintain programmes with an environmental focus (Sulzakimin, M.,2019). To overcome resource limitations, it is imperative that green programmes have special funding, that eco-friendly materials and infrastructure be purchased, and that instructors receive thorough training in green pedagogy.

Sustainable materials and technologies often come with a higher price tag compared to conventional options. This financial barrier can deter developers and builders from adopting green practices, despite the long-term savings and environmental benefits. Financial incentives and subsidies can play a crucial role in mitigating these costs and encouraging the adoption of green building practices (Planning Malaysia Journal, 2024).

Curriculum Integration and Time Constraints

Integrating green activities into the kindergarten curriculum requires careful planning and alignment with educational standards. García-González and Schenetti (2022) suggested that incorporating forest education concepts and nature-based learning can enhance the curriculum and promote holistic child development. However, achieving this integration requires a multidisciplinary approach and collaboration among educators, policymakers, and curriculum developers. Elliott et al. (2016) emphasized the importance of examining environmental education in early childhood education services to identify effective strategies for curriculum integration. This includes developing age-appropriate activities that align with learning objectives and standards, as well as providing teachers with the flexibility to adapt the curriculum to their specific classroom contexts. Additionally, integrating green activities into the curriculum can be supported by creating thematic units that connect environmental education with other subject areas, such as science, math, and language arts.

Parental Engagement and Community Involvement

Parental involvement is vital for the success of green activities in kindergartens, yet inconsistent support often hinders implementation. Public kindergartens benefit from community backing, while private ones face planning challenges due to limited parental engagement (Zhang & Rahman, 2024). Educators' use of outdoor learning environments is also shaped by parental support (Ernest, 2013). Strategies such as workshops, awareness programs, and collaborative activities can strengthen partnerships between parents and educators, fostering a supportive environment for sustainability.

Cultural and Societal Norms

Cultural and societal norms can act as barriers to the successful implementation of green activities in kindergartens. In some communities, there may be a lack of emphasis on environmental conservation or a prevailing attitude of consumerism that contradicts sustainable values. Culturally sensitive pedagogy that places environmental education within regional contexts, encourages alternative viewpoints on consumption and lifestyle decisions, and develops critical thinking

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abilities to question social norms that threaten sustainability is necessary to break down cultural barriers.

Policy and regulatory

Policy and regulatory frameworks are critical for implementing green activities in kindergartens. Sustainability in early childhood often remains marginal due to unclear policies (Davis & Elliott, 2018). Strong frameworks can provide supportive environments, address modern challenges, and foster sustainable mindsets among children (Falkiewicz-Szult, 2014; Hashim et al., 2023). Policymakers play a key role by developing guidelines, allocating resources, and promoting collaboration (Aboud, 2024; Kamarulbaid, 2021). Effective regulations should also include monitoring mechanisms to ensure consistent integration of environmental education (Falkiewicz-Szult, 2014).

Components of Green Activities for Kindergarten

Table 1 outlines components of green activities in kindergartens, combining theoretical insights and empirical evidence to ensure both scientific and practical relevance. Awareness can be raised through workshops and sustainability-focused curricula (Ardoin & Bowers, 2020). Resource management includes recycling programs and school gardens with native plants (Green and Prosperous, 2025; Teach Starter, 2023). Energy efficiency involves LED lighting, efficient appliances, and staff–student education (Hoople et al., 2020). Water conservation can be promoted with low-flow fixtures, maintenance, and water-saving activities (Iwasaki, 2022). Green spaces and biodiversity are enhanced through gardens and nature walks (Iojă et al., 2014; Teach Starter, 2023). Finally, parental and community engagement is strengthened via events, workshops, and volunteer programs (Salter et al., 2019).

Table 1: Components of Green Activities for Kindergarten

Authors	Awareness and Education	Material Resource Management	Energy Efficiency	Water Conservation	Green Spaces and Biodiversity	Parental and Community Engagement
Nicole M. Ardoin, Alison W. Bowers (2020)	TRUE					
Green and Prosperous, 2025		TRUE				
Teach Starter, 2023		TRUE				TRUE
Hoople et al., 2020			TRUE			
Iwasaki, S. (2022				TRUE		
Cristian Ioan Iojă et al., (2014)					TRUE	
Salter, R et. al., 2019						TRUE

METHODOLOGY

Based on the analysis provided, the following is a comprehensive methodology section for the research on challenges in implementing green building activities in kindergartens:

Research Design

This study employed a quantitative survey design to examine the challenges of implementing green building activities in kindergartens. The use of structured questionnaires allowed for systematic data collection from multiple stakeholder groups, including kindergarten owners, teachers, institutional members, and parents. This design was chosen to provide a broad overview of the frequency and distribution of challenges encountered, thereby offering a clear descriptive profile of the issues faced in practice. However, the study relies primarily on descriptive statistics (means, frequencies, and distributions) to analyse the data. While this approach provides valuable insights into the prevalence of specific challenges, it limits the ability to draw deeper inferences about relationships between variables or differences across stakeholder groups.

Participants

The focus group of this research consists of kindergarten operators, teachers and institutional department members around Kinta and Perak Tengah, Perak. Total number of respondents is 80, kindergarten owners: 20, teachers: 50, institutional department members: 10 and parents: 20.

A significant number fall into this category, suggesting they have enough experience to understand the practical aspects of implementing green building activities but may still face learning curves. More experienced individuals who can provide deeper insights into the long-term challenges and benefits of green building activities and might offer valuable historical perspectives and long-term views on the evolution of green building activities. Parents play a crucial role in the successful implementation of green building activities in kindergartens. Their perspectives, support, and involvement can significantly influence the effectiveness and sustainability of these initiatives

Sampling Method

A purposive sampling technique was used to select participants who have direct involvement. This method ensures that the data collected is relevant and rich in context regarding the specific challenges faced. All the participants were competent to answer all the questions and involved directly with the situation.

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Data Collection Methods

Surveys:

Questionnaire: A structured questionnaire was designed to collect quantitative data on the frequency and types of challenges encountered. The questionnaire included closed-ended questions to gather specific information on five key challenges: lack of awareness, resource constraints, parental engagement, social norms, and curriculum integration. The survey was distributed electronically to participants to ensure a wide and efficient reach.

Data Analysis

Quantitative Analysis:

Descriptive Statistics: The survey data were analysed using descriptive statistics to determine the frequency and distribution of each challenge. This included calculating the mean, median, and mode for each type of challenge. Comparative analysis was conducted to examine differences in challenges across the three respondent groups (owners, teachers, institutional department members and parents).

Limitations

This study's findings are limited by a modest sample size and reliance on self-reported data, which may affect generalizability. Future research should expand the sample and include longitudinal or qualitative methods to enhance validity. Despite these constraints, the methodology offers meaningful insights into challenges and strategies for implementing green building activities in kindergartens. This study did not require formal institutional ethics approval as it involved minimal risk and focused on professional stakeholders (kindergarten owners, teachers, institutional members, and parents). However, to ensure compliance with research ethics standards, informed consent was obtained from all participants prior to data collection. Participants were assured of confidentiality, voluntary participation, and the right to withdraw at any time. No personal identifiers were recorded, and data were used solely for academic purposes.

RESULT

The survey results (Figure 1) highlight six primary challenges in implementing green building activities in Malaysian kindergartens. Among these, cultural and societal norms (97 respondents) and curriculum integration and time constraints (85 respondents) emerged as the most pressing barriers, followed closely by policy and regulatory frameworks (84 respondents) and resource constraints (77 respondents). Institutional resistance (72 respondents) and parental engagement

(76 respondents) were also significant, underscoring the multifaceted nature of the obstacles faced.

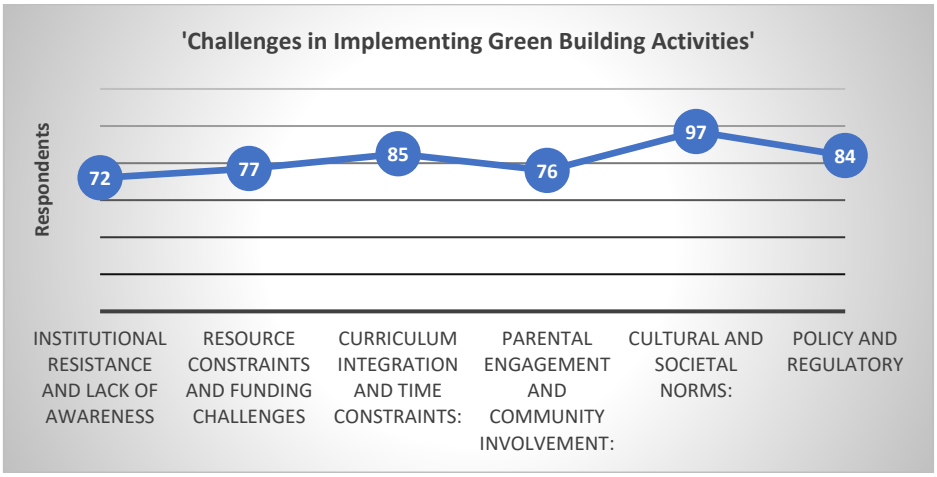


Figure 1: Challenges in Implementing Green Building

Institutional Resistance and Lack of Awareness (72 respondents):
This suggests that there is insufficient knowledge or understanding about green building activities among the stakeholders involved. It indicates a need for more educational initiatives and awareness campaigns to inform and educate people about the importance and benefits of green building.

Resource Constraints and Funding Challenges (77 respondents):
Resource constraints are the most frequently cited challenge. This could include a lack of financial resources, materials, or infrastructure necessary to implement green building activities. Addressing this challenge may require increased funding, better resource allocation, and perhaps more efficient use of existing resources.

Curriculum Integration and Time Constraints (85 respondents):
Integrating green building concepts into the educational curriculum is another significant challenge. This highlights the need for curriculum development and teacher training to embed sustainability effectively. It may also require alignment with educational standards and policies.

Parental Engagement and Community Involvement (76 respondents):
The data indicates that there is some difficulty in getting parents involved in green building activities. This could be due to lack of interest, understanding, or time

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on the part of the parents. Efforts to engage parents might include informational sessions, workshops, and involving them in school activities related to green building.

Cultural and Social Norms (97 respondents):
Social norms represent a smaller but significant barrier. This challenge might stem from societal attitudes and behaviours that are resistant to change or not supportive of green building initiatives. Overcoming this may involve broader cultural shifts and the promotion of green building as a community value.

Policy and Regulatory (84 respondents):
The finding that 86 respondents agreed that policy and regulatory frameworks are significant challenges in implementing green building activities in kindergartens highlights a critical barrier to sustainability efforts in early childhood education settings. One of the primary issues identified by respondents is the absence of clear and comprehensive policies and guidelines that support the implementation of green building activities. Without well-defined regulations, kindergartens may struggle to understand the requirements and best practices for integrating sustainability into their operations.

DISCUSSION

The data highlights several key challenges in implementing green building activities, with resource constraints being the most significant. Addressing these challenges requires a multifaceted approach involving increased awareness, better resource management, enhanced parental engagement, cultural shifts, and curriculum integration. By focusing on these areas, stakeholders can create a more supportive environment for green building initiatives, ultimately leading to more sustainable educational practices.

Institutional Resistance and Lack of Awareness
The finding that 72 respondents identified institutional resistance reflects limited awareness and prioritization of sustainability within early childhood education. This challenge aligns with the broader issue of environmental education being treated as supplemental rather than core in Malaysia's Preschool Curriculum Standards (KSPK). Addressing this requires targeted awareness campaigns and professional development programs for teachers, alongside policy directives that embed sustainability into institutional goals.

Resource Constraints and Funding Challenges
Resource limitations, cited by 77 respondents, remain a critical barrier. Implementing green initiatives often requires financial investment in eco-friendly infrastructure, materials, and training. Without dedicated funding streams, kindergartens struggle to sustain such practices. This finding reinforces the need for government grants, private partnerships, and incentives aligned with Malaysia's *Education Blueprint 2013–2025*, which emphasizes resource equity and innovation in education.

Curriculum Integration and Time Constraints
Curriculum integration was reported by 85 respondents as a major challenge. Current preschool curricula lack explicit sustainability modules, making it difficult for teachers to incorporate green activities within existing time and subject constraints. Aligning sustainability education with KSPK standards and developing thematic units that connect environmental topics with science, mathematics, and language arts would help overcome this barrier. Teacher training programs should also be expanded to build capacity for integrating sustainability into daily classroom practice.

Parental Engagement and Community Involvement
Parental involvement, noted by 76 respondents, is essential for reinforcing sustainability values beyond the classroom. Limited engagement reflects both time constraints and a lack of awareness among parents. Strengthening communication strategies through newsletters, workshops, and community-based projects can foster collaboration between schools and families. Linking these efforts to local authority initiatives, such as municipal recycling programs, can further embed sustainability into community life.

Cultural and Social Norms
The most frequently cited challenge, with 97 respondents, relates to cultural and societal norms. Prevailing consumerist attitudes and limited emphasis on conservation hinder the adoption of sustainable practices. Addressing this requires culturally responsive pedagogy that situates environmental education within Malaysian values and traditions. Encouraging critical reflection on consumption and lifestyle choices can help shift societal attitudes toward sustainability.

Policy and Regulatory
Policy gaps, identified by 84 respondents, highlight the absence of clear guidelines for integrating sustainability into early childhood education. Without robust regulatory frameworks, kindergartens lack direction and support for

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implementing green initiatives. Policymakers must develop comprehensive guidelines, allocate resources, and establish monitoring mechanisms to ensure consistent adoption of sustainability practices. This aligns with Malaysia's national sustainability agenda and supports the broader goal of embedding environmental stewardship across all levels of education.

Table 2: Strategic Actions by Challenge Area

Challenge Area	Strategic Action	Stakeholders Involved
• Institutional Resistance	• Awareness campaigns, policy advocacy	• MOE, JPN, Kindergartens
• Resource Constraints	• Grants, partnerships, efficient budgeting	• Government, NGOs, Private Sector
• Curriculum Integration	• Curriculum reform, teacher training	• MOE, Curriculum Developers, Educators
• Parental Engagement	• Communication tools, volunteer programs	• Schools, Parents, Community Leaders
• Cultural Norms	• Community education, media engagement	• Local Authorities, NGOs, Cultural Groups
• Policy & Regulatory	• National guidelines, funding, monitoring	• Policymakers, Education Ministries

This action plan outlines six key challenges and targeted strategies for integrating green building activities in Malaysian kindergartens. Institutional resistance requires awareness campaigns led by MOE, JPN, and schools. Resource constraints demand funding via grants and partnerships. Curriculum integration calls for reform and teacher training. Parental engagement needs better communication and involvement. Cultural norms must shift through education and media. Policy gaps require national guidelines and monitoring. Success depends on coordinated efforts across sectors to embed sustainability in early education.

CONCLUSION

As shown in Figure 1, cultural and societal norms (97 respondents) and curriculum integration and time constraints (85 respondents) were identified as the most pressing barriers to implementing green activities in Malaysian kindergartens. Policy and regulatory gaps (84 respondents) and resource constraints (77 respondents) also emerged as significant challenges, while institutional resistance (72 respondents) and limited parental engagement (76 respondents) further complicated efforts. These findings underscore the multifaceted nature of sustainability implementation in early childhood education, where cultural attitudes, curriculum design, and policy support intersect. By situating these challenges within Malaysia's localized context, the study highlights the need for systemic reforms. Aligning sustainability education with the *Preschool Curriculum Standards (KSPK)*, embedding green practices into national planning frameworks, and providing targeted funding and teacher training are critical steps forward. Strengthening parental engagement through community-based initiatives and culturally responsive pedagogy can also help shift societal norms toward sustainability. Ultimately, this study contributes to advancing sustainable practices in Malaysian kindergartens by emphasizing localized challenges and policy implications. By addressing the barriers identified in Figure 1, policymakers, educators, and communities can foster eco-consciousness among young learners, thereby supporting Malaysia's broader sustainable development agenda and cultivating a generation committed to environmental stewardship.

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CONSTRUCTION CHARACTERISTICS OF TRADITIONAL VILLAGES FROM A RESILIENCE PERSPECTIVE IN CENTRAL JIANGXI, CHINA: CASE STUDIES OF ZHUQIAO AND YOUDIAN VILLAGES

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Abstract

Despite centuries of development, many traditional villages in China retain complete settlement forms and traditional buildings, reflecting strong spatial resilience. The village construction system is vital for spatial resilience, yet research on traditional village resilience remains limited. This paper explores traditional village construction's spatial and cultural characteristics through the lens of rural resilience, using Zhuqiao and Youdian Villages in Jiangxi Province as case studies to support heritage preservation and transmission. This study employs literature research, fieldwork, and space syntax analysis to examine the construction characteristics of traditional villages. Key findings include: (1) Traditional villages rely on production space and choose high ground and shallow water to live in, forming a pattern of "Forest-Village-Field-Water." (2) The overall layout of the villages is compact and closed externally to ensure defence and open internally to promote communication. The public space assumes essential spiritual and religious functions, enhancing the village's stability and continuity. (3) The water management system is the core wisdom of village construction. It plays a vital role in improving the village's adaptability to natural disasters and enhancing the comfort of the living environment. These findings offer insights into modern village construction systems.

Keywords: Construction Characteristics, Resilience Theory, Traditional Villages, Youdian and Zhuqiao Villages

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INTRODUCTION

During the long development of China's farming civilisation, numerous traditional villages with rich historical and cultural value gradually emerged. Since 2012, national rural revitalisation programmes—such as the Catalogue of Traditional Villages in China—have further promoted the preservation of these settlements, providing official recognition and policy support (Jia et al., 2023; Yuan et al., 2021; Ou et al., 2022; Jing et al., 2024). However, contemporary village construction has increasingly shifted from adapting to natural conditions toward reshaping them, leading to ecological disturbance and the gradual homogenisation of rural landscapes (Xiao & Yong, 2017). The concept of "resilience," defined as the capacity of socio-ecological systems to adjust and respond to external pressures (Walker et al., 2004), offers a valuable perspective for guiding sustainable rural development(Yan & Lu, 2017). Traditional village construction embodies accumulated local wisdom in terrain adaptation, water management, ecological practices, livelihoods, and cultural norms, yet systematic research linking these elements to resilience theory remains limited.

This study examines two representative villages in central Jiangxi and adopts a resilience perspective to identify their spatial characteristics and formation mechanisms across both physical and social dimensions, to inform a more harmonious human–land relationship in contemporary rural development. Although the analysis is based on two case sites, the in-depth qualitative evidence enables a nuanced understanding of place-specific mechanisms. In line with case-study methodology, the findings are not intended to be statistically generalisable but to offer analytical insights applicable to similar contexts. These insights can therefore support comparative research and guide resilience-oriented settlement planning in culturally and geographically comparable settings.

LITERATURE REVIEW

Research on Rural Community Resilience

Rural community resilience concentrates on the capacity of rural communities to cope with disasters. It represents the intrinsic dynamics of rural community systems to adapt and thrive in adversity (Imperiale & Vanclay, 2016). In particular, the main elements of the research include analysing the key elements of social, economic, and environmental capital in rural communities' flood resilience using the Relative Importance Index (RII) method (Omar Chong & Kamarudin, 2023). It also utilises the measurement of community capacity to cope with disasters through community resilience modelling (Cutter et al., 2008). In the context of globalisation and urbanisation, social, economic and political changes have shifted the discussion of rural community resilience from a single disaster perspective to an integrated perspective. It explores the capacity of rural

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communities to adapt and develop as a whole (Yan & Lu, 2017). Furthermore, specific topics mostly revolve around the development path of community resilience and the selection of its assessment indicators. This emphasises the shift from the physical environment to the role of society and people and the construction of an indicator system that includes institutional resilience, infrastructure resilience, economic resilience, social resilience, and other aspects (Sharifi, 2016).

In addition, community resilience is included in rural policy-making to stop population loss in rural areas and to maintain and improve the living and service levels in rural areas (Imperiale & Vanclay, 2016). As a particular part of rural communities, resilience research on traditional villages is focused chiefly on the adaptability of settlements to the water environment. This is mainly in the watery areas of the South (Wang, 2020) and the water-scarce regions in the Northwest (Ou et al., 2022), and other specific geographical areas or typical settlements as an example. It summarises the attributes of the water ecosystem adaptability of the settlements from the aspects of settlement siting and camping, the overall layout, and the farmland and water conservancy. This includes the influencing factors and the revelation of modern floods and flooding disasters (Guo et al., 2022; Han et al., 2023).

Research on Traditional Villages in Jiangxi Province

Jiangxi, China, is a prominent province rich in traditional villages, both in number and value. Jiangxi's geography, surrounded by mountains on three sides, makes external transportation less convenient and causes economic development to be relatively lagging behind. This is also why many ancient villages with complete layouts, stable structures, and rich cultures have been preserved during the process of urbanisation. As of 2023, 413 ancient villages in Jiangxi have been listed in China's Catalogue of Traditional Villages. This is in addition to one model city and three model counties for the concentrated and continuous protection and usage of traditional settlements.

Existing research has achieved relatively affluent results in the spatial characterisation of traditional settlements. At the macro level, the spatial layout, spatio-temporal evolution characteristics (Chen et al., 2021; Hu et al., 2021), and site selection characteristics (Li et al., 2018) of traditional villages in Jiangxi have been explored in depth using Geographic Information System (GIS) tools. At the micro level, the research focuses on case studies revolving around the rationality analysis of village site selection (Zhou et al., 2022), the ecological wisdom of water management and its inspiration to contemporary times (Xu et al., 2017), the selection of building materials for traditional architecture (Yang & Long, 2021), and the characteristics of façade (Duan et al., 2018). However, current research focuses on traditional settlements, mainly in terms of physical space. It

pays less attention to the natural, social, and economic environments in which villages are situated and the wisdom-building methods embedded in their interactions with human beings.

METHODOLOGY

Choice of Research Locations

This research selected Zhuqiao and Youdian Villages in Jinxi County, central Jiangxi Province, which exhibit significant spatial and social resilience characteristics, as research samples. Both villages are listed in the List of Famous Historical and Cultural Chinese Villages and the List of Traditional Chinese Villages for their complete spatial patterns and traditional architectural features. This highlights their high historical and cultural value and representativeness. In addition, the two villages, in terms of site selection, defence system, streets and lanes, and building layout, unite the survival wisdom of the villagers in coping with the natural environment and social changes. They also fully reflect traditional villages' adaptive capacity and stability in facing external risks and environmental changes. Accordingly, these construction features provide an essential reference for modern village planning and resilient community shaping. The location, building period, topographic feature, surname, economic strength, and number of traditional buildings of the two villages are provided in Figure 1 and Table 1.

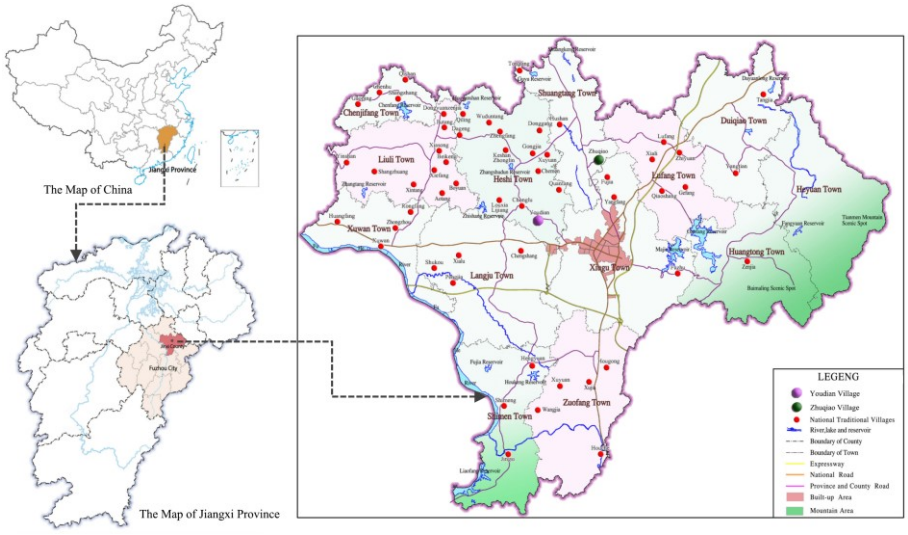


Figure 1: The Location of Zhuqiao and Youdian Villages, Jiangxi Province, China
Source: Author, (2024)

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Table 1: Background of Zhuqiao and Youdian Villages

Aspects	**Zhuqiao Village**	**Youdian Village**
Building period	Late 14th century	Early 15th century
Topographic feature	Flatland	Foothill
Surname	Yu surname	Hu surname
Economic strength	Relatively strong, engaging in business in ancient time	Relatively weak, engaging in agriculture in ancient time
Traditional buildings	109 buildings, mainly built in the Qing Dynasty, including gatehouses, ancestral clans, academies, temples, workshops, residential buildings, etc	38 buildings, mainly built in the Ming Dynasty, including gatehouses, ancestral clans, temples, residential dwellings, etc

Source: Author, 2024

Research Methods

Data for this study were obtained through field surveys, semi-structured interviews, and documents from sources such as Jinxi county records, genealogies, relevant academic papers, media, and official websites. The research methodology combines qualitative and quantitative analysis.

First, primary data were collected through Google Maps, village genealogies, academic papers, and documentaries to gain a preliminary understanding of the villages. Second, a field survey of the two villages was conducted to record the construction elements of the villages using photography, aerial photography, and architectural mapping to collect first-hand data. Third, interviews with villagers were undertaken to supplement and deepen the understanding of some historical information. Fourth, Space syntax provides a quantitative basis for analysing the relationship between spatial layout and social function, but the purpose of this study is explanatory rather than predictive. Integrating space syntax analysis with qualitative evidence from fieldwork, documentary materials, and interviews allows for a more holistic understanding of the construction logic and resilience mechanisms of traditional settlements. Fifth, the qualitative analysis method compares the differences and similarities between the two villages regarding settlement pattern, site selection wisdom, space layout and social functions, and water management system and habitat concept.

RESULTS

Combined with examining research cases, the paper analyses the spatial construction characteristics of traditional settlements from three aspects: settlement pattern and site selection wisdom, spatial layout and social function, and water management system and concept of human habitation, and then explores their potential social semantics.

Settlement Pattern and Site Selection Wisdom

Site selection is the first step in the construction of a settlement. In farming societies, arable land, water, and climate are the most basic human survival resources and decisive factors for the sustainable advancement of villages. Therefore, the fertility of the soil, the flatness of the terrain, the adequacy of the water source and the suitability of the climate are the primary considerations for the construction of the village (Zhou & Feng, 2015). After determining the settlement site, the people conducted the overall construction of the settlement habitat. This includes transforming the landscape environment, opening fields, planting forests, and constructing housing.

Feng Shui is the study of site selection and layout of human settlements formed by ancient people as they adapted to the natural environment. Feng Shui believes the ideal settlement environment should follow the principle of "pillow mountain facing the water, sitting in the north and facing the south" (Zeng & Zhu, 2018). Meanwhile, Pillow Mountain refers to a settlement that faces the water and is surrounded by hills to shield it from the chilly north wind. It is intended to satisfy the daily water consumption and agricultural irrigation needs of the inhabitants. Moreover, sitting in the north and facing the south refers to the orientation of the building for good ventilation and lighting. The siting of Zhuqiao and Youdian Villages reflects traditional Chinese Feng Shui theories and principles. In particular, Zhuqiao Village is in the downstream plain area of the Fuhe River, with a flat terrain. The village faces the endless farmlands in the west, and continuous small hills embrace it in the east. Furthermore, a small stream flows from south to north and eventually joins the Fuhe River (Figure 2-a). Conversely, the topography of Youdian Village is high in the north and west, low in the south and east, built around hills on three sides, with farmland in the southeast and a river passing through in the northwest (Figure 2-b).

According to the literature analysis and the fieldwork on the village, the farmland is the core factor for the site selection of the settlement in the farming era. On this basis, further consideration was given to the coordination between the natural environment of mountains and water and the construction of villages. First, the ancients created fields in the flat land and drew water from rivers for irrigation. Second, the surrounding hills were planted with woods, which, on the one hand, were conducive to soil and water conservation and climate regulation

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and, on the other hand, provided fuel for village life. Third, the villages were built at the foot of the hills, sheltered by the woods, which provided some defence, protected from floods, and had easy access to the fields for cultivation. After long-term construction process, the traditional villages in Jinxi generally formed an overall pattern of "Forest-Village-Field-Water" (Figure 3). This kind of site selection aligns with China's ancient Feng Shui concept. That is to say, it conforms to the natural geographic conditions and environmental patterns, reflecting the harmony between man and nature.

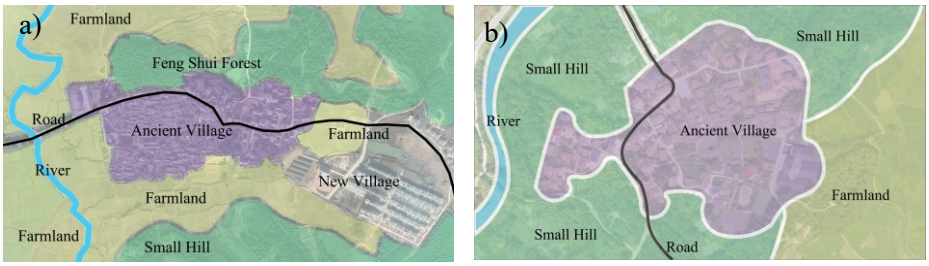


Figure 2: Siting Patterns of Zhuqiao and Youdian Villages
Source: Author, (2024)

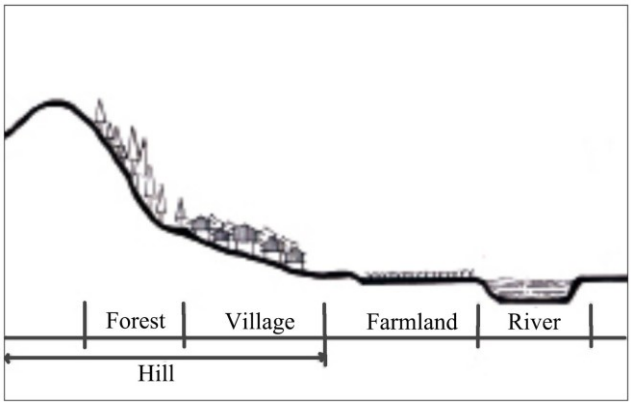


Figure 3: Typical Section of the Traditional Settlements
Source: Author, (2024)

Spatial Layout and Social Function

Streets and lanes are crucial constituents of the internal space of traditional settlements, connecting traffic, public space, and various types of functional buildings. They have a significant function in stabilising the spatial order of villages (Li & Liu, 2020). Spatial syntax, a theory for studying the relationship between spatial organisation and human activities, reveals spatial features and

their intrinsic laws through quantitative analysis (Bill & Sheng, 2014). In this study, we adopt the axial analysis method of spatial syntax and use 'integration degree' and 'selection degree' as the core parameters to analyse the spatial features of the case villages and the connection between space and human activities.

To ensure the scientificity of the study, the topographic map of the villages and satellite image map, combined with on-site research and aerial photography, were integrated into this study and traced in Computer-Aided Design (CAD) to generate the road network and village texture maps of Zhuqiao and Youdian Villages. Subsequently, quantitative analysis was performed using Depthmap software to obtain the integration and selectivity analysis maps of the road axes, with the colours of the maps going from darker to lighter and the values decreasing thereafter.

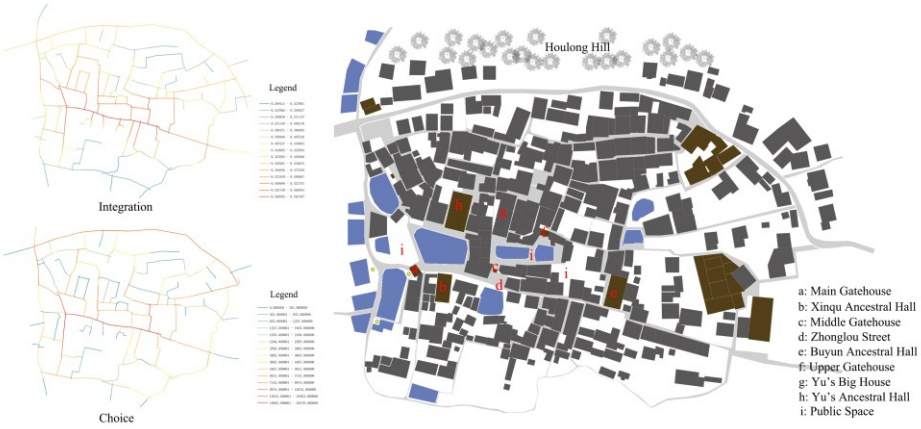


Figure 4: The Space Syntax Analysis of Zhuqiao Village
Source: Author, (2024)

As displayed in Figure 4, the axis system of Zhuqiao Village is more complex. The most integrated red axis is Zhonglou Street, which divides the village into north and south parts and links critical public buildings and spaces such as the main Gate House, Zhonglou, Yu Clan Ancestral Hall, Buyun Ancestral Hall, and Yangzheng Workshop, making it the core area of the village. This area carries critical social functions such as clan rituals, religious ceremonies and festivals. In addition, public buildings such as Canglan Academy and Yu's Big House are distributed near the highly integrated orange axis, further strengthening the village's spatial organisation. The ponds in front of the main, middle, and upper gatehouse indicate that the water environment positively enhances spatial integration. Meanwhile, the blue axes with lower integration are

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located at the edge of the village, have poor accessibility, and are mainly quiet residential areas. Note that the axis with the highest degree of selection is concentrated in the area of the main gatehouse and Zhonglou Street. It serves as the main entrance and passageway of the village. It becomes the core area for villagers to gather, rest, and engage in commercial activities, fully demonstrating its convenience and centrality.

By analysing Figure 5, the spatial pattern of Youdian Village is relatively straightforward, with half buildings and half ponds. The village has a relatively simple axial system that can be summarised as a one horizontal and five vertical layout structure, with access to five north-south alleys through five gatehouses. Conversely, the red and orange axes, which are highly integrated, are mainly located in the 'Jinshi Di,' 'Shilang Fang,' 'Shangshu Fu,' 'Fangbo Xing,' and the Hu Ancestral Hall. Together with the water ponds, these public buildings constitute the public space of Youdian Village, demonstrating the close correlation between social functions and spatial layout. The highly selective area is the cross-street, the central passageway connecting both within and outside of the village and simultaneously connecting the five north-south alleyways with high penetration capacity.



Figure 5: The Space Syntax Analysis of Youdian Village
Source: Author, (2024)

By analysing the spatial syntax of the case villages, the relationship between traditional villages' social roles and their geographical arrangement can be better understood. The general spatial shape of the two villages is compact, illustrating a pattern of 'external closure and internal openness,' balancing defence and communication functions. In particular, external closure helps to protect against natural disasters and external intrusion, while internal openness

promotes villagers' interaction and cooperation. In addition, the analysis reveals that areas with high integration and selectivity tend to have public spaces such as ancestral halls, water ponds, squares and temples. They are the centres of villagers' lives and social lives and essential venues for spiritual and religious activities, particularly ancestral halls, which are vital vehicles for family rituals and strengthen the villages' social stability and cultural continuity.

Water Management System and the Concept of Human Habitation

Water management is an adaptive hydrological regulation and sustainable use based on the systematic knowledge of natural elements such as geography, environment, climate and hydrology. It aims to satisfy the demands of production and life, spirituality and culture, as well as disaster prevention and avoidance (Ou et al., 2022). Traditional villages' water management systems include diversion and storage (Xu et al., 2017). Diversion comprises: firstly, the diversion of the water system on the village's periphery to prevent flooding; secondly, the construction of the village's internal drainage system to reduce waterlogging caused by heavy rainfall. Water storage is mainly reflected in the village's pond system layout. Thus, designing ponds in low-lying areas has the functions of storing and collecting rainwater as well as meeting the multiple needs of daily life, agricultural irrigation, and ecological maintenance.

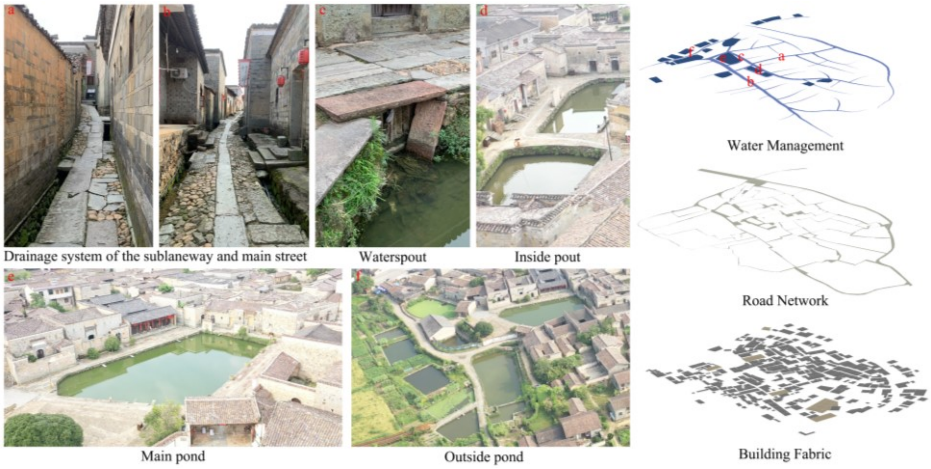


Figure 6: The Water Management System in Zhuqiao Village
Source: Author, (2024)

Zhuqiao Village is situated on high east and low west terrain, with hills to the east and a river to the west. The site selection for the high ground avoids flooding and facilitates flood discharge during the rainy season. As displayed in

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Figure 6, the village is large in scale and has a complex internal water management system comprising major streets, lanes and ponds. Among them, Zhonglou Street is the main drainage channel, about 300 metres long and 3 metres wide. The middle of the street is paved with green stone slabs, and the edges are equipped with open ditches to ensure smooth drainage over the centuries. Furthermore, the network of alleys is perpendicular to Zhonglou Street in the shape of a fishbone, which facilitates drainage in the northern area. Each lane is provided with a 60-80 cm drainage ditch, either an open ditch or a culvert underneath the bluestone slabs, connecting to the drainage system of the residential houses and ultimately diverting the rainwater into the ponds. Moreover, the village's water storage system comprises eight ponds connected by large ditches and small drainage holes. When the rainwater pools and exceeds the storage capacity of the ponds, it flows into the next pond along the terrain to prevent waterlogging. Additionally, the decentralised ponds reduce the pressure on rainwater drainage and storage and provide villagers in each area with water for living and fire-fighting purposes. Correspondingly, the seven ponds outside the village are connected to farmland to provide agricultural irrigation during the dry season.



Figure 7: The Water Management System in Youdian Village
Source: Author, (2024)

Youdian Village is smaller in scale, and the internal drainage system is clearly defined. According to Figure 7, the village is bounded by a cross-street, with drainage areas to the north and water storage areas to the south. The cross-

street is the main drainage channel, and most houses are located north of the cross-street, effectively reducing the impact of heavy rainfall on the village. In addition, the street network is laid out perpendicular to the cross-street, with rainwater being discharged along the road to the cross-street according to the land's topography and then into the ponds. Ditches connect seven ponds within the village and can be separated as required. The pond system can adjust the water level and volume with seasonal changes. For example, during the flood season, the water level is kept constant by opening gates and releasing water. Conversely, during the dry season, the stored water can meet the basic water needs of the residents.

The water management system of traditional villages is an essential wisdom in the construction of villages and has a direct connection to the human environment. It consists of ponds, ditches, and wells, to name a few. It undertakes collecting, storing, and distributing water resources, which meets the needs of residents living and fire-fighting water, guarantees agricultural irrigation, and is an essential support for village ecology and agrarian production. The water management system design makes traditional villages demonstrate strong adaptability and resilience when dealing with disasters such as floods, droughts and fires. At the same time, the water management system profoundly influences the formation and evolution of the habitat. The rational layout of water conservancy facilities, such as ponds and ditches, improves the village environment and enhances living comfort. Public buildings and green facilities such as ancestral halls, temples, squares, and ancient trees, to name a few, are mostly arranged around the water ponds, which become places for villagers to relax and socialise, enriching the village landscape and reinforcing the cohesion and social stability of the village.

DISCUSSION AND CONCLUSION

This study reveals the construction characteristics of traditional villages in central Jiangxi, exemplifying the core principle of resilience theory: settlements sustain system stability through continual adaptation and reorganization in response to external changes (Walker et al., 2004). The analysis demonstrates that village construction incorporates three interrelated dimensions of resilience. First, ecological resilience is embedded in site-selection strategies—the 'Forest–Village–Field–Water' layout shows how villages adapt to local climate, hydrology, and terrain to reduce risk and support agricultural productivity. Second, social resilience derives from spatial organization; enclosed perimeters, interconnected lanes, and culturally meaningful public spaces promote social interaction, shared identity, and community stability. Third, infrastructure resilience is evident in decentralised water-management systems, with ponds, ditches, and wells providing robust capacity for water use, irrigation, drainage,

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and flood control, ensuring durable village function. Collectively, these features highlight that traditional villages function as integrated socio-ecological systems shaped by ongoing adaptation and hold valuable lessons for current rural development.

Extending these findings, the study integrates site-selection, socio-spatial function, and water management within a unified resilience framework, offering a holistic perspective on how traditional settlements operate and how daily spatial practices shape adaptive capacities. While the research is grounded in Chinese cases, the mechanisms identified, including ecologically informed siting, cohesive social spatial structures, and decentralised water management systems, can inform analyses of traditional and vernacular settlements in diverse contexts. The main limitation of this study is its focus on two cases; despite the depth of qualitative insights, the findings are not intended for statistical generalisation. Future research should expand the comparative analysis to include additional settlement types and employ more systematic quantitative validation, such as locally adapted resilience indices, to further assess and extend the analytical framework proposed here.

ETHICS STATEMENT

All field investigations, interviews, and data collection conducted in this study complied with established research ethics guidelines. Informed consent was obtained from all participants, and anonymity and confidentiality were ensured throughout the study.

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THE ROLE OF RIVER ESTUARIES IN SHAPING TRADITIONAL MALAY KAMPONG IN JOHOR STATE, MALAYSIA: A DESCRIPTIVE ANALYSIS

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Abstract

Malay traditional settlements, known as 'kampung' (kampongs or villages), have been established for centuries, primarily in rural areas near river estuaries, riverbanks, and coastlines. These locations were historically significant for early Malay communities, serving as centres for trade, ports, forts, and administration due to their advantageous transportation links and reliable access to food and clean water. Johor State, Malaysia, features 14 major rivers connecting to the Melaka Straits, Tebrau Straits, and the South China Sea, all of which have played a vital role in the development and history of Malay kampongs in Johor. This study explores the role and significance of river estuaries in shaping traditional Malay kampongs in Johor. The objective is to analyze the historical and contemporary settlement patterns, particularly the establishment of the Old Johor Kingdom along Sungai Johor in the 15th century and the subsequent expansion along the West Coast in the late 18th century. Presently, Johor hosts 1,610 units of traditional kampongs, mostly located near riverbanks and agricultural zones, with a preference for riverfront and seashore locations. Using a descriptive methodology, this study categorizes traditional Malay kampongs into two main types: coastal settlements/ fisherman villages/ water villages (kampung nelayan/ kampung air) and hinterland settlements (kampung darat or kampung parit). The research employs aerial photographs from Google Earth to analyze the layout and arrangement of houses in these kampongs, considering both natural factors (geography, topography, environment) and non-natural factors (technology, socio-cultural influences). The findings highlight the significant contributions of river estuaries to the spatial organization and development of Malay traditional kampongs, emphasizing the intricate relationship between natural landscapes and human settlements. This study also discusses the potential of the Spatial Characteristics of Rural Malaysia System (S-CHARMs), as it provides a comprehensive geographic information system (GIS) database and spatial analysis tools that can significantly enhance the understanding and planning of these settlements. S-CHARMs offer detailed spatial information about village locations, infrastructure, and public facilities, which is crucial for analyzing the historical and contemporary settlement patterns of traditional Malay kampongs in Johor.

Keywords: River Estuaries, Malay Kampong, Settlement Patterns, Johor, S-CHARMs

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INTRODUCTION

The term 'traditional villages' encompasses a diverse array of communities, each with its unique customs and practices, yet bound together by a shared reliance on the natural resources provided by river estuaries. In Malaysia, traditional villages are known as *'kampung'* or 'kampongs.' J. Widodo (2012) defines *'kampung'* in the Malay language as a settlement situated near a riverbank that serves as a landing point. Physically, kampongs refer to settlements located along riverbanks, near landing points (jetties), extending to settlements further uphill from the waterfront. Kampungs are predominantly inhabited by Malay communities and have developed organically over time, often without professional intervention or a development blueprint. As such, they are considered a type of vernacular settlement. These villages are deeply rooted in Malay culture and heritage, embodying a unique way of life that has been passed down through generations. In Malay traditional villages, houses are typically built on stilts, with roofs made from *atap* (palm leaves) or zinc sheets. The layout of the village is often organic and reflects the close-knit community spirit. One of the defining features of traditional villages in Malaysia is the sense of communal living. Residents often share resources and responsibilities, fostering a strong sense of unity and cooperation. Community events and celebrations are common, providing opportunities for villagers to come together and strengthen social bonds. Traditional Malay villages in Malaysia are also characterized by their close connection to nature. The surrounding environment often plays a central role in village life, with activities such as fishing, farming, and gathering wild fruits and herbs being integral to the local economy and culture. On the other hand, 'traditional kampong' denotes a settlement area inherited by the Malay community across generations, characterized by Malay architecture, environmental features, and a courtyard layout following the Malay village concept. Many villages are located near rivers, forests, or agricultural land, providing residents with access to natural resources for food, water, and livelihoods. One of the most critical geographical influences on these settlements is the river estuary system and its surrounding basin. For example, the Johor River Basin, covering approximately 2,286 km² (Department of Irrigation and Drainage, 2022), flows from the central eastern highlands of Johor to the South China Sea. As a Category 1 river basin (entirely located within one state), it supports a dense network of tributaries, wetlands, and lowland floodplains that have historically provided fertile land and water connectivity essential for early Malay settlement. The definition of a river basin—as adopted from the EU Water Framework Directive (2000) and translated into the Malaysian context—refers to the total land area drained by surface water through a river system, ending in an estuary or delta. According to national records, Malaysia comprises 2,986 river basins, with 189 identified as major basins. Johor itself contains several such

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basins, of which the Johor River is among the most extensive and historically important. The basin has long facilitated socio-economic activities such as paddy farming, fisheries, and river transport, and continues to play a role in spatial planning and environmental conservation. These river basins, especially in lowland coastal zones, have influenced not only the physical structure of kampongs but also their spatial logic, orientation, and socio-cultural practices. Understanding this hydrological geography is key to re-evaluating how kampongs formed, evolved, and continue to adapt within the wider planning context of Johor. However, rapid urbanisation and shifting socio-economic priorities have eroded these patterns, prompting the need to re-examine the relationship between natural settings and traditional settlement forms. This paper aims to analyse how river estuaries influenced the spatial formation of traditional Malay kampongs, particularly in Johor. The study contributes to understanding the spatial logic of traditional settlements and their potential role in modern rural development frameworks.

THE PHYSICAL ATTRIBUTES OF KAMPONGS

The surrounding environment often plays a central role in village life, with activities such as fishing, farming, and gathering wild fruits and herbs being integral to the local economy and culture. On the other hand, ‘traditional kampong’ denotes a settlement area inherited by the Malay community across generations, characterized by Malay architecture, environmental features, and a courtyard layout following the Malay village concept. Many villages are located near rivers, forests, or agricultural land, providing residents with access to natural resources for food, water, and livelihoods. In this context, Peninsular Malaysia is surrounded by oceans, with numerous rivers flowing into the seas. There are approximately 100 rivers with around 1,800 subsidiary rivers and tributaries in Peninsular Malaysia, totaling over 38,000 km in length (Abdullah, K., 1999, in Ahmad Sanusi Hassan, 2001). Settlement patterns evolve spatially due to various factors, such as climate, resource access, and spatial position, as suggested by Trausti Valsson et al. (2013). In Malaysia, river estuaries have played a significant role in the nation's history, particularly in the formation of early kingdoms and civilizations. River estuaries play a critical role in the ecological and socio-economic fabric of traditional Malay kampongs, including those in Johor State, Malaysia. This study explores the multifaceted functions of river estuaries and their significant values to these communities, highlighting their environmental, economic, and cultural importance. In this study, these settlements are referred to as "Malay traditional kampongs" to avoid confusion. This term denotes any settlement inhabited by Malay communities in rural areas, characterized by traditional Malay houses and landscapes. Recent scholarly contributions further reinforce the significance of spatial and technological

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approaches in understanding traditional Malay settlements. Fatin Farhana et al. (2020) identified three key orientation patterns—clustered, linear, and scattered—that are influenced by environmental, kinship, and socio-cultural contexts, mirroring the spatial logic observed in *kampung air* and *kampung darat* typologies. Norzailawati et al. (2019) demonstrated the value of drone-based 3D city modelling and GIS analysis in documenting traditional urban forms, particularly in Kota Bharu, where royal institutions and riverine geography shaped Malay urban morphology. This supports the present study's approach using aerial imagery and spatial overlays to assess settlement evolution. Additionally, Ishak et al. (2022) illustrated how GIS tools such as the container index and LISA (Local Indicators of Spatial Association) can be applied to evaluate the spatial equity of public facilities like mosques—key communal anchors in kampungs. These studies provide methodological and contextual justification for the use of S-CHARMs in this research, highlighting the importance of geospatial analysis in preserving and planning for the continuity of traditional Malay settlement patterns. By examining this traditional living environment, the study aims to understand the significant values and contributions of river estuaries to the spatial patterns of Malay traditional kampongs. This research provides fundamental knowledge of the spatial arrangement of kampongs in Malaysia.

KAMPONGS TYPOLOGIES

Based on the Dasar Perancangan Fizikal Desa Negara 2030 (National Rural Physical Planning Policy 2030), eight main categories of kampongs exist in Malaysia (PLANMalaysia, 2018), including *Kampung Traditional* (Traditional Village) – A classic rural Malay settlement pattern. These are the most common rural Malay settlements, characterized by organic growth patterns with houses typically built in clusters or linear formations along roads or riverbanks. They feature traditional Malay architecture, including stilted wooden houses with raised floors for ventilation and flood protection. Traditional villages are often self-sufficient, relying on agriculture, small-scale trade, and fishing. Second, *Kampung Nelayan* (Fisherman Village). These villages are predominantly located along coastal areas or river estuaries, where fishing serves as the primary economic activity. The houses are often built on stilts along the shoreline. These villages frequently feature jetties, fish markets, and processing areas for drying and storing fish. Third, *Kampung Tersusun* (Well-Planned Village) – Unlike organically grown traditional villages, this village is a planned settlement introduced by the government to provide structured housing layouts with better infrastructure. These settlements are designed with grid-like arrangements, modern amenities, and proper access roads, ensuring improved living conditions while preserving rural lifestyles. Fourth, *Kampung Atas Air* (Water Village).

These settlements, often found in coastal or estuarine regions, consist of houses built entirely above water on wooden stilts. Connected by wooden walkways, these villages have a distinctive landscape and are highly dependent on fishing and water-based trade. Fifth, *Kampung Orang Asli* or *Orang Asal* (Indigenous Village). These settlements are home to Malaysia's indigenous (Orang Asli) communities, who traditionally live in forested and riverine environments. Their houses, made from natural materials like bamboo and rattan, reflect their deep connection to the environment. Many of these villages are semi-nomadic or have adapted to government resettlement programs. Six, *Petempatan Tanah Rancangan* FELDA/ FELCRA/ RISDA (Planned Land Settlement). These structured agricultural settlements were introduced through land development schemes by FELDA, FELCRA, and RISDA to support Malaysia's agricultural sector. Designed primarily for large-scale plantations such as rubber and palm oil, these settlements consist of uniform housing, well-planned roads, and community facilities. Seventh, *Kampung Baru Cina* (Chinese New Villages) – Established during British colonial rule, these villages were originally fortified settlements created to control Chinese communities during the Malayan Emergency (1948–1960). Over time, they evolved into permanent settlements with economic activities centred around agriculture, small industries, and retail and eight *Petempatan Estet* (Estate Settlement) – Primarily found in plantation areas, these settlements were historically built to house workers in rubber, palm oil, and tea estates. Unlike traditional Malay villages, estate settlements often feature barrack-style housing and dormitories, reflecting their function as labour accommodations. According to PLANMalaysia (2018), 12,259 units (81.3%) of traditional kampongs are distributed across Peninsular Malaysia and Labuan, forming a significant part of the national rural landscape. These kampongs play a crucial role in preserving Malaysia's cultural heritage, supporting rural economies, and ensuring sustainable development through strategic planning and conservation efforts.

RIVER ESTUARY AND EARLY SETTLEMENT

In the early settlement of the Malay community, traditional Malay villages were intricately connected to the river. Moorhead (1965) described the river as the primary means of communication and transportation to the interior regions. Additionally, the river served as an ideal location for settlement due to its strategic positioning and accessibility. Historically, river estuaries offered safety for fishermen and traders from harsh weather conditions. According to Abdullah Sani Ahmad in Chen Voon Fee (1998), rivers were the only means of transportation into hinterland areas due to dense rainforests and the lack of efficient road systems. It was only in the early 20th century that the British colonial administration introduced infrastructure such as railways and roads to

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connect mining areas to the west coast of the peninsula for economic benefit. Before colonization, river transportation was the most effective way for local people to connect upstream (*hulu*) and downstream (*hilir*) settlements or river estuaries (*kuala*). Siti Norlizaiha Harun & Azira Ibrahim (2011) also noted that most traditional settlements were located along river flows with swampy topography, encouraging settlers to engage in rice cultivation and fisheries as major socio-economic activities. Traditional societies adapted their economic activities to the existing topography, influencing the design of traditional houses to accommodate ground-level dampness, tropical climate, and flooding (Siti Norlizaiha Harun & Azira Ibrahim, 2011). Since the 18th century, the role of rivers in national development has transformed from providing basic functions to multiple purposes. Many urban areas, such as Melaka, Kuala Terengganu, Kelantan, Kuantan, and Kuala Kangsar, are concentrated around river estuaries, drawn by the attractive water features of seashores and riverfronts (Azlina Md. Yassin, 2010). In Johor, settlements like Muar, Batu Pahat, Johor Bahru, Kota Tinggi, and Mersing developed from river estuaries and extended along rivers. Some settlements, such as Segamat and Kluang, exist inland but remain connected to rivers. Residents in the hinterland (*hulu*) areas could travel to the sea (*hilir*) by small boat (*sampan*) through the river, emphasizing the importance of river accessibility rather than direct frontage. Initially, these areas started as fishing settlements but gradually evolved into important trading ports or administrative centres due to their strategic locations. According to Azlina Md. Yassin (2010), the function of rivers for human life and transportation has diminished due to rapid urbanization, industrialization, and intensive agricultural activities. The differences between inland villages (*kampung darat*) and water villages (*kampung air*) are significant in understanding the spatial patterns and cultural adaptations of Malay traditional settlements. Inland settlements are typically situated further away from direct river access and rely on irrigation and road networks for connectivity. Water villages, on the other hand, maintain direct interaction with waterways, adapting their housing and livelihoods to the dynamic river environment.

THE KAMPONG FORMS AND SETTLEMENT PATTERNS

A review of existing literature reveals the historical and contemporary significance of river estuaries in shaping Malay traditional kampongs. Previous studies have highlighted the ecological functions of estuaries as nurseries for marine life and natural barriers against coastal erosion. Additionally, scholars have explored the economic importance of estuaries for fishing and agriculture, as well as the cultural significance of these water bodies in Malay folklore and traditions. For example, Ahmad Sanusi Hassan and Ku Azhar Ku Hassan (2001) categorize kampongs in Malaysia into three types: 1) *kampung darat* (inland

settlements), 2) *kampung air* (water village), and 3) *kampung gabungan* (mixed settlements). This classification is based on the settlement's growth patterns towards either the hinterland or river areas. The *kampung gabungan* combines characteristics of both inland and water settlements, making it more challenging to identify distinctly. The *kampung darat* and *kampung air* settlements are influenced by river estuary topography and riverbanks. Houses built near riversides often use high stilts, unlike those in hinterland areas. Settlements near or over water, where the river estuary is deep, support large fishing boats anchoring near landing points or jetties (Ahmad Sanusi Hassan and Ku Azhar Ku Hassan, 2001). Malay carpentry innovations and building technologies also shaped early Malay traditional kampong patterns (Siti Norlizaiha Harun & Azira Ibrahim, 2011). The *kampung air* features strong jetties or wooden platforms supporting houses above water levels. These houses, known locally as "*rumah tiang seribu*" (a thousand stilt houses), stand on hundreds of stilts planted in the river. Each house is connected by small wooden pathways, creating dense housing patterns due to the limited land size at river estuaries. Houses are built closely together, maximizing the use of available space. In contrast, *kampung darat* typically has larger land parcels. Often, a single land parcel contains multiple houses owned by family members, such as siblings. Groups of related families might settle near each other, fostering a concentrated settlement pattern influenced by strong kinship ties. These houses have no physical boundaries separating them, leading to organic and free-form arrangements. This layout creates communal spaces between houses, enhancing social interactions and community bonding. According to Siti Norlizaiha Harun & Azira Ibrahim (2011), the spatial structure of Malay traditional kampongs organically follows the river form. The *kampung darat* and *kampung air* settlements are influenced by river topography, either paralleling the riverbank or concentrating near river estuaries. The *kampung darat* settlements extend inland, while *kampung air* settlements remain close to or over water. This natural alignment with river forms dictates the organic and adaptive nature of traditional Malay settlements, reflecting both environmental and socio-cultural influences. The strategic location of Malay traditional kampongs has significantly influenced their development. The general layout and arrangement of houses in both kampung darat and kampung air depend on natural factors (geography, topography, natural environment) and non-natural factors, including construction technologies and socio-cultural influences. Natural factors like water levels encourage settlers to build houses on high stilts to avoid flooding. To ensure harmonious relationships between humans, nature, and spirits, the choice of location for settlement built-up areas is carefully considered. J. Widodo (2012) noted that the location of houses is usually selected based on traditional beliefs, aesthetic views, and high accessibility to jetties or natural resources. Consequently, settlers often prefer to build houses facing the

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river or seashore. The village was mainly a fisher, hunter and gatherer of forest produce. The Malay settlements concentrated along the coastal and estuarine fishing villages, followed by wet paddy growing, including the establishment of the fruit orchard (A. A. Rahman, 2018).

METHODOLOGIES

This study employs a qualitative, descriptive research approach using triangulated methods that collectively uncover the historical, spatial, and socio-cultural dimensions of kampong settlements in Johor. 1) Archival Research: Primary and secondary historical sources, including colonial maps, government reports, and historical texts, were reviewed to trace the emergence and evolution of kampong settlements along Johor's rivers. This stage offered insight into the socio-political and environmental context behind kampong establishment. 2) Field Surveys: Direct field visits were conducted in selected kampongs to observe architectural styles, spatial arrangements, and community interactions. Interviews with elderly residents and local leaders provided qualitative narratives about the historical dependency on river systems. These ground observations enhanced the authenticity of archival interpretation and offered local perspectives on spatial organisation. 3) Spatial Analysis using GIS and Google Earth: Satellite imagery from Google Earth was used to identify settlement patterns and their physical proximity to river estuaries. The Spatial Characteristics of Rural Malaysia System (S-CHARMs), a GIS-based planning tool by PLANMalaysia, was referred to map and analyse the distribution, accessibility, and infrastructure of kampongs with riverine systems. This geospatial assessment provided quantitative validation for historical and observational data. The integration of these methods allowed a triangulated view of kampong evolution and its contemporary spatial relevance. The study also acknowledges its limitations, including the regional focus on Johor, which may not generalise across all Malaysian kampongs, and the availability of up-to-date spatial data for certain kampong sites.

FINDINGS

PLANMalaysia (2018) reported that in Johor, there are 1,610 kampongs identified as 'traditional villages', representing 13.1% of the total 1,958 kampong units found in the state. Nationally, these kampongs make up 12.9% of traditional villages. Of the Johor total, 1,119 units (57.1%) are located in urban areas, while 839 units are situated in rural zones.

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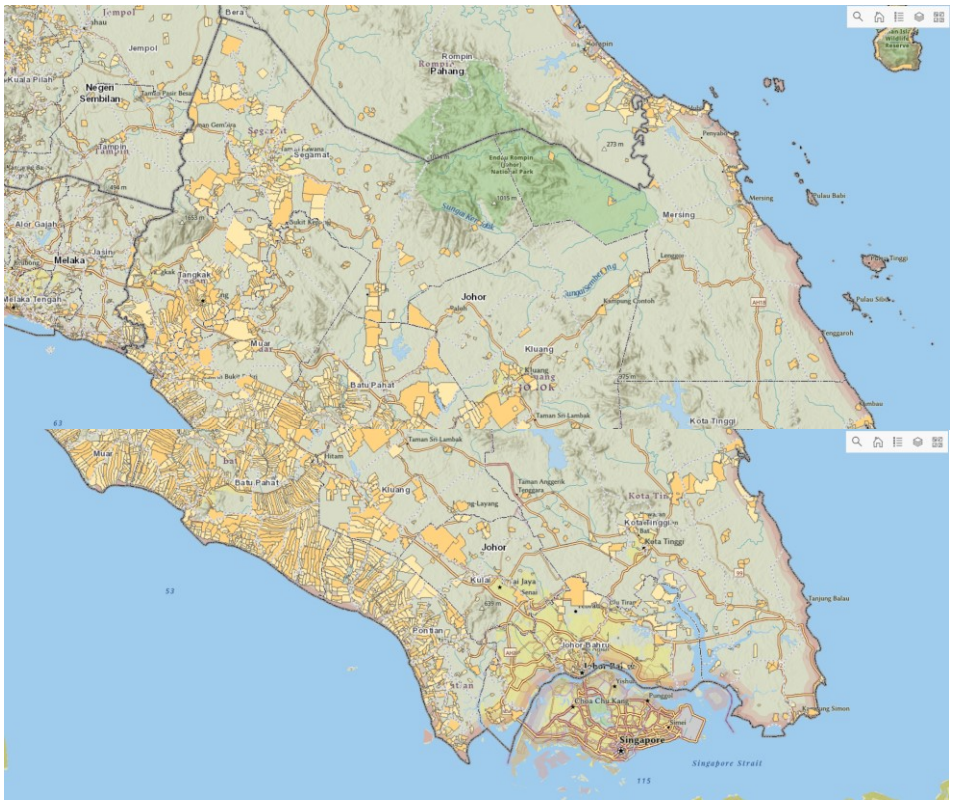


Figure 1: Distribution of traditional Malay kampungs across Johor State, highlighting settlement clusters along river estuaries and inland parit systems. Generated by using S-CHARMs

Source: PLANMalaysia (2025).

Distribution of traditional Malay kampungs across Johor State, highlighting settlement clusters along river estuaries and inland parit systems (Figure 1). Studied along the Johor River (East Johor) shows an early riverbank settlement pattern of Johor. Historical analysis traces kampong establishment in Johor to as early as the 15th century, beginning with the Old Johor Kingdom founded by Sultan Alauddin Riayat Syah II in 1528. Johor River in Kota Tinggi served as the nucleus for these early settlements, where administrative centers and royal forts were strategically positioned along the riverbanks. Multiple settlements were developed along the river to facilitate trade and defence, including notable sites like Panchor, Pekan Tua, Sayong Pinang, Seluyut, Batu Sawar, and Pasir Raja (Figure 2):

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Figure 2: Several early settlements along the riverbank of the Johor River, Kota Tinggi
Source: Asyaari Muhammad (2012).

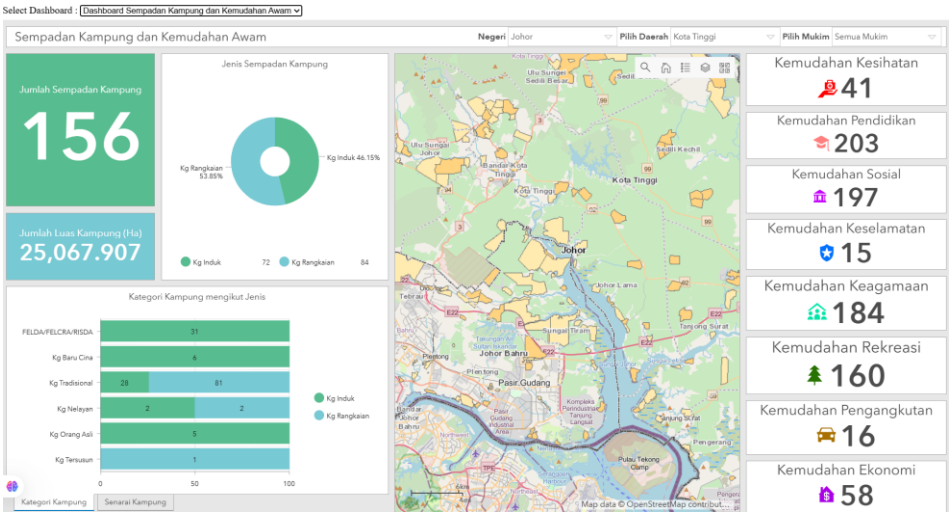


Figure 3: Distribution of traditional kampongs along the riverbank of the Johor River. Data generated using S-CHARMs portal.
Source: PLANMalaysia (2025).

It visualises the strategic positioning of settlements along Sungai Johor, reinforcing the idea that river estuaries shaped the location and significance of early Malay kampongs in Johor. Such maps align well with archival insights, such as from Kassim Thukiman and Asyaari Muhammad studies. To evade external

threats, including attacks from the Portuguese (1535–1587) and Acheh (1564–1623), the royal administration frequently relocated, establishing settlements such as Kampung Johor Lama (1500s), Kampung Panchor (1699), Kampung Makam (1700s), and Kampung Lukut (1890s). Archaeological studies (Muhamad, 2020) validate the historical presence of these administrative and trading kampongs along the Johor River corridor.

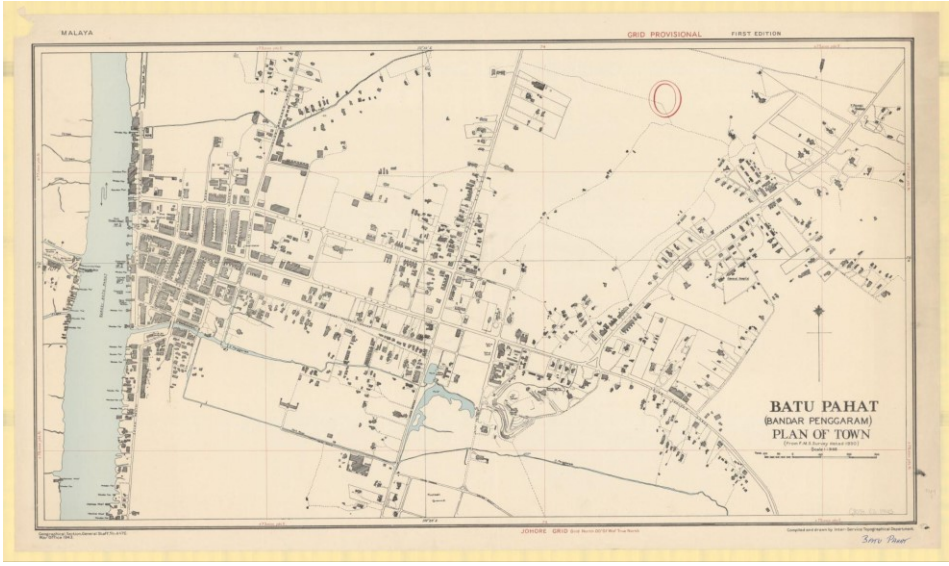


Figure 3: The Bandar Penggaram Plan in the year 1930 revealed several early settlements in Batu Pahat established along the main road, arranged in a grid pattern. The linear form was established due to the alignment of the drainage system (parit).
Source: F. M. S. Survey (1930). National Library of Australia.

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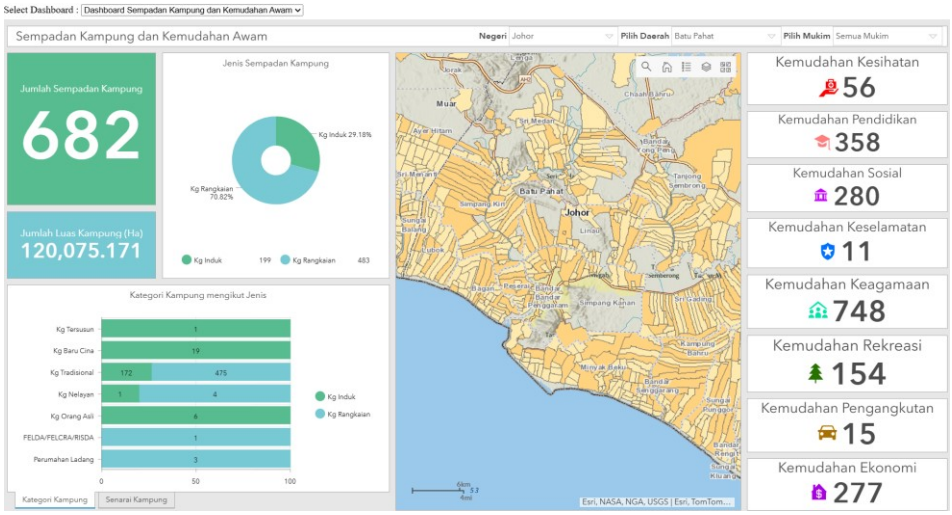


Figure 4: Distribution of traditional kampongs along the riverbank of the Batu Pahat River and the coastal. Data generated using S-CHARMs portal.
Source: PLANMalaysia (2025).

The West coast of Johor, Figure 3, demonstrates the spatial outcomes of colonial and agricultural development in Bandar Penggaram, Batu Pahat, Johor. During the late 19th to early 20th century, the expansion of agricultural settlements led to a different spatial form in the west coast regions of Johor, particularly in districts such as Muar, Batu Pahat, and Pontian. This archival map exemplifies the morphological evolution of kampongs from organic riverside clusters to more linear, grid-like layouts under colonial influence. The characteristic of *kampung darat* illustrates a typological contrast to *kampung air*.

- Visual confirmation of the drainage-based linear layout (parit system). Supports the identification of kampung darat and its spatial adaptation to agriculture and planning.
- The 1930 map contextualises the emergence of parit settlements during the New Modern Johor Kingdom period.
- This figure enriches the typological discussion by showcasing how settlements like Batu Pahat transitioned into formalised, infrastructure-aligned towns. It illustrates the dual narrative of natural and engineered spatial evolution.

For example, this pattern can be found in Kampung Parit Sakai (1707) and Kampung Parit Pinang Seribu (1818) in Muar, Kampung Parit Bakar Darat (1864) in Batu Pahat (Figure 4), and Kampung Parit Ayer Baloi (1900s) in Pontian. Traditionally, the Malay community engaged in agricultural activities in

hinterland areas like paddy cultivation, coconut plantations, small-scale estates, and orchards, relying heavily on efficient irrigation systems. These kampongs—collectively known as *kampung parit*—are characterised by prominent drainage channels or "*parit*" that shape the spatial layout of settlements. Typically located away from the immediate coastline due to swampy or muddy terrain, these kampongs were established on flat lands between mangrove coastlines and hilly hinterlands. According to Abdullah (2011), commercial and traditional agricultural activities significantly influenced the physical and cultural features of these settlements. Archival maps such as the Bandar Penggaram Plan (1930) further illustrate this evolution, revealing a linear grid arrangement reflective of the engineered parit system and colonial urban planning practices. In sum, two main typologies of kampongs were identified 1) *Kampung Air* (Water Villages): Typically built on stilts directly over water or adjacent to riverbanks, these kampongs exhibit linear arrangements clustered around jetties and docks and; 2) *Kampung Darat* (Inland Villages): Located further from the coast, these kampongs are structured around agricultural canals (*parit*) with more expansive land parcels and dispersed family plots. S-CHARMs spatial analysis affirms these settlement patterns. It reveals that kampongs formed organically in alignment with the terrain, river networks, and land use activities such as fishing, rice cultivation, and trade.

DISCUSSION

The discussion reveals the profound influence of estuarine systems, particularly the Johor River, on the formation and evolution of traditional Malay kampongs. River estuaries served not only as natural transportation corridors and economic zones but also as foundational geographic structures around which kampong settlements organically emerged. The strategic position of kampongs along these estuaries reflects a longstanding adaptation to the natural environment, where proximity to water was essential for livelihoods, agriculture, and mobility.

Kampung located near estuaries, especially in areas such as Kota Tinggi (East of Johor), were historically part of the early administrative and cultural centers of the Johor-Riau-Lingga Sultanate. These riverine environments enabled socio-political connectivity, allowing communities to thrive through fishing, trade, and agricultural activities. In contrast, the *kampung darat* or *parit* typology such as Batu Pahat (West of Johor) area developed later in inland areas, where engineered irrigation systems—parit—were constructed to support plantation economies and population growth during colonial expansion. The spatial character of these settlements illustrates how environmental adaptation shaped local vernacular patterns. Modern spatial tools such as the Spatial Characteristics of Rural Malaysia System (S-CHARMs) have enhanced our ability to document and analyze these settlement patterns. S-CHARMs allows planners and

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researchers to overlay historical data with current satellite imagery and village infrastructure, providing a clearer picture of the continuity and transformation of kampong landscapes over time. The spatial data reveal that many kampongs retain their original alignment with riverbanks or drainage systems, although urban expansion and road construction have altered their orientation in some areas. PLANMalaysia has developed S-CHARMs as a comprehensive GIS-based planning and analysis system tailored for rural environments. Built on the policy foundation of the National Rural Physical Planning Policy 2030 (NRPP 2030), S-CHARMs provides planners with accessible, real-time spatial information regarding village infrastructure, facilities, and demographic patterns. This integration allows for data-informed decision-making in identifying development priorities, preserving heritage areas, and improving rural service delivery. S-CHARMs also contributes to the cultural mapping of kampongs by identifying socio-cultural anchors such as mosques, balai raya (community halls), and traditional Malay houses. This data provides critical insight into how kampong life remains oriented around collective spaces that reinforce community ties. By incorporating spatial and socio-cultural dimensions, S-CHARMs helps visualise the layered character of kampongs—not only as physical settlements but as living socio-ecological systems. In sum, integrating historical geography, environmental adaptation, and contemporary spatial planning tools highlights the continued relevance of traditional Malay kampongs in rural Johor. Sustainable development efforts should prioritise preserving these historically rooted communities' spatial integrity, cultural identity, and ecological resilience.

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THE IMPACT OF BIOPHILIC DESIGN ON RESIDENT WELL-BEING IN MALAYSIA

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Abstract

Biophilic design that integrates natural elements into the built environment is recognized to enhance human well-being and support sustainable development. However, the application of biophilic principles in low-cost housing in Malaysia is still limited, due to financial constraints and a lack of awareness and understanding among residents and stakeholders. This study aims to investigate the key factors of biophilic design in low-cost housing projects in Malaysia, focusing on the level of knowledge and awareness of residents. The study also assesses the potential impact of these design elements on the well-being of residents and their contribution to the Sustainable Development Goals (SDGs), particularly in the aspects of health and sustainable communities. A quantitative approach was used through a structured questionnaire distributed online (Google Form). The survey involved residents of public housing projects such as PPR in Negeri Sembilan and Melaka and PPAM in Putrajaya. The 229 Google Form was analyzed to assess the level of awareness, identify valued design factors, and understand perceptions of the benefits of biophilic design. The study findings show that although residents appreciate natural elements in residential spaces, the level of awareness of biophilic design principles is still low. This study highlights the importance of integrating biophilic elements into low-cost housing designs to improve residents' well-being and support environmental sustainability. This study also suggests the need for educational and policy programs to raise awareness and encourage the adoption of biophilic design in future housing developments. Further research is recommended involving larger sample sizes and expert perspectives for a more comprehensive understanding.

Keywords: Biophilic Design, Low-Cost Housing, Resident Knowledge, Sustainable Development Goal (SDG), Urban Well-being

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INTRODUCTION

Living in dense urban areas is often associated with high psychological stress, especially among low-income communities who are exposed to less conducive residential environments. Environmental stressors such as congestion, noise pollution, lack of green space, and high population density have been shown to contribute to negative impacts on the mental health and well-being of urban residents (Mouratidis, 2021). Meanwhile, low-income communities, especially in low-cost housing areas, the majority do not have access to natural elements that can contribute to natural stress recovery. Referring to previous studies, in this context, the biophilic design approach offers the potential as a cost-effective strategy to improve the indoor environment of the home and support the mental well-being of residents. Biophilic design that integrates natural elements such as natural light, good ventilation, views towards greenery, and the use of natural materials has been shown to be able to reduce stress levels, improve mood, and promote mental recovery (Kellert, 2018; Pouso et al., 2021). Therefore, strategically applying biophilic design principles in low-cost housing can be an effective intervention in addressing the pressures of living in urban areas, while improving the quality of life of low-income communities.

Sustainable Development Goal (SDG) has become central to the global agenda, to ensure safe and affordable housing. In this regard, the application of biophilic design in low-cost houses can help achieve these goals. Residents' knowledge and awareness of these design principles is important, as it affect how they interact with their environment. However, studies on residents' knowledge and awareness of biophilic design in the context of low-cost housing in Malaysia are still limited, particularly in urban settings (Bahauddin et al., 2021). Residents of low-income housing should receive special attention because their living conditions frequently negatively affect their well-being. Although individuals are not well-informed about biophilic design, it can enhance their surroundings.

Low-cost housing, globally and in Malaysia, often faces challenges such as overcrowding, poor indoor environmental quality, poor indoor air quality, limited access to natural resources, and a lack of aesthetic appeal (Amerio et al., 2020; Singh et al., 2019). These issues, including poor lighting and ventilation, can have a detrimental effect on the residents' physical and emotional health, causing tension and discontent. By enhancing the environment and the health of the occupants, biophilic design, which incorporates natural features such as plants and natural light, offers a potential remedy. Despite its advantages being in line with the Sustainable Development Goals (SDGs), biophilic design in low-cost housing is not widely known or used, especially when it comes to how it affects the quality of life of its occupants. Despite the demonstrated advantages of biophilic design, such as reduced stress and enhanced mental health, its use in low-cost housing is still restricted, and residents are not sufficiently aware of its benefits. This disparity matters because biophilic integration has the potential to

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elevate living conditions and advance sustainable development priorities. Closing the theory–practice gap is thus essential, as biophilic design an approach that embeds natural elements within built environments supports occupants' well-being and strengthens residents' overall quality of life.

The literature that is currently available on biophilic design in housing and planning mostly focuses on descriptive awareness levels rather than actionable frameworks or implementation dynamics. By offering an empirically supported guiding model that connects biophilic design features to stress recovery results and low-cost housing realities, our work closes that gap and advances the field in a more significant and useful way.

By employing a quantitative survey as the methodology, this study will involve residents from various low-cost housing projects in Malaysia. The findings of this study are expected to provide valuable insight into the relationship between biophilic design and the well-being of residents, as well as support efforts in achieving sustainable development goals in this country. Therefore, this study has the potential to be a guide in the development of more sustainable and quality housing.

LITERATURE REVIEW

Advantages of Biophilic Design in Housing

Biophilic design integrates natural elements into built environments to enhance human well-being and foster connections with nature. It encompasses various principles, including the incorporation of natural elements, adaptive features, and social strategies in residential buildings (Shakhshir & Sheta, 2023). It involves principles such as incorporating adaptive features and creating inclusive spaces, promoting restorative activities for diverse occupants (Tracada & Sorensen Allacci, 2023). Related to "green" architecture, it emphasises sustainability and eco-friendly practices (Merenkov et al., 2019). However, current policies often fail to achieve universal well-being and true sustainability. A design-based approach that enhances public spaces and ecological foundations may be necessary to address these issues and create genuinely sustainable urban environments (Birkeland, 2018). Collectively, these principles redefine and expand the application of biophilic design across various contexts.

Biophilic design in architecture combines nature and innovation to create sustainable, energy-efficient buildings that enhance well-being. This approach necessitates interdisciplinary collaboration and strong research frameworks for effectiveness (O et al., 2023). Studies have evaluated occupant satisfaction with biophilic features in residential buildings and proposed strategies to strengthen the human-nature connection(Shakhshir & Sheta, 2023). Researchers develop multidisciplinary tools to evaluate designs that support healthy living behaviours in various building typologies (Tracada & Sorensen Allacci, 2023). Furthermore, sustainable development principles are applied in

mountain regions to balance natural and built environments, serving as models for similar challenges elsewhere.

Advantages of Biophilic Design in Housing

Biophilic design in housing offers many advantages, including increased occupant satisfaction, energy efficiency, and improved well-being. Biophilic design and green exercise have significant benefits for the occupants' mental and physical well-being. Green exercise, which combines physical activity with natural environments, offers multifaceted psychological, hormonal, and neuroimmunology benefits, contributing to sustainable health and improved quality of life (Durusoy & Mutuş, 2021). Studies show high acceptance of biophilic features such as indoor gardens and vertical farming (Shakhshir & Sheta, 2023). Nature-inspired design enhances sustainability by incorporating natural elements, generating energy-efficient homes, and promoting social well-being(O et al., 2023). Integrating biomimetic design into housing policies can improve resource and energy conservation (Tambe et al., 2023). Additionally, active design for healthy living encourages social interaction and restorative activities, supporting the physical and psychological well-being of occupants of various ages and abilities (Tracada & Sorensen Allacci, 2023). These findings underscore the value of integrating biophilic elements and promoting well-being initiatives in residential.

Low-Cost Housing Design in Malaysia

Biophilic design involves building components, elements, and systems. Components include foundations, walls, floors, and roofs, while elements refer to physical parts such as doors and windows. Building systems include electrical, mechanical, and security. There are two design approaches: active, which uses mechanical devices, and passive, which relies on building design to maximise energy and reduce reliance on mechanical systems (Sharif Bala et al., 2023). Using biophilic and passive design strategies, the four main strategies include incorporating natural elements, maximising natural ventilation, using natural lighting, and promoting biodiversity for well-being.

Several design factors involving and related to building design and services need to be considered in indoor housing. Notably, through previous studies, 11 factors have been identified, namely, Natural light (Kellert, 2008), View of Nature (Ulrich, 1984), Indoor plants and green walls (Lohr et al., 1996), Water Features (Browning et al., 2014), Natural Materials and Textures (Kellert & Calabrese, 2015), Colours and patterns (Kaplan & Kaplan, 1989), Thermal Comfort and air quality (Shakhshir & Sheta, 2023), Acoustic Comfort (Alvarsson et al., 2010) and, Refuge and Pattern and sensory variability (Ahmed & Shukur, 2022). Based on Ibrahim and Al-Chaderchi, (2022) there are different approaches

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to the studies of the aspects that contribute to sustainability in several publications and authors.

Low-cost housing in Malaysia faces challenges despite government initiatives that are aimed at alleviating the affordable housing crisis. Key issues include high construction costs, financial constraints for developers, and insufficient enforcement (Syed Jamaludin et al., 2020; Teoh et al., 2018). Factors such as taxes, location, and urbanisation further drive-up prices (Mohd Thas Thaker & Ariff, 2020). Meanwhile, programs such as the 1Malaysia concept support low-income groups, stakeholders recommend adopting alternative construction methods, using local materials, and fostering public-private partnerships to improve affordable housing projects.

The development of low-cost housing faces challenges such as quality, accessibility, and high initial costs for sustainable practices. Financial constraints and lack of design expertise hinder the integration of affordability and sustainability (Adetola Adewale Akinsulire et al., 2024; Syed Jamaludin et al., 2020). Compromises often arise in design, construction quality, and access to amenities due to rapid urbanisation (Hasan et al., 2018). However, policy innovations such as green building standards and public-private partnerships offer potential solutions, emphasising the need for economic, socio-cultural, and environmental sustainability (Agarwal et al., 2021).

The design of low-cost housing is shaped by local culture, climate, and economic factors. Incorporating traditional elements and passive solar systems can enhance sustainability, however, challenges such as cheap energy and limited access to sustainable materials exist (Al-Haroun, 2021). Inclusionary housing policies and adaptive reuse of buildings can address shortages while preserving local identity (Jamelle, 2021). Quality function deployment methods help prioritise customer needs, emphasising cost-effective materials and flexible designs (Salim & Alabdouli, 2022). Government support through incentives and policy-making is vital for promoting sustainable, affordable housing solutions.

Case Study of Biophilic Housing in Malaysia

In Malaysia, factors influencing house-buying decisions include income, location, and government incentives, with variation among income groups (Zulkifli & Ismail, 2023). There is a positive relationship between awareness levels and green building practices in Malaysia, with government support being crucial to increase awareness (Sabar et al., 2018). According to Syed Jamaludin et al. (2020), a lack of commitment from stakeholders is the key challenge in developing affordable and sustainable housing in Malaysia despite financial constraints. These studies highlight the importance of sustainable and biophilic design in housing, as well as the challenges in implementing such practices in developing countries like Malaysia.

Residents' Knowledge and Awareness

Recent studies emphasise the importance of biophilic and sustainable design in residential buildings, with a focus on the knowledge and perceptions of stakeholders. Although residents appreciate the conservation and biophilic elements, with high acceptance of adaptive balconies and interior gardens, awareness of certain programs is still low (Shakhshir & Sheta, 2023; Ureta et al., 2021). Factors such as environmental concerns, marketing, and government incentives influence the acceptance of green buildings (Durdyev & Tokbolat, 2022), but cost remains a major obstacle, even if the residents are willing to invest in energy improvements (Vassiliades et al., 2023).

To promote adoption, experts suggest financial incentives, better communication, and stakeholder-oriented strategies. Incorporating biophilic design can enhance the occupant's experience and guide future development. In areas such as Dubai, residents value biophilic features such as roof gardens (Shakhshir & Sheta, 2023) but awareness of certain urban planning measures is low in places such as Bangkok and Bangladesh.

Residents' awareness of biophilic design is influenced by various factors. Satisfaction with biophilic features varies by building type (Shakhshir & Sheta, 2023). In Malaysia, greater awareness correlates with effective green building practices (Sabar et al., 2018) However, socio-economic barriers, particularly costs, hinder the adoption of bioclimatic strategies (Vassiliades et al., 2023). While government support and education can help overcome cost challenges, a participatory approach with multiple stakeholders can improve integrated decisions (Eker et al., 2018). Resident knowledge is essential in creating energy-efficient homes, and benefits mental health

Implications for Sustainable Development Goal (SDG)

The relationship between biophilic design and the Sustainable Development Goals (SDGs) encompasses green innovation, climate change mitigation, and sustainable forestry practices. Green innovation in SMEs significantly impacts community development and environmental activities, bolstered by government support (Ullah et al., 2023). Climate change actions can offer co-benefits and trade-offs with the SDGs, necessitating a deep understanding of these interactions for effective policies (Cohen et al., 2021). The SDGs aim to address global challenges such as poverty and health, with connections between SDG 4, SDG 11, and SDG 9. Biomimetic architecture offers insights for designing housing that promotes energy efficiency, waste management, and occupant well-being (Tambe et al., 2023). Participatory system dynamics modelling reveals that investments in communal spaces positively impact the adoption of energy-efficiency measures and resident well-being (Eker et al., 2018) In response to challenges posed by the COVID-19 pandemic, recommendations for healthy and sustainable housing include incorporating visible green spaces, flexible living

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areas, and sustainable architecture principles (D'alessandro et al., 2020). These findings underscore the importance of integrating nature-inspired elements and communal spaces in housing design to enhance community well-being and promote sustainable living environments.

Based on the literature review, there is a lack of adoption of biophilic design in low-cost housing, particularly in Malaysia, due to financial constraints and lack of expertise. There is a need for more practical guidance models, taking into account cost-effective biophilic elements. Population awareness of biophilic design is also still low, and this affects its acceptance in low-cost housing. Further research is needed to understand the impact of this design on mental and physical well-being, as well as how it supports the Sustainable Development Goals (SDGs), especially SDG 3 and SDG 11.

RESEARCH METHODOLOGY

This study conducts a quantitative survey. Data is collected through the distribution of a questionnaire in Google Form. This questionnaire was produced through the findings found in the previous stage, whereby 11 factors are identified that can be considered in biophilic design in housing. 11 factors that have been identified, namely, Natural light (Kellert, 2008), View of Nature (Ulrich, 1984), Indoor plants and green walls (Lohr et al., 1996), Water Features (Browning et al., 2014), Natural Materials and Textures (Kellert & Calabrese, 2015), Colours and patterns (Kaplan & Kaplan, 1989), Thermal Comfort and air quality (Shakhshir & Sheta, 2023), Acoustic Comfort (Alvarsson et al., 2010) and, Refuge and Pattern and sensory variability (Ahmed & Shukur, 2022).

The open questions are to enable the respondents to share their thoughts about biophilic design before closed-ended questions are used to validate the results from the open questions that have been given (Creswell & Creswell, 2018). This survey includes PPR residents from Negeri Sembilan and Melaka, while PPAM is designated for residents in Putrajaya. These three areas are classified as having the highest urban population percentages according to the Department of Statistics Malaysia (DOSM) in 2022: Putrajaya at 100%, Melaka at 90.9%, and Negeri Sembilan at 69.3% (Perdana et al., n.d.) The other criterion is household income, which falls within the low range and is insufficient for homeownership based on the national median house price of RM 293,000.00. Melaka has been identified as one of the states with relatively unaffordable housing, while Negeri Sembilan has been categorised as very unaffordable for homeownership (Ismail et al., 2019). A total of 229 responses were collected from respondents. This questionnaire uses a self-administered and an on-site distribution method. This combination method can reduce measurement error and at the same time speed up the response rate. This research applies Roscoe's guidelines and utilizes a sample size ranging from 100 to 200 for data analysis. It includes considerations

for sampling and sample size by estimating a response rate plan and distributing questionnaires accordingly to ensure an adequate sample size. The Likert scale employed for this survey is a binary yes/no format. This questionnaire uses self-administered and on-site distribution method. This combination method can reduce measurement error and at the same time speed up the response rate. The questionnaire distribution period is for 1 month starting from the beginning of July 2024 until the beginning of August 2024. On site survey also uses the same google form.

Although the study obtained responses from a relatively large sample of 229 residents, the analytical depth is limited by the use of a binary Yes/No response scale. While this dichotomous format allowed for straightforward interpretation and clear categorisation of residents' perceptions, it restricted the ability to capture more nuanced variations in attitudes, strength of agreement, or underlying motivations. The absence of intermediate response options may have oversimplified residents' actual experiences and preferences, thus constraining the potential for deeper statistical or inferential analysis. Future studies should consider employing multi-point Likert scales in order to derive richer, more granular insights into residents' perceptions and behavioural tendencies.

This research complied with institutional ethical standards. Approval was granted by the UiTM Research Ethics Committee according to CH Good Clinical Practice Guidelines, Malaysian Good Clinical Practice Guidelines, and the Declaration of Helsinki. Participants were fully informed of the study purpose, procedures, confidentiality measures, and their right to withdraw at any time. All participants provided written informed consent before taking part in the survey and interviews.

ANALYSIS AND DISCUSSION

Respondent Demographics

Residences Location

The demographic profile consists of 229 participants, with 21.8% (50 individuals) answering the Google Form in English and 78.2% (179 individuals) in the Malay language. Regarding their residence, 48.9% (112 individuals) live in PPAM (Perumahan Penjawat Awam) in Putrajaya, 30.6% (70 individuals) in PPR (Program Perumahan Rakyat) in Negeri Sembilan, and 20.5% (47 individuals) in PPR in Melaka. By revealing the number of residences based on location, the respondents' sample size was descriptively described.

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Table 1: Residents Locations

Demographic Profile	n	%
live at		
PPAM (Perumahan Penjawat Awam) in Putrajaya	112	48.9
PPR (Program Perumahan Rakyat) in Negeri Sembilan	70	30.6
PPR (Program Perumahan Rakyat) in Melaka	47	20.5

Source: Authors' Analysis, 2024

SocioEconomics

Employment status reveals that 44.1% (101 individuals) are employed, 23.1% (53 individuals) are unemployed, 12.2% (28 individuals) are retired, and 20.5% (47 individuals) are students. Regarding income, 75.5% (173 individuals) fall into the B40 category (earning less than 6k), 21.0% (48 individuals) are in the M40 category (earning 6k to 10k), and 3.5% (8 individuals) are in the T20 category (earning above 10k). Household sizes vary, with 3.1% (7 individuals) having 1 member, 11.4% (26 individuals) having 2 members, 20.1% (46 individuals) having 3 members, 25.3% (58 individuals) having 4 members, and 40.2% (92 individuals) having more than 4 members.

Table 2: Employment Status, Income Level and Household

Demographic Profile	n	%
employment status		
Employed	101	44.1
Unemployed	53	23.1
Retired	28	12.2
Students	47	20.5
income		
B40 (<6k)	173	75.5
M40 (6k – 10k)	48	21.0
T20 (>10k)	8	3.5
household		
1	7	3.1
2	26	11.4
3	46	20.1
4	58	25.3
More than 4	92	40.2

Source: Authors' Analysis, 2024

This data shows that the highest household in affordable housing is more than 4 persons per house based on a sample size (n=92), and they consist of employed persons classified within the income category B40 with a monthly income of <6k.

Further analysis on the biophilic design factors that can be considered in indoor housing is through the residents' perspectives, which focus on knowledge and awareness.

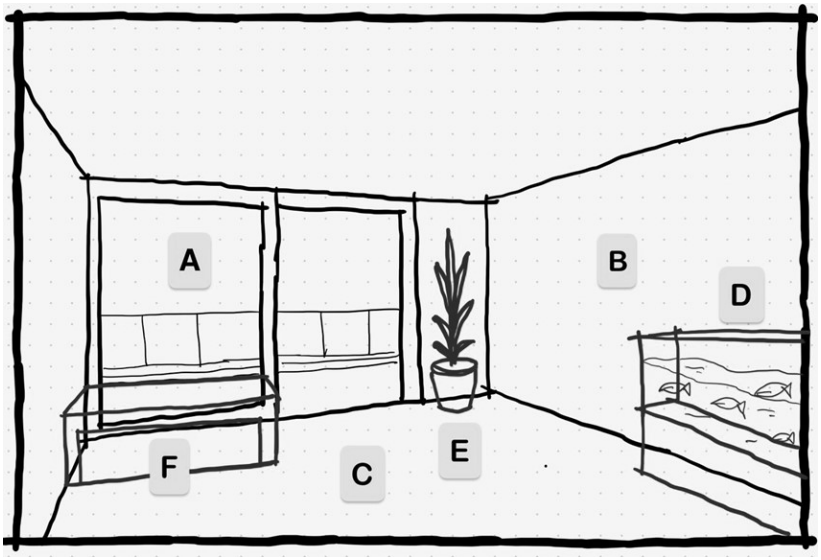


Figure 1: Spaces Illustration for Questionnaire

Table 3: Analysis on Residents Knowledge and Awareness

Item	Mean	Std. Deviation
A1. Natural Light: Are you aware of the benefits of natural light from A on your well-being?	1.1135	0.31794
A2. View of Nature: Do you know that having a view of nature through A can reduce stress?	1.2227	0.41697
A3. Natural Ventilation: Are you familiar with the advantages of natural ventilation that get through from A in giving you comfort feeling in the house?	1.2183	0.41402
A4. Material Texture: Did you aware that by looking at the nature materials (eg : wood and stone) that apply on B and C can improve your emotional condition? ?	1.2661	0.44291
A5. Colour and Patterns: Are you aware that natural colours and patterns (eg: botanical and animal pattern) that apply on B can create a calming and aesthetically pleasing environment?	1.2500	0.43397
A6. Thermal & Air Control: Do you understand the importance of balanced heat gained and losses to maintain the body's core temperature for a healthy indoor environment?	1.2412	0.42877
A7. Acoustic Comfort: Are you aware of the impact of natural materials and design such as wood, stone, and bamboo on reducing noise pollution indoors?	1.2807	0.45033
A8. Water Features: Do you know that indoor water features such as D can enhance relaxation and stress recovery?	1.2996	0.45908
A9. Indoor Landscape: Are you familiar with the benefits of having indoor plants and green spaces like E?	1.3100	0.46352
A10. Refuge and Prospects: Do you know that designing cozy window seating as F to provides views of the surrounding areas can enhance feelings of security and well-being?	1.2807	0.45033

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Item	Mean	Std. Deviation
A11. Sensory Variability: Are you aware of the importance of textures such as wood and stone and scents of aromatic plants in creating a stimulating indoor environment?	1.2096	0.40792
	1.2448	**0.42598**

Source: Authors' Analysis, 2024

Through this analysis, it can be identified that of the 11 biophilic design factors listed, several of them can be implemented in the context of low-cost housing. The results of interviews and surveys show that residents have a good level of awareness of the benefits of indoor landscaping, in line with the findings of Shakhshir and Sheta (2023) who reported residents' satisfaction with biophilic elements such as adaptive balconies and indoor gardens. In addition, residents also showed an understanding of the benefits of water features, refuge and prospects, acoustic comfort, natural materials and textures, and the use of color and pattern in improving their psychological and emotional well-being (Ahmed & Shukur, 2022; Browning et al., 2014; Kaplan & Kaplan, 1989; Shakhshir & Sheta, 2023)

However, the implementation of some elements such as water features faces physical constraints, especially in terms of limited space in low-cost houses. As an alternative, some residents choose to place small aquariums as a source of tranquility and the element of water in their homes. This shows that despite design constraints, residents' creativity and awareness allow them to adapt biophilic elements in an appropriate and effective way (Durusoy & Mutuş, 2021).

At the same time, this study also revealed that there are four design factors that are poorly understood or not paid attention to by residents, namely indoor temperature and ventilation control, view of nature, natural ventilation, and sensory variability. The lack of awareness of these factors may be due to the lack of information or direct experience about them, especially elements that are not in their daily line of sight (Kellert, 2008; Lohr et al., 1996; Ulrich, 1984). These findings indicate that residents' level of awareness of biophilic design is greatly influenced by its visibility and accessibility in residential spaces (Ureta et al., 2021; Vassiliades et al., 2023)

The order of design factors identified in this study based on residents' knowledge and awareness can be used as an initial guide in developing a model for implementing biophilic design in low-cost housing. However, this order should be re-evaluated in terms of its suitability for implementation according to needs, physical space, and financial capabilities in the actual context of affordable housing (Syed Jamaludin et al., 2020; Tambe et al., 2023). Adapting this order can strengthen the effectiveness of the design in achieving the main goal of improving well-being and reducing stress among residents (Tracada & Sorensen Allacci, 2023).

CONCLUSION

This study has been able to identify residents' knowledge and awareness of the presence of biophilic design in their housing. The eleven design factors identified were acknowledged by residents; however, due to cost constraints that resulted in low-cost housing design standards, some design factors were less recognised. Among the various factors contributing to residents' unawareness is a lack of knowledge regarding biophilic design in their homes. They do not realise that these factors can positively influence their mental health and improve their well-being. The residents' socioeconomic status also contributes to their lack of awareness. Notably, the B40 group is obliged to buy a house based on their income level. Due to a lack of input and awareness regarding the implementation of biophilic design, they tend to focus solely on the existing features of the house, believing that this is all they are entitled to, without attempting to adapt biophilic design principles to their own preferences. This mindset contributes to the reason why biophilic design is often associated with being unaffordable. The implementation of biophilic design is very important to help achieve the Sustainable Development Goal (SDG). The limitation of the study is a certain sample size, which does not represent the entire population of low-cost housing in Malaysia. The recommendation for future work is a study related to how this biophilic design factor can be implemented in low-cost housing with a low-cost setting so as not to affect the price of the house, so that this biophilic benefit can be savoured by low-income residents. Further research is strongly encouraged involving larger sample sizes and perspectives from experts in various fields such as environmental psychology, architectural design, and cost estimators. This approach will allow for a deeper and more comprehensive understanding of the effectiveness of biophilic design elements in the context of low-cost housing.

Overall, this study strengthens the planning and housing literature by moving beyond descriptive awareness studies to the development of a guiding model based on empirical analysis. This study explains how biophilic elements can be practically integrated into low-cost housing while enhancing occupant stress relief, thus contributing new approaches to theory and practice.

Furthermore, the involvement of experts can help identify real challenges on the ground and formulate more practical and interdisciplinary recommendations. This is important to ensure that the guidance model developed is truly relevant, applicable, and has a positive impact on the well-being of residents holistically.

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AUTHOR CONTRIBUTIONS

Author 1 and 3 contributed to the conceptual framework development, provided academic guidance, and secured publication funding. *Author 2* was responsible for conducting the literature review, designing the research methodology, collecting and analyzing the data, and drafting the manuscript. All authors reviewed and approved the final version of the article.

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ILLUMINATING LIVES: ENHANCING COMMUNITY SATISFACTION THROUGH SOLAR ENERGY IN INDIGENOUS SCHOOLS OF PAHANG

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Abstract

In remote Orang Asli communities, especially in Pahang, where the majority of these communities live, solar lighting is a practical way to address electricity shortages. Energy reliability is increased by incorporating solar lights into schools, which serve as important educational hubs and central gathering spaces for them. The purpose of this study is to evaluate the effectiveness of solar lighting applications for a remote school with 40 school users, who represent a diverse group of staff, who will participate voluntarily. In a case study conducted in Jerantut, the effects of solar lights are assessed using field installations, observations, and questionnaire surveys. The study assesses community involvement, sustainability, and energy efficiency. The findings show night illumination has significantly improved, going from 15 lux to 100 lux, and almost 90% of the respondents are satisfied. These results address important energy concerns in rural areas, foster a resilient learning environment, and add to the larger conversation on sustainable energy availability.

Keywords: Indigenous Community, School, Solar Lighting, Sustainable Energy

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INTRODUCTION

The Orang Asli were the first indigenous tribes to have settled in Malaysia, which they populated around 5,000 years ago amid the peninsula's thick rainforest(Mat Dong et al., 2022). As time passes, Orang Asli, who live inland or in the outback, are viewed as a marginalised group because they are unable to receive any facilities or incentives from the government, like schools (Nazmi et al., 2021). Besides that, the indigenous people have pivoted their lives to be closely related to nature; for instance, the forest serves as the basis for their primary income sources and economic activities (Ismail et al., 2024).

Living in remote areas has caused the Orang Asli limited access to government incentives for basic utilities such as electricity supply. According to Jamil et al. (2018), power interruptions that lead to blackouts during a natural disaster may interrupt the telecommunication networking of the people. Being part of a minority (0.7%) of Malaysia's overall population, which is estimated to be over 33 million, the power disruption issues that take place among the Orang Asli community do not get enough attention from the authorities (Mat Dong et al., 2022). The issues of electrification among these communities have led to many associated issues. Contrary to reports claiming Malaysia is 100 percent electrified, out of 142 Orang Asli villages, 17% of Orang Asli communities remain left behind and in the dark (Malaysia Kini, 2023). The rural communities' lack of basic infrastructure and facilities, such as schools, is a sign that they are usually overlooked by the authorities(Hayder & Kareem, 2015; Jamal & Naghmeh-Abbaspour, 2020).

The objective of the study is to evaluate the effectiveness of solar lighting applications for a remote school; one of the best solutions comes from utilising solar energy technologies for the institution. Malaysia has a great potential for solar uptake, as it is estimated that monthly solar irradiation for Malaysia is at 400-600 MJ/m2 (Abdullah et al., 2019). One of the solar energy applications widely used is solar photovoltaic (PV) (Soonmin & Taghavi, 2022), through which sunlight is converted into electricity. Moreover, this type of solar lighting system is suitable for the Orang Asli communities, especially at schools, since solar lighting can bring low-cost and environmentally friendly lighting (Khan et al., 2019).

This study focused on the state of Pahang, where 37.9% of Orang Asli communities are situated (Hussain et al., 2017). The Jahut tribe is part of the Senoi tribe, and the population of Jahut in Jerantut and Temerloh is currently above 5000 and expanding (Idrus et al., 2023). Tok Batin, the community leader, mentioned that the Sungai Kiol settlement in Jerantut, Pahang, is home to approximately 200 Orang Asli Jahut families (Burhan et al., 2023), where they are more community-focused, and there is a school nearby, SK Sungai Kiol. The school for the indigenous communities in Kampung Kiol was chosen as the main

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case study for this paper to assess the effectiveness of solar lighting applications for remote schools. Moreover, the school users comprise a diverse group of school staff who play a crucial role in enhancing the learning environment for the students participating in the surveys. Their perspective can help increase the engagement level of solar energy implementations among the students and the communities as well.

It thereby addresses critical knowledge gaps within the literature on sustainable planning and energy access through its specific focus on the context of Indigenous schools in Malaysia, hence practically proving the usefulness of solar energy in a resource-scarce educational setting. Desirably, this concept can guide the government in creating 'solar communities,' where locally generated solar energy is distributed and managed by the community (N. A. Ahmad et al., 2024).

LITERATURE REVIEW

Orang Asli is a term in the Malay language that translates to 'original people' or '*Orang Asal'*. According to Ahmad et al. (2015), Orang Asli account for 149,723 of the total population of 30 million people in Malaysia. In September 2021, the population of Orang Asli communities in Malaysia was estimated to be around 178,197 individuals. The distribution of Orang Asli indicated that Pahang and Perak have the highest and second-highest numbers in Peninsular Malaysia, respectively, as stated (see Table 5):

Table 5: Total Distribution of Orang Asli

STATES	DISTRIBUTION OF ORANG ASLI
Pahang	67,506
Perak	53,299
Selangor	17,587
Kelantan	13,457
Johor	13,139
Negeri Sembilan	10,531
Melaka	1,515
Terengganu	893
Kedah	270
TOTAL DISTRIBUTION OF ORANG ASLI: 178,197	

Source: (Hussain et al., 2017)

Issues of Electrification Disruption for Orang Asli Communities

Poor lighting in the evenings and at night simply makes them afraid to be outside because they are exposed to threats by wild animals that usually roam the area during that time (Mahmud et al., 2022). As mentioned by Mazlan et al. (2021), students would normally share illumination at school for group study sessions

after sunset, but this was less prevalent in their study environment because of the dangers of letting little children out after dark. Because of their restricted connectivity to the national electrical grid, these remote, rural settlements can benefit greatly from off-grid solar lighting systems, which are more reasonably priced, perform dependably year-round, and are quick and simple to install (Inc, 2017). The lack of electricity supply has far-reaching implications that significantly affect various aspects of the school-related activities among the Orang Asli, contributing to issues such as poverty (J. Abdullah et al., 2015), deprived education (Fitri et al., 2020), and restricted use of digital tools (Yasin, 2018).

i) Poverty

The lack of electricity forces Orang Asli communities to rely on kerosene, diesel generators, or firewood, which are inefficient energy sources: they face the greatest poverty rates, disproportionately bad health conditions, and a lack of basic infrastructure and services (Jamal & Naghmeh-Abbaspour, 2020).

ii) Deprived Education

Education is the main agenda in the Orang Asli's development program for Malaysia, and stable electricity that can give proper artificial lighting, which is most needed, especially for young children, to get themselves ready for school in the early morning, since it is still dark during that time (Azizul Sulaiman et al., 2020). Besides that, the lack of electricity also affects students' ability to study at home, where they cannot study effectively after dark, perhaps due to its location in a rural area: this predicament would negatively impact their studies (Abdullah et al., 2015).

iii) Restricted Use of Digital Tools

Modern educational resources, like computers and the Internet, are needed in rural areas to provide access to a vast amount of information. According to Sulaiman & Junaenah (2021), in places without electricity, teachers are unable to obtain online training, which restricts their ability to improve their teaching abilities, and Orang Asli students are deprived of these opportunities, resulting in a major educational disadvantage (Figueirêdo Neto & Rossi, 2019). The teachers find it difficult to apply creative teaching techniques that meet the cultural and academic needs of Orang Asli pupils when they lack access to digital learning platforms (Mazlan et al., 2021).

Studies assessing solar illumination's direct effects on lighting quality, safety, and satisfaction with use in indigenous schools are still lacking, despite research highlighting its advantages. Understanding community knowledge and involvement in the deployment of solar energy has also received scant attention.

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To close this gap, a thorough analysis of community views and lighting performance improvements is necessary, offering important information for creating sustainable energy models for Orang Asli schools in Pahang.

Empowering Orang Asli Communities Through Solar Energy Technology Transfer Program

Orang Asli face multiple challenges, including low literacy rates and poor school attendance due to difficult transportation and road conditions (Bala & Tan, 2021). By providing reliable lighting and reducing dependence on conventional energy, solar energy can play a key role in addressing these issues. Therefore, technology transfer programs focused on solar energy are essential to empower Orang Asli communities, especially for students to further enhance educational opportunities and foster sustainable development.

The Suitable Types of Solar Lighting Technologies for Orang Asli

The minimal number of infrastructures due to the remote locations of the settlement makes access to centralized electrification limited to the village. This causes the communities to depend on traditional methods for producing electricity. Not having access to electricity has impacted the community's daily life, side incomes, and school attendance due to insufficient illumination (Munajat et al., 2021). Today, various types of solar lighting technologies are particularly suitable for the needs of Orang Asli communities (see Figure 5):

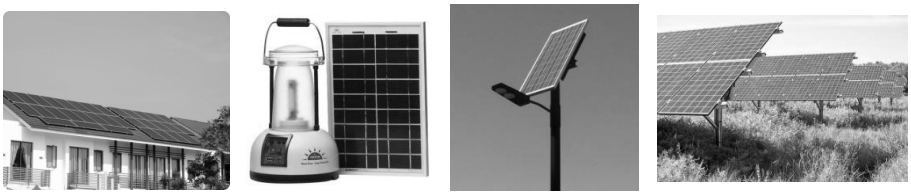


Figure 5: Solar Lighting Technologies
Source: Verdant Solar (2024), Moglix (2024), IndiaMART (2024), Energy Gov (2024)

(i) Solar Home Systems (SHS)

Solar Home Systems (SHS) are designed to provide electricity for household use in rural settings and do not rely on a connection to the national electricity grid, which is often unavailable in remote areas. SHS can provide a reliable and cost-effective alternative to diesel generators as the primary energy source for electricity (Khan et al., 2019).

(ii) Solar Lanterns and Portable Lights

Portable solar lanterns are small, rechargeable lights that are useful for students who need adequate lighting to study at night and for families to navigate their

homes safely after dark. According to Kudo et al. (2019), replacing kerosene lamps with solar products could potentially improve students' health, such as their respiratory systems, which may, in turn, positively affect academic performance.

(iii) Solar Street Lights
Solar streetlights are installed along pathways to improve the visibility and safety of the community, especially students who walk to school. With the aid of enhanced street lighting, dangers can be reduced, people are more encouraged to do outdoor activities and social interactions after dark: these contribute to a stronger sense of community. Lights are produced by absorbing solar energy during the daytime to convert it into electricity (Singh et al., 2019).

(iv) Solar Photovoltaic (PV) Systems
Solar Photovoltaic (PV) systems convert sunlight directly into electricity. Solar PV systems have a lifespan of around 10 years, making them a reliable source of energy for rural communities (Khan et al., 2019). These systems can power various applications, from lighting to small household appliances, enhancing overall living standards, offering flexible, dependable, and clean energy that is free of pollutants, which is more reliable (Hamid et al., 2018; Jamil et al., 2019).

METHODOLOGY

Research methods are the various procedures used by a researcher during a research study, and this research employs the exploratory approach in that area (Goundar, 2012; Hunter et al., 2019). This research used a mixed-method approach, consisting of a field survey and observation as qualitative methods and questionnaires for the quantitative method for data collection (see Figure 6), as the main objective is to evaluate the effectiveness of solar lighting applications for a school in a remote area.

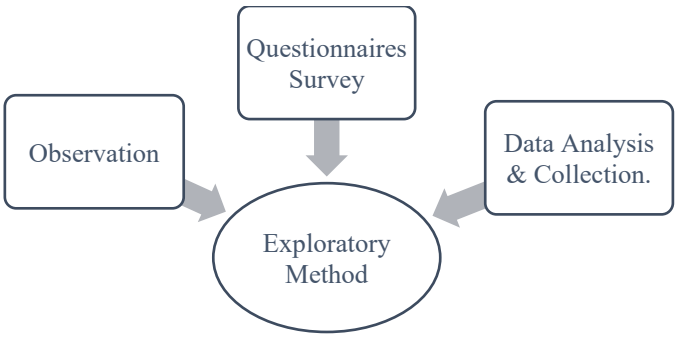


Figure 6: The Methodology Flowchart
Source: The authors (2023)

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DATA COLLECTIONS

FIELD SURVEY AND OBSERVATION

The primary data was collected via a field survey, including direct observation and questionnaires. The observation was done during the field survey, where the researcher prepared a checklist that consisted of (i) the communities surrounding, (ii) solar efficiency, (iii) technology assessment, and (iv) safety impact, to address the issue of inadequate electricity supply, particularly in rural schools. During the observation, the location of Orang Asli settlements for communities surrounding the element was identified in deep forests with lush vegetation, as there were many surrounding trees: their heights and thick leaves can affect the performance of PV panels (Borhanazad et al., 2013). For solar efficiency, the sunlight exposure at the solar panel location was sufficient, and the solar panels were installed on the roof to avoid any shade from trees (Khan et al., 2019).

Next, for the technology assessment, PV systems present interesting technological possibilities, whereas the existing options used by indigenous people offer poor illumination for their children to go to school and pose health risks as they have been using kerosene oil lamps (J. Abdullah et al., 2015). Even with the lack of safety, 37% of 869 Orang Asli settlements remain rural and forested (Munajat et al., 2021). To observe the possibilities of adopting solar lighting technology for indigenous tribes, a daytime field survey was conducted in the school's area (Ahmad et al., 2015). The lack of electricity also affects students' ability to walk home or study at home, since darkness makes it challenging for them to study or do their homework. The checklists are sorted out according to the group of elements as a guide during the data collection based on the recommendation by Idrus et al. (2023), as shown in Table 6.

Table 6: Observation Checklist for the Field Survey

Element	Data
Communities Surrounding	The sunlight availability is based on the school's geographical location, the site orientation, and types of roofs used by the for solar installations.
Solar Efficiency	The sunlight exposure at the located solar panel that is installed on the roof, with no interference of potential shading from any structures or trees.
Technology assessment	The durability of the solar technologies installed at the school, and the community's willingness to learn the skill of repairing the technologies.
Safety impact	More social activities are done at nighttime, the communities' level of awareness and identify the areas that are required to improve for safety reasons in the school's area.

Source: (Idrus et al., 2023)

The observation was carried out during peak hours, approximately from 11:00 AM until 3:00 PM in the school's area. The temperature on the day of installation was 32°C, and the sky condition was clear. There are about 17 units of solar panels installed in selected areas of the school (see Table 7). The layout plan for solar installation is shown in Figure 8. Sekolah Kebangsaan Sg Kiol, which serves as both a school and a community gathering center, is built at an isolated location. The school is located far from the main road, and electricity is not always accessible. Due to the location of the school, inadequate lighting raises safety issues for both the community and the school. This might make criminal activity more likely to happen, particularly at night. The current condition of the school before the installation of solar lighting (see Figure 7).



Figure 7: The current condition at SK Sg Kiol in Jerantut, Pahang.
Source: The author (2023)

Table 7: The total of solar installations at SK Sg Kiol in Jerantut, Pahang.

Items	Units	Installation location
25 watts solar	1 x 3 locations: 3 units	Mini hostel, block A, badminton court
25 watts solar	2 units	Parking area
40 watts solar	1 x 2 locations: 2 units	Post guard, computer lab
60 watts solar	4 units	Canteen
60 watts solar	3 x 2 location: 6 units	Preschool playground, classroom area
Total	**17 units**	

Source: The author (2023)

The 17 units of solar panels, consisting of five (5) units of 25 watts, two (2) units of 40 watts, and 10 units of 60 watts, were installed at the school. The canteen area installed four (4) units of 60 watts; meanwhile, in the preschool playground and classroom area, three (3) units of 60-watt solar panels. At the mini hostel, badminton court, block A, post guard, and computer lab, only one (1) unit was installed, each from 25 watts and 40 watts, respectively. For the parking area, two (2) units of 25 watts were installed for proper lighting. The

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installations empower Orang Asli communities, especially for the students who now enhance their educational opportunities and foster sustainable development through solar implementation at their school.

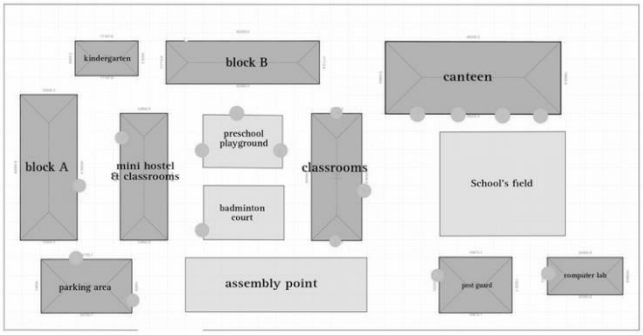


Figure 8: The layout plan of solar installation at SK Sg Kiol, Jerantut
(Source: the author, 2023).
Remarks: The dots indicate the location where solar panels were installed

Questionnaires

The survey consisted of two sections, Section A and Section B, with 34 structured questions altogether. The questionnaire was developed ahead of time before the field survey to guarantee validity and the effectiveness of data collection. The primary purpose of the questionnaires was to gauge the Orang Asli's level of engagement in solar lighting technology by improving the lighting conditions in the school areas.

In the questionnaire, three (3) sections were designed. Section A is Respondent Information, where all the basic information about the respondents is required, and Section B consists of the question about "The Level of Awareness and the Involvement of the Rural Communities in Malaysia with Solar Energy," which consists of two (2) parts. The respondent's knowledge or engagement level among the communities will be identified in five (5) levels of agreement, where strongly disagree (SD), disagree (D), neutral (N), agree (A), and strongly agree (SA), to obtain pertinent information and greater relevance to achieve the objective.

For this study, purposive sampling and a small sample of 40 respondents reduced the generalizability of the findings, which were further constrained by (i) natural behavioral differences, (ii) language barriers, (iii) geographical challenges, and (iv) the lack of a lux meter for precise measurement. Thus, results must be interpreted with caution, and studies in the future should use larger samples and improved tools to strengthen validity. In addition, for this study, light intensity measurement will be limited, and the focus is only on solar radiation as the usage of a Lux meter may result in incomplete data and might not

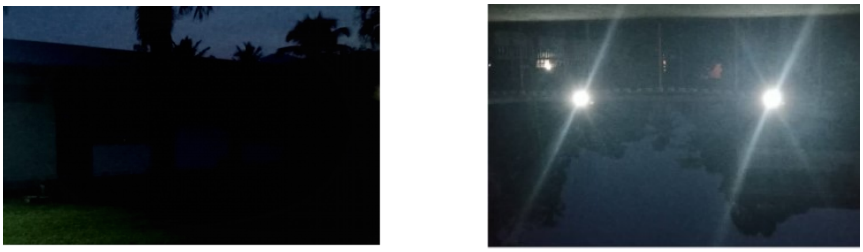
be a true representation of the community's total lighting conditions since the time of day, the weather in the settlements, and site orientation can have an impact on Lux meter readings.

This study followed proper ethical procedures, including informed consent, voluntary participation, and adherence to research guidelines among Indigenous communities. All participants were a few indigenous community members, above 18 years, and any minor discomfort during focus groups or questionnaires was reduced by providing clear explanations and keeping the group sizes small enough to maintain comfort. The main objective is to improve the lighting system effectiveness, and community satisfaction should be considered to provide sufficient lighting for them, since it can affect the community's safety in the school's area.

FINDINGS

Observation

The lighting around the school makes it brighter and safer for the communities to have their social activities at night. In the morning, the dark conditions in the school area can be alleviated with the aid of solar lighting, enhancing the safety of the students and the teachers. Increased visibility lowers the risk of mishaps and security problems, making the learning environment safer and more comfortable. The condition of the case study in SK Sungai Kiol, Jerantut, before and after the installation is shown in Figure 9.



Before After

Figure 9: The conditions before and after solar installation at SK Sg Kiol, Jerantut, Pahang.
(Source: the author, 2023).

The installation of solar lighting technologies helps to reduce the crime rates that might happen at night. Furthermore, the social activities and the community meetings during the nighttime can be extended. The parameter will produce the results of average solar radiation in kilowatt-hour times per square meter ($kWh/m^{2)}$ per day. The east coast of Malaysia, including Pahang, has an annual average daily sun irradiation ranging from 4.21 kWh/m²/day to 5.56 kWh/m²/day (Amirruddin et al., 2011). An effective conversion factor between

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solar radiance (W/m2) and lux illuminance (lx) would allow light meters to be used to assess photovoltaic performance, which is measured in lux (Michael et al., 2020). During the night, the illumination increased from 15 to 100 lux, effectively illuminating the school.

Hence, the solar irradiance for SK Sungai Kiol located at Jerantut, Pahang is 5.04 kWh/m^2 per day, which is high radiation (see Table 8). This improved lighting quality ensures brighter, more uniform illumination, which in turn enhances visibility, safety, and the overall learning environment. Additionally, the high solar irradiance enables consistent and sustainable lighting performance, maximizing the efficiency of the installed solar system.

Table 8: Annual data for Solar Radiation in SK Sungai Kiol, Jerantut, Pahang

Month	Solar Radiation (kWh/m^2/ day)
January	5.98
February	5.95
March	5.78
April	4.81
May	4.62
June	4.48
July	4.60
August	4.67
September	4.83
October	4.88
November	4.73
December	5.14
Annual Solar Radiation: 5.04	

(Source: the author, 2023)

Questionnaires

Through group discussions, the survey engaged 40 respondents, comprising a diverse group of school staff and teachers, providing valuable insights into their experiences and perspectives on solar lighting implementation. The questionnaires about awareness level - *knowledge, installation, participation, and maintenance* - where that knowledge has the highest percentage of strongly agree with 45%, followed by installation with 31%, participation with 28% and maintenance with 26% as the lowest. The building's users, who are also part of the communities, strongly agree that knowledge regarding solar energy technology can enhance community involvement, encourage responsible energy consumption from an early age, and foster a sense of ownership over technology. Data collected from the questionnaires concluded that communities were satisfied with the solar installation using solar photovoltaic (PV) at SK Sg Kiol, Jerantut, Pahang. The summation of the questionnaires was presented as shown in Table 9 and Figure 10.

Table 9: The awareness level of solar lighting technologies

Awareness Level	Percentage of Strongly Agree (SA) (%)
Knowledge	45
Installation	31
Participation	28
Maintenance	26

Source: the authors (2023)

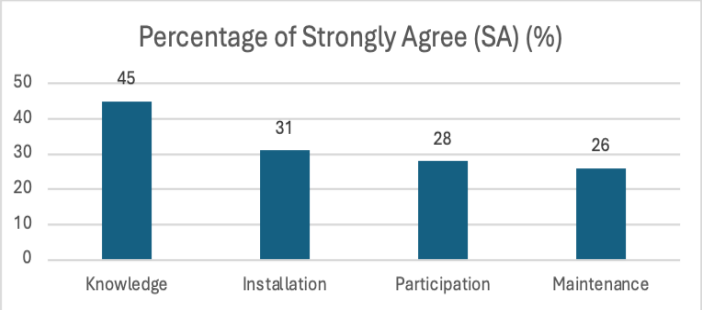


Figure 10: The percentage of awareness level of solar lighting technologies
Source: the author (2023)

DISCUSSION

It was found that the greater engagement in the community within SK Sungai Kiol, Jerantut, is because of knowledge beyond – installation, maintenance, and participation. Community satisfaction after the solar installation also reinforces their willingness to engage with renewable energy solutions that support the long-term sustainability of solar lighting in Indigenous schools.

Engagement Level Increased Among Orang Asli Communities

The implementation of solar lighting systems in schools within Orang Asli communities may have allowed the institutions to offer evening lessons and activities due to sufficient lighting at night. The teachers play a crucial role in helping gauge the level of awareness by conducting educational programs and practical training for the students, starting from a young age, to gauge the willingness to adopt the renewable energy solutions within the school. In addition, the heightened sense of safety can create greater community involvement in school activities, which enhances the relationship between families and the school. The higher the satisfaction, the higher the engagement with solar energy technologies.

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Improved Lighting Quality and Increased Safety

Solar lighting improves visibility around the school area, providing better safety and facilitating evening lessons or other activities. With improved lighting, the atmosphere is safer for both students and teachers. In the bigger picture, this translates to an improved quality of life for the Orang Asli community, with safer spaces and better educational opportunities for the children. The consistent availability of light also encourages more structured after-school programmes, giving students additional time to learn and interact. Over time, improvements in these areas provide further support and a more enabling learning environment for Indigenous students.

CONCLUSION

The effort of installing solar lighting systems in Indigenous schools throughout Pahang marks a very important step toward sustainable energy solutions, ensuring safer and more conducive learning environments. Better lighting would mean better educational outcomes, better attendance, and a more comfortable study atmosphere for the students. Solar energy serves as a reliable source of electricity and increases awareness of renewable energy among the school community. Schools should therefore consider implementing systematic monitoring and evaluation procedures to ensure long-term impacts on well-being and performance resulting from the solar lighting. This paper identifies how solar systems can be used to improve learning spaces and community wellbeing within Indigenous schools, supporting more inclusive energy strategies. In addition, collaborating with government agencies, non-government organizations, or the private sector can help to fund the project and sustain solar technologies for long-term usage.

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IMPROVING SUSTAINABILITY AND REDUCING DISASTER RISK THROUGH MAPPING POTENTIAL LAND FOR COMMUNITY RELOCATION IN BANDA ACEH

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Abstract

Banda Aceh's history of recurrent disasters highlights the urgency of prevention, mitigation, and strategic relocation planning. This study identifies potential relocation sites for communities affected by disasters based on sustainable site selection criteria. A GIS-based Multi-Criteria Decision Analysis (MCDA) is employed, incorporating seven criteria: safe zones from disasters, land use, sufficient area, land slope, soil type, and accessibility to various service facilities and infrastructure. The analysis focuses on peri-urban areas of Banda Aceh within Aceh Besar Regency. The GIS-based MCDA categorizes relocation sites into five suitability levels: very high suitability, high suitability, moderate, low suitability, and very low suitability. The findings suggest that highly suitable relocation sites cover a total area of 256,37 hectares, including eight villages in Darul Kamal and Darul Imarah districts. This study contributes to disaster mitigation literature by offering a scientifically grounded and socially inclusive framework for residential relocation planning in Banda Aceh.

Keywords: Community relocation, Disaster risk, Mapping, Potential land, Sustainability

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INTRODUCTION

According to the United Nations Environment Programme (UNEP), Asia accounted for 40% of global natural disasters between 2005 and 2014 (UNEP, 2015). Events such as the 2004 Indian Ocean earthquake and tsunami, which affected 14 countries and caused approximately 227,000 deaths, illustrate the region's extreme vulnerability. Comparable impacts were seen in the Sichuan earthquake, with nearly 87,000 fatalities, and the 2011 Tohoku earthquake, which resulted in more than 15,000 deaths. More recently, the 2020 South Asian floods affected millions across India, Bangladesh, Nepal, and Pakistan. In Indonesia, the Disaster Risk Index (2022) documents frequent hazards including floods, earthquakes, tsunamis, liquefaction, strong winds, and forest fires. Banda Aceh remains one of the country's most exposed regions due to its coastal location and repeated disaster history (Indonesia Disaster Data and Information, 2022).

Disaster Risk Management (DRM) encompasses risk assessment, preparedness, response, and recovery (UNDRR, 2019). Recovery efforts extend beyond emergency relief to ensuring safe, long-term resettlement for displaced communities (Kumar, 2017). Relocation becomes essential when original settlements are severely damaged or located in high-risk zones. Consequently, resettlement planning is a key component of post-disaster recovery (Imura & Shaw, 2009; Wu & Lindell, 2004). One persistent challenge, however, is securing land that is both safe and suitable. While relocation typically occurs after disasters, pre-disaster relocation is increasingly recognised as a necessary strategy for risk reduction (Dikmen, 2013).

Appropriate site selection requires integrating spatial and social considerations. Permana et al. (2017) stress the importance of vulnerability assessment and proximity to original settlements, whereas Utami et al. (2019) highlight the need to maintain access to livelihoods and essential services. Sustainable relocation should also account for future hazards, economic opportunities, land availability, and tenure security (Imura & Shaw, 2009; Nilsson, 2010; Oliver-Smith, 1991). Yet rapid urban expansion often reduces green areas and agricultural land, exacerbating land scarcity (Wijayanti, 2012). These pressures underscore the need for sustainability-oriented approaches to prevent new socio-environmental challenges in resettlement areas.

This study identifies and maps potential relocation sites for disaster-affected communities by prioritising sustainability and risk-informed criteria. Its novelty lies in integrating environmental, social, and economic dimensions into the site selection process to ensure long-term resilience. Unlike conventional relocation strategies, which frequently overlook sustainability and lead to inadequate infrastructure and socio-economic difficulties (Sabita et al., 2024; Permana et al., 2017), this research applies a GIS-based Multi-Criteria Decision

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Analysis (MCDA) using ArcGIS to provide a systematic, data-driven basis for selecting safer and more sustainable resettlement locations.

LITERATURE REVIEW

Relocation as Disaster Risk Management Effort

Disaster Risk Management (DRM) provides a structured framework for reducing disaster impacts and guiding response and recovery (UNDRR, 2019). It comprises four phases: mitigation through regulations and early warning systems (Coppola, 2015); preparedness through improved planning, communication, and drills (Alexander, 2015); response involving search and rescue and emergency medical care (Coppola, 2015); and recovery that restores infrastructure, economic activity, and social systems (Tierney, 2019). Within this framework, relocation is a key strategy for communities exposed to recurrent hazards, reducing long-term risk by moving residents from unsafe areas. Although often resisted due to emotional and economic ties (Fernando & Punchihewa, 2013), relocation becomes necessary when displacement is extensive, areas are uninhabitable, or resettlement can prevent future losses (Jha, 2010). Effective relocation requires not only rebuilt housing and infrastructure but also restored livelihoods (Comerio, 2014), and may be implemented preventively, as seen in Cukur Village, Turkey, where residents were moved away from rockfall hazards (Dikmen, 2018).

Empirical experiences show varied relocation outcomes. In Donggala, Indonesia, post-disaster resettlement after the 2018 Sulawesi earthquake and tsunami successfully moved communities to safer areas with improved infrastructure and services (World Bank, 2021). In Chiang Rai, Thailand, relocation in flood-prone areas also provided safer housing, upgraded drainage, and livelihood support, reducing future displacement risks (UNDRR, 2019). Conversely, in Tsholotsho District, Zimbabwe, limited community participation and insufficient attention to cultural and economic factors led many residents to leave designated sites (Ngulube et al., 2024). These cases highlight that sustainable relocation relies on integrated, participatory, and context-sensitive planning aligned with community needs and socio-cultural conditions.

Criteria for Selecting Potential Land for Sustainable Relocation

Literature on sustainable relocation emphasises that resettlement must not only move communities from hazardous areas but also ensure long-term socio-economic stability. Dikmen (2018) highlights that successful resettlement protects lives while avoiding new risks, shaped largely by the suitability of the receiving site. Abe et al. (2014) likewise argue that relocation success depends on adequate infrastructure, viable economic opportunities, and preserved social cohesion. Fernando and Punchihewa's (2013) study in Batticaloa, Colombo, and Galle shows how distance and site conditions influence outcomes: communities

returning to original settlements maintained stability, those relocated nearby adapted more easily, while those moved up to 15 kilometers away faced job losses and weakened networks. These patterns are consistent with Shriver and Kennedy (2005), who note that relocation often results in economic loss, social fragmentation, and disconnection from familiar environments.

Collectively, these studies indicate that effective relocation requires integrating disaster-risk reduction, economic recovery, and strong community engagement. They also highlight that site evaluation and land acquisition are central, yet often challenging, components of the process, as unsuitable locations tend to intensify livelihood disruption and weaken community ties. Based on these considerations, this study applies the following criteria to assess potential relocation sites:

Safe zones from disasters (Hazard)
Relocation land must be free from major hazards, such as landslides, floods, fires, earthquakes, and liquefaction, especially in areas with moderate to high risk (Oliver-Smith, 1991; Imura & Shaw, 2009; Nilsson, 2010; Permana et al., 2017; Few et al., 2021; Fakhri & Jumadi, 2023). Such exposure can severely damage housing and infrastructure, making hazard-free zones essential for sustainable resettlement planning.

Sufficient Area (Non-Built-up Area)
Relocation sites must provide adequate non-built-up land to accommodate resettled households, with a minimum area of 3,000 m² (Eriawan & Setiawan, 2021; Nurfikasari & Yuliani, 2021; Fakhri & Jumadi, 2023). The land must also be designated for residential use in Regional Spatial Planning and possess adequate carrying capacity for future development.

Land Slope
SNI 03-1733-2004 specifies that land with a slope greater than 15% should be avoided for settlements due to landslide risks and construction challenges. Nurfikasari and Yuliani (2021) further recommend that residential development be situated on land with slopes of less than 8%, as steeper gradients can increase hazard exposure, particularly landslides.

Soil Type
Selecting suitable soil types enhances the safety and long-term resilience of relocated communities by minimizing environmental hazards. Alluvial, Latosol, and Mediterranean soils are recommended for residential development because of their stability and suitability for construction (Permana et al., 2017; Nurfikasari & Yuliani, 2021; Fakhri & Jumadi, 2023).

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Accessibility, Infrastructure Services, and Public Facility Services

SNI 03-1733-2004 identifies eight key infrastructure components and six public facility criteria for settlements, whose availability strengthens the suitability of relocation sites (Eriawan & Setiawan, 2021; Nurfikasari & Yuliani, 2021; Fakhri & Jumadi, 2023). Adequate access to these services supports economic activity, enhances quality of life, and reduces environmental vulnerability.

Therefore, the selection of relocation sites must prioritize safety, accessibility, and socio-economic viability. A well-planned relocation not only minimizes risks but also strengthens community resilience and supports long-term stability for disaster-affected populations.

METHODOLOGY

This study utilizes GIS-based Multi-Criteria Decision Analysis (MCDA) to identify sustainable relocation sites for disaster-affected communities in Banda Aceh. MCDA facilitates a systematic evaluation of multiple spatial factors, using ArcGIS for spatial analysis. Malczewski (2006) emphasized the critical role of GIS-MCDA in complex spatial decision-making. However, certain technical limitations persist, particularly the reliance on existing map overlays, which may not account for real-time environmental changes, land tenure complexities, or data inaccuracies.

The search for potential relocation sites focuses on peri-urban areas of Banda Aceh within Aceh Besar. As transitional zones between urban and rural regions, peri-urban areas offer several advantages, including proximity to essential services, relative affordability, and opportunities for future spatial expansion (Adell, 1999; Nilsson, 2010; McGee, 1991). Their flexible land-use patterns and generally lower land values compared to fully urbanized zones further strengthen their suitability for sustainable resettlement. Accordingly, this study evaluates seven key criteria (Table 1), forming a structured framework that integrates technical, environmental, and socio-economic aspects to assess the overall feasibility of relocation sites.

Table 1: Criteria for Evaluating Potential Land Relocation

Categories	**Criteria**		**Very High Suitability**	**High Suitability**	**Moderate**	**Low Suitability**	**Very Low Suitability**
			(4)	(3)	(2)	(1)	(0)
Hazard Exposure	C1	Hazard	No hazard	Low hazard	Moderate hazard	High hazard	Very high hazard

Land Use	C2	Non-Built-up Area	Non-built-up area with >15.000 m^2	Non-built-up area with 10.000-15.000 m^2	Non-built-up area with 5.000-10.000 m^2	Non-built-up area with <5.000 m^2	Non-built-up area with built-up area
Geological Factor	C3	Slope	0-2%	2-8%	8-21%	21-40%	>40%
	C4	Soil	Alluvial. Gleiplanosol, hidomorf kelabu, laterita	Latosol	Brown forest soil, Non-calsic, brown, mediteran	Andosol, laterit, grumusol, podsol, podsolik	Regosol, litosol, organosol, renzina
Accessibility	C5	Proximity to roads	0-500 m	501-1000 m	1001-1500 m	1501-2000 m	>2000 m
	C6	Accessibility to infrastructures	Served by >6 types of infrastructure	Served by 4-6 types of infrastructure	Served by 2-4 type of infrastructure	Served by <2 type of infrastructure	Served by no infrastructure
	C7	Accessibility to Public Facilities	Served by >5 types of facilities	Served by 3-5 type of facilities	Served by 2-3 type of facilites	Served by <2 type of facilities	Served by no facilites

Source: Oliver-Smith, 1991; Imura & Shaw, 2009; Nilsson, 2010; Bronen & Chapin, 2013; Permana et al., 2017; Nurfikasari & Yuliani, 2021; Few et al., 2021; Eriawan & Setiawan, 2021; Fakhri & Jumadi, 2023

The application of GIS-based MCDA in disaster relocation planning has been extensively studied. Zaki et al. (2023) demonstrated its effectiveness in urban gardening site selection, while Sabita et al. (2024) employed overlay and scoring methods using Geographic Information System (GIS) applications to determine relocation areas following the Cianjur earthquake and landslide. While prior studies primarily emphasized site suitability, this research integrates spatial and sustainability factors to ensure that relocation sites are not only safe but also socially and environmentally viable and provides a scientific framework for disaster mitigation and sustainable relocation planning in Banda Aceh.

RESULTS AND DISCUSSION

Relocation for High-Risk Settlement Area

Banda Aceh is one of the Indonesian cities with the highest disaster exposure due to its low-lying coastal geomorphology and proximity to tectonic sources in the Indian Ocean. The 26 December 2004 tsunami exposed the magnitude of

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destruction along the northern coast and redirected urban expansion toward the higher eastern and southern sectors. Yet, increasing density in these areas over the past decade has produced new spatial pressures that gradually push development back toward the northern corridor, reinforcing the need to control settlement expansion into officially identified hazard-prone zones (Akbar & Ma'rif, 2014; Al-fath, 2022; Irwansyah et al., 2025).

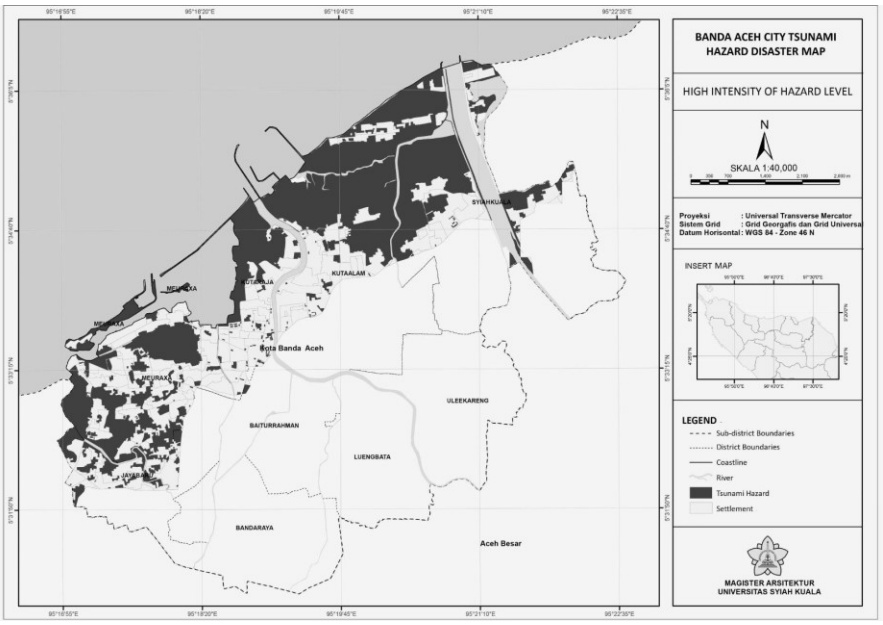


Figure 1: Tsunami Disaster Map

Figure 1 illustrates the spatial extent of tsunami hazard zones in Banda Aceh, shown in blue, relative to residential areas in yellow. The map reveals that much of the northern coastline, particularly Jaya Baru, Meuraxa, Kutaraja, Kuta Alam, and Syiah Kuala Districts, lies within a broad hazard band that directly overlaps existing settlements, indicating high exposure and the need for stricter spatial regulation. The inland continuity of this hazard zone suggests that all neighbourhoods within this corridor face substantial risk, reinforcing the necessity of relocation as a mitigation strategy. In addition to the threat of tsunamis, the area is also susceptible to liquefaction hazards.

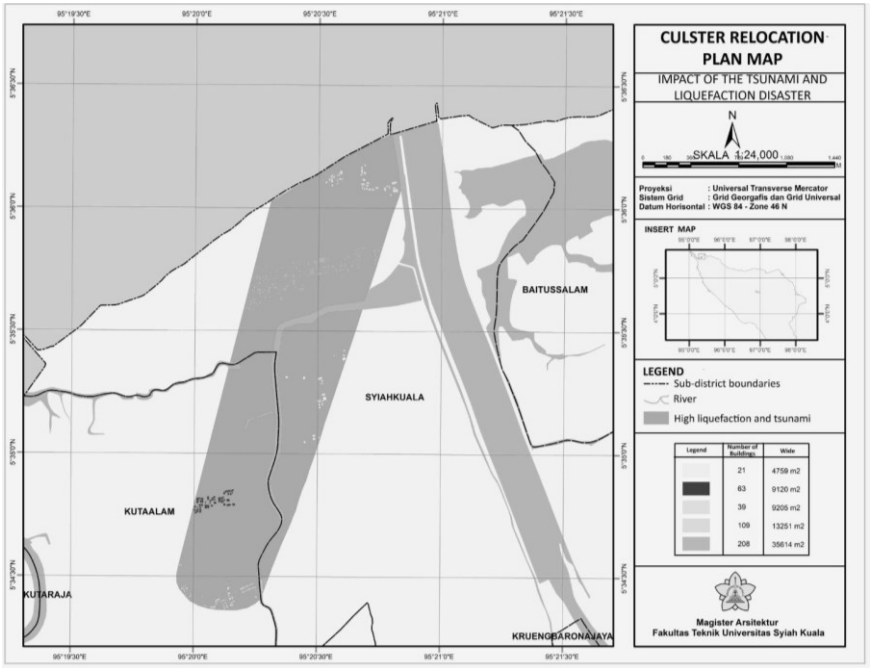


Figure 2: Liquefaction Disaster Map of Banda Aceh and the cluster recommendation

Figure 2 highlights areas simultaneously exposed to tsunami and liquefaction hazards, marked in pink, traversing several coastal gampong: Alue Naga, Deah Raya, Tibang, and Lambaro Skep, all of which also lie within the tsunami hazard zone shown in Figure 1. The combined map interpretation identifies 440 housing units across roughly 7.19 hectares within this dual-hazard area. To support more effective planning, the affected settlements are grouped into five clusters: Cluster 1 (9,205 m²; 39 houses), Cluster 2 (3.56 ha; 208 houses), Cluster 3 (4,759 m²; 21 houses), Cluster 4 (9,120 m²; 63 houses), and Cluster 5 (1.32 ha; 109 houses). This clustering offers a structured basis for systematic relocation, enabling clearer estimation of safe-land needs, phased resettlement planning, and assessment of receiving areas capable of supporting sustainable community relocation.

Spatial Analysis for Identifying Potential Relocation Sites for Communities Displaced by Disasters

Banda Aceh's vulnerability map shows that most of the city is highly hazard-exposed, while dense urbanisation limits safe relocation land, shifting feasible options to peri-urban districts of Aceh Besar—Peukan Bada, Syiah Kuala, Krueng Barona Jaya, Kota Baro, Darul Imarah, Darul Kamal, Ingin Jaya, and Darussalam. Aceh Besar spans 2,903.50 km², with the 2012–2032 RTRW

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indicating dominant land uses such as secondary dryland forest (82,843.21 ha; 28.53%), dryland agriculture (40,165.63 ha; 13.83%), and savanna (54,778.43 ha; 18.87%), while settlements account for only 9,806.14 ha (3.38%). PERMEN PU No.41/PRT/M/2007 requires residential development on flat to gently undulating slopes (0–25%), as shown in Figure 3.

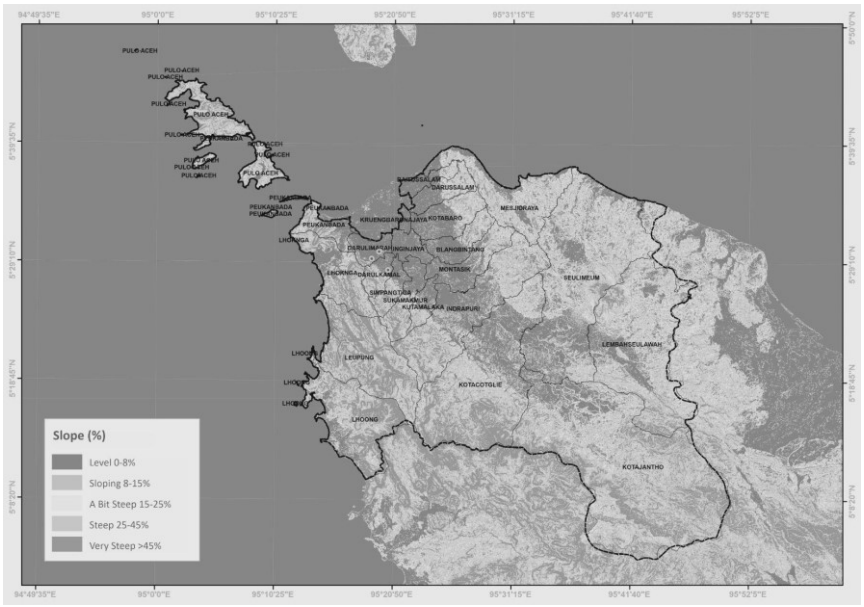


Figure 3: The land slope Map of Aceh Besar

Among the peri-urban zones, Darul Imarah and Darul Kamal emerge as the most suitable relocation areas due to their comparatively lower disaster risks (Inarisk, 2025). Both districts exhibit moderate earthquake exposure, low tsunami potential, and moderate-to-low flood vulnerability, positioning them as safer settlement alternatives. Their extensive agricultural landscapes (BPS Aceh Besar, 2023) with gentle 0–8% slopes further support sustainable residential expansion (Figure 3). Darul Imarah benefits from stronger infrastructure and direct connectivity to Banda Aceh, whereas Darul Kamal offers broader land availability. Figure 4 delineates their spatial boundaries, proximity to Banda Aceh's urban core, existing settlement distribution, and remaining non-built-up land suitable for development.

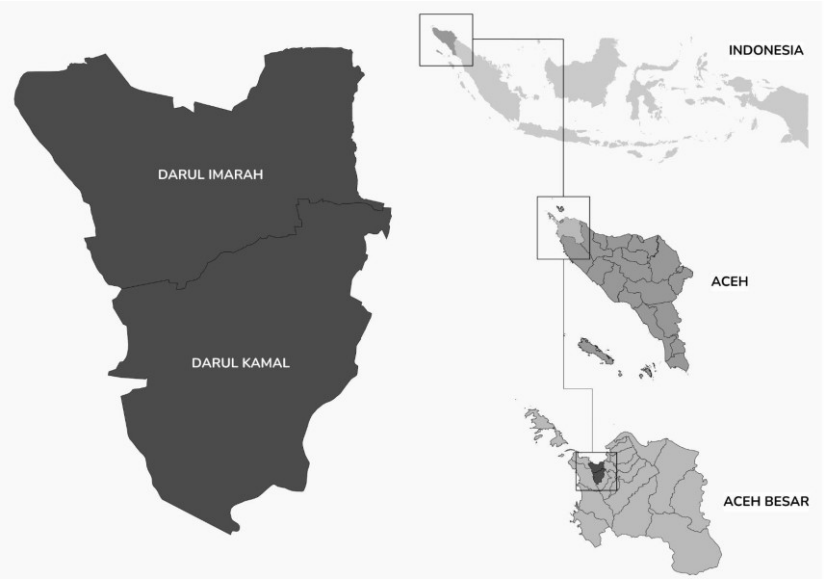


Figure 4: Districts for relocation (Darul Imarah dan Darul Kamal)

Accessibility remains a crucial determinant of relocation success, as adequate infrastructure and social connectivity strongly influence community satisfaction. Empirical evidence shows that well-developed facilities enhance resettlement outcomes, whereas inadequate services and weakened social ties contribute to dissatisfaction (Abdul et al., 2021; Isa et al., 2021). The subsequent table provides descriptive statistics of the Multi-Criteria Decision Analysis used to evaluate land suitability for relocation.

Table 2: Descriptive Statistics of MCDA Criteria for Settlement Suitability

	Criteria	min	max	sum	mean	Std. dev
C1	Hazard	0	2	578	1.467005	0.556619
C2	Non-Built-up Area	0	2	534	1.35533	0.761134
C3	Slope	0	2	734	1.862944	0.948682
C4	Soil	0	1	569	1.444162	0.496872
C5	Proximity to roads	0	4	1502	3.812183	1.085321
C6	Accessibility to infrastructures	0	3	719	1.824873	1.023724
C7	Accessibility to facilities	0	2	526	1.335025	0.59562
LS	Land Suitability of Settlement Relocation	0	3	580	1.472081	0.600746

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The analysis shows that the average hazard risk (C1) is 1.467 with a low standard deviation (0.557), indicating moderate and relatively uniform risk. Non-built-up areas (C2) average 1.355 with a higher standard deviation (0.761), reflecting notable variation in land availability. Slope (C3) has an average of 1.863 and a high standard deviation (0.949), suggesting substantial topographic differences, while soil quality (C4) averages 1.444 with moderate variability (0.497). Proximity to roads (C5) records the highest mean (3.812) and a standard deviation of 1.085, showing uneven accessibility. Access to infrastructure (C6) and public facilities (C7) averages 1.825 and 1.335, respectively, both with moderate fluctuations. The overall land suitability score (LS) averages 1.472 with a standard deviation of 0.601, indicating generally suitable yet spatially varied conditions for relocation.

While these quantitative results provide a sound technical foundation for relocation planning, several non-technical factors remain particularly challenging in the Acehnese context. Many residents are reluctant to relocate because land ownership in their pre-tsunami settlements is already well-established and secured, while relocation sites often lack clarity (Oliver-Smith, 1991; Shriver & Kennedy, 2005). Cultural preferences and a strong attachment to familiar environments also make communities hesitant to leave their comfort zones and adapt to unfamiliar settings (McMichael et al., 2019; Nilsson, 2010). In addition, proximity to workplaces and daily economic activities plays a crucial role in residents' willingness to move, as relocation to distant areas may disrupt livelihood patterns (Bower et al., 2023; Nalau & Handmer, 2018). These factors highlight that relocation feasibility is shaped not only by spatial suitability but also by social acceptance and livelihood considerations.

In relation to these challenges, the overlay analysis for Darul Kamal and Darul Imarah, based on seven relocation criteria, is shown in Figure 5 and classifies land into five suitability levels. As indicated in Table 3, no areas fall under the "very high" suitability category, reflecting inherent constraints within both districts. High suitability areas amount to 256.37 ha, while moderately suitable zones dominate with 4,373.05 ha. Low suitability areas extend across 2,935.47 ha, and very low suitability zones cover 144.21 ha. This distribution underscores that although ample land is available, the most optimal sites remain limited, necessitating careful prioritisation and phased planning.

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Figure 5: Suitability map for relocation sites

Table 3: Land Suitability Classification and Area Size

Index	Land Suitable	Area (Ha)
4	Very High Suitability	0
3	High Suitability	256,37
2	Moderate	4373,05
1	Low Suitability	2935,47
0	Very Low Suitability	144,21

The primary recommended relocation sites fall under the high suitability category, located mainly on agricultural land in Teubalui, Neusok, Turam, Blang Kiree, and Lam Bleut (Darul Kamal), as well as Lheu Blang, Lamblang Manyang, and Lamreung (Darul Imarah). Moderately suitable zones may be used with strict land-use controls, while low and very low classes remain unsuitable. Although technically appropriate, these agrarian landscapes require careful planning for livelihood transitions, as coastal households reliant on fisheries and maritime activities may experience long-term income disruptions when shifted to agricultural environments (Wardana et al., 2020). Global evidence similarly stresses livelihood-sensitive relocation: experiences in Fiji, Bangladesh, and Merapi demonstrate that skills retraining and integration into agricultural value chains are essential for sustaining resettled populations (UNDP, 2013; Nalau & Handmer, 2018; McMichael, 2019). Without such

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measures, top-down resettlement often erodes livelihood resilience (Bower et al., 2023), heightens risks of irreversible losses (Nand et al., 2023), and weakens adaptive capacity when access to natural resources is disrupted (Zhao et al., 2024).

The proposed villages in Darul Kamal District are characterised by productive agricultural landscapes, paddy fields, mixed crops, and livestock, which sustain local economies and food security. These areas are supported by essential infrastructure, notably paved roads and reliable electricity, which enhance mobility and enable diverse socio-economic activities. In Darul Imarah District, the three recommended villages lie on relatively flat, low-elevation terrain suitable for both agriculture and settlement. Their proximity to Banda Aceh (5–10 km) ensures access to urban services, while existing facilities such as mosques, primary schools, and community centres provide the social and religious functions necessary for daily life. Well-developed transportation and energy networks further support economic activity and overall living standards in both districts.

Such social infrastructures are particularly significant in Aceh, where mosques, meunasah, schools, and communal spaces anchor social cohesion. High physical suitability alone is insufficient if relocation separates communities from these networks; failures following Typhoon Haiyan highlight how disconnection undermines resettlement outcomes (Cuaton, 2019; Fernando & Punchihewa, 2013). Preventive relocation, such as in Cukur Village, Turkey, where residents were moved away from rockfall hazards, underscores the importance of aligning safety with social continuity (Dikmen, 2018). Accordingly, MCDA-based spatial suitability must be interpreted alongside community acceptance, cultural ties, and livelihood restoration to maintain social resilience (Comerio, 2014; Bower et al., 2023). This is consistent with international lessons: Japan post-2011 stresses combining hazard analysis with participatory planning (Jha, 2010), Christchurch demonstrates MCDA's effectiveness when paired with transparent engagement (Tierney, 2019), and cases from Sri Lanka, the Philippines, Indonesia, and Thailand show that technically optimal sites can still underperform when socio-cultural and economic factors are overlooked (Abe & Shaw, 2014; Cuaton, 2019; World Bank, 2020; UNDRR, 2019). Together, these findings affirm that spatial metrics must be complemented by socio-cultural and livelihood considerations to ensure sustainable post-disaster relocation.

CONCLUSION

This study demonstrates that successful relocation requires meeting a set of multidimensional criteria that extend beyond physical displacement. The analysis emphasises that suitable relocation sites must satisfy hazard-safety considerations, appropriate land characteristics, and sufficient accessibility to

public services, while also aligning with the social, economic, and cultural needs of affected communities. By applying these criteria, relocation becomes not only a risk-reduction strategy but also a pathway to enhancing long-term resilience, livelihood continuity, and sustainable settlement development.

Through GIS-based spatial assessment, the study identified eight villages in Darul Kamal and Darul Imarah Districts as the most suitable potential relocation sites. These locations, Teubalui, Neusok, Turam, Blang Kiree, Lam Bleut, Lheu Blang, Lamblang Manyang, and Lamreung, fulfil the established criteria in terms of hazard exposure, land capability, and integration with surrounding infrastructure. Their spatial characteristics provide a technical foundation for guiding government decisions on safer resettlement planning and contribute to a more systematic, transparent, and evidence-based approach to relocation in disaster-prone regions.

Nevertheless, despite providing a strong technical basis, this study acknowledges several limitations that may affect the transition from spatial assessment to practical implementation. The absence of detailed field verification limits the ability to fully confirm on-site conditions, including potential challenges related to land tenure security, where overlaps between formal property titles and customary claims may hinder legal clarity and compensation processes. In addition, environmental dynamics, such as rapid land-use change, evolving hydrometeorological patterns, and emerging climate-related hazards, may alter the long-term suitability of the identified sites. Equally important, this study did not directly assess community acceptance, even though social cohesion, cultural practices, and livelihood preferences are critical determinants of relocation success. To address these limitations, future research should incorporate systematic field surveys, comprehensive assessments of legal and institutional land-tenure frameworks, and participatory approaches such as stakeholder consultations and participatory mapping to validate GIS findings. Thorough documentation of these processes will enhance transparency, improve planning accuracy, and support the development of a relocation framework that is adaptive, inclusive, and effectively aligned with long-term disaster risk reduction goals.

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THE EVALUATION OF ISLAMIC GARDEN DESIGN CHARACTERISTICS IN URBAN PARKS IN BANDA ACEH

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Abstract

Urban parks in Banda Aceh serve as vital public and green spaces. In Islamic tradition, gardens symbolise paradise and divine unity. However, despite the city's strong Islamic identity, contemporary urban parks often lack these design principles. This study evaluates five parks in Banda Aceh to assess their alignment with Islamic garden design, using 12 main indicators and 42 sub-indicators. The findings reveal that Putroe Phang Park most closely reflects Islamic garden principles (83.33%), while Krueng Neng Park ranks lowest (38.09%). The results underscore a disconnect between urban park design and the preservation of Islamic architectural heritage. This study recommends integrating Islamic design elements into future park development to strengthen cultural identity and historical continuity. These insights offer strategic guidance for the Banda Aceh government in enhancing urban parks, ensuring they reflect Islamic architectural values while serving as high-quality public spaces.

Keywords: Islamic garden, Urban parks, Green open space, Islamic architecture

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INTRODUCTION

Islamic gardens have historically served as earthly representations of paradise, embodying the concept of eternal bliss as described in the Qur'an (Clark, 2004). The term "paradise" is derived from the ancient Persian word *pairidaeza*, denoting an enclosed garden or walled sanctuary of beauty and tranquillity. In Islamic teachings, paradise is the ultimate aspiration for Muslims, a place of eternal happiness and divine reward. This vision has inspired the creation of gardens that offer peace, joy, and spiritual reflection (Jannah et al., 2015).

Banda Aceh, located in the westernmost region of Indonesia and serving as the capital of Aceh Province, is a predominantly Muslim city. According to the Central Bureau of Statistics of Aceh (2020), 89.6% of its population – 242,221 out of 270,328 residents – identify as Muslim. The region has a deep-rooted history of Islamic governance, with the implementation of Islamic Sharia law dating back to the era of the Aceh Sultanate, long before Indonesia's independence. This religious tradition was later institutionalised through Law No. 44 of 1999 and Law No. 18 of 2001, which strengthened the application of Islamic law in Aceh. Despite this strong Islamic identity, the design of many urban parks in Banda Aceh often fails to reflect the architectural principles and values rooted in Islamic tradition.

Acehnese society, grounded in Islamic values, traditionally diverges from the Western concept of urban parks, which tend to prioritise leisure and entertainment. In contrast, recreation in the Acehnese context emphasises social cohesion, spiritual fulfilment, and harmony with nature, reflecting a holistic relationship with God, humanity, and the environment. This contrast highlights the need for urban parks in Banda Aceh to reflect Islamic values and cultural heritage while fulfilling their role as functional public spaces.

This study develops and applies a practical, operational framework of 12 indicators and 42 sub-indicators to systematically evaluate Islamic garden design in contemporary urban parks. While previous works have mostly focused on historical case studies or conceptual discussions, this research demonstrates how Islamic garden principles can be translated into measurable criteria and applied to existing green public spaces in a Sharia-based city. In the specific context of Banda Aceh, the findings offer actionable guidance for municipal planners to integrate Islamic architectural and landscape values into urban park design, thereby strengthening cultural identity and spatial governance.

Accordingly, this study aims to evaluate the extent to which Islamic garden design characteristics are reflected in five selected urban parks in Banda Aceh. By assessing their alignment with these principles, the research generates concrete recommendations for the future development and management of urban parks in Banda Aceh. These efforts seek to enhance the quality of public open spaces, support the implementation of Islamic law, and promote Islamic tourism

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unique to the region. Ultimately, the study advances planning practice by positioning Islamic garden design not only as a heritage reference, but as a contemporary framework for resilient, culturally rooted urban green infrastructure.

LITERATURE REVIEW

According to Banda Aceh Urban Qanun No. 2 of 2018, which amends Qanun No. 4 of 2009 on the Banda Aceh Urban Spatial Plan (2009–2029), urban parks in Banda Aceh form an integral part of the city's Green Open Space (RTH). This includes 38 urban parks and 4 urban forests distributed across various sub-districts. These parks serve as key recreational spaces for the community, offering alternatives to beaches and other outdoor recreational destinations.

Qardhawi (2000), as cited in Janna et al., (2015), emphasises that parks, as part of *muamalah* (social interaction), are governed by Islamic legal principles that permit artistic and creative expressions, provided they do not contravene Sharia law. Islam, as a comprehensive way of life, includes guidelines for the planning and design of gardens (Hapsari et al., 2018). The fundamental legal principle in Islamic garden design is permissibility, as long as it avoids elements that are explicitly prohibited (Ansari & Nazia, 2011). These prohibitions include anything associated with Allah (*shirk*), elements that do not benefit humans or nature, and the use of materials or designs considered excessive or inappropriate, such as statues, gold, and silver (Hanurrhaza et al., 2015).

Jannah et al., (2015) further developed a set of parameters for Islamic garden design based on the Qur'an and Hadith. These include aspects such as order, space, form, texture, pattern, light, movement, garden elements, and user considerations. Additionally, Tajuddin (1999), in The Concept of Islamic Comparison, highlights the principles of *Habluminallah*, *Habluminannas*, and *Habluminal'alam* as foundational to Islamic architecture.

Tajuddin (1999) explains that *Habluminallah* is derived from the Arabic words *Hablun* (relationship or bond), *Min* (from or with), and *Allah* (referring to God), signifying the relationship between humans and their Creator. *Habluminannas* (*Annaas* meaning humans) refers to the relationship between individuals and other people, while *Habluminal'alam* (*'Alam* meaning the natural world) represents the connection between humans and the environment. These three principles form the core of Islamic architectural and garden design, emphasising harmony across spiritual, social, and environmental dimensions (Hanurrhaza, Harun, Mansor, & Zen, 2017).

METHODOLOGY

This study was conducted in active urban parks in Banda Aceh, the capital of Aceh Province, Indonesia. Banda Aceh comprises 9 sub-districts and 90 *Gampong* (urban villages). The research focused on five selected urban parks: Tibang Urban Forest, Bustanussalatin Park, Trembesi Urban Forest, Krueng Neng Park, and Putroe Phang Park. These parks were chosen based on their activity levels, land size, and the availability of supporting facilities. The selection also considered their alignment with the physical and conceptual characteristics of Islamic parks, as described in the Qur'an and Hadith, including attributes such as beauty, shade, spaciousness, accessibility, and suitability as communal public spaces.

According to Hamdani Basyah, Head of DLHK3 Banda Aceh (personal interview, 2023), these parks are among the most active in the city and are equipped with comprehensive facilities such as children's play areas, parking spaces, *mushalla* (prayer rooms), toilets, park furniture, security personnel, cleaners, and easy visitor access. These features make them representative of public open spaces in Banda Aceh and suitable for evaluating the integration of Islamic garden design principles.

A descriptive qualitative research method was employed to systematically describe and analyse the application of Islamic garden design principles within the selected parks. The research aimed to identify existing issues, evaluate the degree of compliance with Islamic garden design parameters, and propose improvements based on the findings.

This study has several methodological limitations that should be acknowledged. First, the sample is restricted to five active urban parks in Banda Aceh, which limits the generalisability of the findings to the wider urban green space system. Second, the scoring approach is primarily descriptive and observation-based, which may introduce observer bias and does not formally address inter-rater reliability. Third, the absence of granular quantitative data at the sub-indicator level constrains the use of more advanced inferential statistical tests. These limitations mean that the results should be interpreted as indicative rather than definitive. Future research could expand the sample size, employ scoring instruments with tested inter-rater reliability, and collect more detailed numerical data to enable more robust statistical analysis and comparison.

The research process involved two main stages, namely 1) Literature Review: a comprehensive review of relevant literature and previous studies was conducted to define Islamic garden design concepts and establish the research parameters; and 2) Field Observation: structured field observations were carried out at each park using a pre-designed observation sheet to evaluate the application of Islamic garden design principles.

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Data collection involved three main techniques, namely 1) Observation: guided by an observation sheet comprising 12 main indicators and 42 sub-indicators (Table 1), observations evaluated the degree of Islamic garden design application. A score of 100% represented full compliance. 2) Documentation: photographs and videos were taken using cameras and mobile phones to capture the parks' physical features and facilities. 3) Informal Interviews: conducted with stakeholders such as officials from the Banda Aceh City Hygiene and Beautification Environment Agency (DLHK3) to gain insights into park management and design considerations. The evaluation framework, based on Islamic garden design principles, included the following 12 main indicators, elaborated into 42 sub-indicators:

1. Order: Refers to balance and unity, achieved through symmetrical, asymmetrical, or radial layouts (Lehrman, 1980; Clark, 2004; Jannah et al., 2015).
2. Space: Involves varying spatial dimensions to support different uses and accommodate multiple users simultaneously (Lehrman, 1980; Jannah et al., 2015).
3. Form: Designs should avoid representations of humans or animals (Allah's creations) to prevent idolatry or association with Allah (Lehrman, 1980; Qardhawi, 2000; Ruggles, 2007; Jannah et al., 2015).
4. Texture: Emphasises natural, beneficial textures in line with Islamic aesthetics (Lehrman, 1980; Qardhawi, 2000; Jannah et al., 2015).
5. Pattern: Typically features Arabesque motifs inspired by flora and calligraphy, avoiding human or animal figures (Lehrman, 1980; Qardhawi, 2000; Jannah et al., 2015).
6. Light: Ensures adequate shade and comfort by avoiding excessive heat (Lehrman, 1980; Fireza, 2007; Jannah et al., 2015).
7. Movement: Concerns the flow of both visitors and water, promoting clarity and harmony in circulation (Lehrman, 1980; Simonds, 2013; Jannah et al., 2015).
8. Garden Elements: Encompasses soft elements (water, vegetation, fruits, animals) and hard elements (structures, doors, accessories like rugs, cots, and vessels) inspired by paradise (Qardhawi, 2000; Arifin & Nurhayati, 2000; Fireza, 2007; Jannah et al., 2015).
9. User: Gardens are open to the public, provided users adhere to Sharia principles regarding attire and behaviour (Clark, 2004; Sherer, 2006; Qardhawi, 2000; Jannah et al., 2015).
10. Habluminallah: Reflects remembrance of God through elements resembling divine unity, worship, the beauty of creation, and the inevitability of death (Tajuddin, 1999; Fikriarini, 2008; Handryant, 2010).

11. Habluminannas: Promotes social integration, open communal spaces, education, reminders of spiritual struggle, social welfare, and cultural tolerance (Tajuddin, 1999; Fikriarini, 2008; Handryant, 2010).
12. Habluminal'alam: Emphasises sustainable development, conservation, recycling, ecological regulation, and the promotion of sustainable living (McHarq, 1967; Sternloff & Warren, 1984; Tajuddin, 1999; Muhirdan, 2008; Fikriarini, 2008; Handryant, 2010; Simonds, 2013).

The collected data were analysed qualitatively. Field observations were conducted in the five selected parks using a structured checklist form based on previously formulated Islamic garden design parameters. Twelve main parameters were employed to evaluate the extent to which each site fulfils the characteristics of an Islamic garden. These twelve parameters were further operationalised into a total of forty-two sub-indicators, where full fulfilment of all sub-indicators was defined as 100% compliance with Islamic garden design characteristics. The sub-indicators were compiled into observation tables, which were used during on-site surveys to systematically record the presence or absence of each parameter in the study locations. This procedure enabled a clear assessment of the degree to which Islamic garden design characteristics are applied in each park. The resulting compliance levels were then compared across the five parks to identify patterns, strengths, and opportunities for improving the implementation of Islamic garden design principles.

RESULTS

1. Tibang Urban Forest

Tibang Urban Forest is characterised by extensive vegetation coverage and a non-symmetrical spatial arrangement. The urban forest park features clearly defined zones that facilitate visitor movement and navigation. However, from the perspective of the architectural principle of *habluminannas* (the human relationship with others), the park lacks essential facilities such as plazas, stages, or open spaces that promote social interaction. Although there is a designated children's play area, it does not sufficiently cater to the needs of adults seeking spaces for communal engagement.

In contrast, the principle of *habluminallah* (the human relationship with God) is relatively well-fulfilled, particularly due to the presence of historical tombs and graves. These elements serve as contemplative reminders of mortality and are unique among the parks studied. Nevertheless, the park does not incorporate traditional Islamic design elements such as the *chahar bagh* layout, curved domes, arabesques, calligraphy, or other characteristic Islamic patterns.

With regard to garden elements, several features commonly associated with Islamic gardens are absent. These include both soft and hard landscaping

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elements, as well as traditional accessories such as doors, gates, pillars, rugs, cots, glasses, vessels, goblets, plates, and jars. Additionally, while artificial shading structures are not fully implemented, the park's dense vegetation offers ample natural shade during the day (Figure 1).



Figure 1: Tibang Urban Forest – *dense vegetation provides natural shade, but the absence of artificial shade structures and Islamic architectural motifs is still evident. Source: Researcher Documentation, 2023.*

To enhance Tibang Urban Forest's alignment with Islamic garden principles, specific design interventions are recommended. These include incorporating spatial formations and decorative patterns such as chahar bagh layouts, domes, horseshoe arches, arabesques, calligraphy, mashrabiya pergolas, and pillars. The integration of colourful tiles with Islamic, Arabic, or Middle Eastern motifs would further reinforce the park's cultural and aesthetic identity. Additionally, the introduction of artificial shading structures or shelters would significantly improve visitor comfort, addressing a current gap in the "light" indicator. While Tibang Urban Forest effectively promotes environmental sustainability and serves as an urban "lung," its design can be further enriched by these culturally resonant elements. Based on the evaluation, Tibang Urban Forest satisfies 33 out of 42 Islamic garden design parameters, achieving a compliance rate of 78.57% (Table 1), making it the second most compliant park in this study.

2. Bustanussalatin Park

Bustanussalatin Park, located in the city centre, serves as one of the main hubs for community activities. It is managed by the Banda Aceh municipal government and is leased for both commercial and non-commercial purposes. The park features a symmetrical landscape arrangement, centred and surrounded by pedestrian pathways and jogging tracks, though these paths are not yet fully connected (Figure 2). The zoning within the park is clearly defined, facilitating visitor movement. However, the presence of a large and visually dominant main stage building at the park's centre, alongside other substantial structures – such as the Handicraft Council building on the southern side – detracts from the

application of Islamic garden design principles. Furthermore, the depiction of human figures on the walls of the main stage building reduces the value of the park's alignment with Islamic design aesthetics (Figure 2).

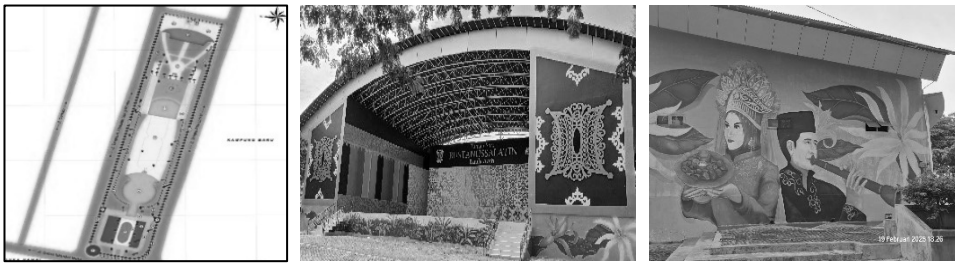


Figure 2: Bustanussalatin Park – *the dominant main stage and the human figures on the walls conflict with Islamic design principles; path connectivity is not yet comprehensive.*
Source: Researcher Documentation, 2023.

In terms of the architectural principles of *habluminallah*, *habluminnas*, and *habluminal'alam*, the Proclamation Monument serves as a symbolic reminder of mortality, aligning with Islamic teachings. However, the use of artificial and luxurious elements is inconsistent with Islamic garden design values. The principle of *habluminnas* (human relationships with others) is also insufficiently addressed, due to the absence of designated communal areas such as meeting rooms, canteens, and fully connected exercise facilities including sports fields and jogging tracks. Additionally, the architecture lacks local or traditional Islamic elements, instead adopting a predominantly modern and generic style.

Some Islamic design elements, such as curved domes, arabesques, and calligraphy, are present at the gate and the exhibition building located on the northern side of the park. Nevertheless, these features are inconsistently applied throughout the park. Several key Islamic garden parameters remain unfulfilled, particularly in relation to garden elements. The park lacks both soft elements (flowering plants, fruit trees, and water features) and hard elements (animal motifs, rugs, cots, glasses, vessels, goblets, or plates), which are typically associated with classical Islamic garden aesthetics.

To improve Bustanussalatin Park's adherence to Islamic garden principles, a comprehensive redesign is recommended. This should focus on integrating Islamic architectural forms and patterns into hardscape elements, such as chahar bagh layouts, domes, horseshoe arches, and arabesques. The inclusion of artificial shelters and a greater diversity of ornamental and fruit-bearing plants would also enhance the park's alignment with Islamic aesthetics. Crucially, the existing human imagery on the main stage building's walls should be replaced

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with botanical motifs or Islamic calligraphy to align with the "form" indicator. Furthermore, worship facilities should be made more prominent and designed as distinct structures. Currently, Bustanussalatin Park ranks fourth, fulfilling 23 out of 42 parameters with a compliance rate of 54.76% (Table 1).

3. Trembesi Urban Forest

Trembesi Urban Forest is a shaded and inviting park that functions effectively both as a public green space and as one of the city's ecological "lungs". The park, with an area of 23,334 m², contains 26 tree species, a children's play area, parking facilities, an information building, a mushalla (prayer room), ablution facilities, signage, toilets, pedestrian paths, park lighting, a nursery area, an open grass field, and a sundial (Figure 3). However, it lacks dedicated sports facilities and a central plaza or amphitheatre for large public gatherings.

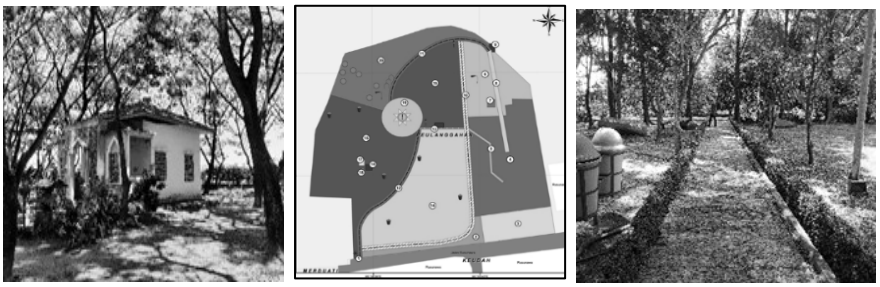


Figure 3: Trembesi Urban Forest – *the presence of a prayer room supports the Habluminallah principle, yet the absence of a plaza or amphitheatre limits large communal gatherings, reflecting partial fulfilment of the "user" and Habluminannas indicators.*
Source: Researcher Documentation, 2023

From the perspective of Islamic garden design, Trembesi Urban Forest performs moderately well. The availability of worship facilities supports the Habluminallah principle, while tree cover contributes to thermal comfort under the "light" indicator. Nonetheless, universal Islamic geometric forms and decorative patterns—such as chahar bagh layouts, domes, horseshoe arches, arabesques, and calligraphy are largely absent, limiting the park's expression of the "form" and "pattern" indicators. Communal spaces are present but not yet articulated as strong focal points for social integration under Habluminannas.

To strengthen alignment with Islamic garden principles, several design interventions are recommended. These include incorporating traditional Islamic spatial formations and ornamental patterns into key hardscape elements, and enhancing softscape diversity through flowering and fruit-bearing plants that support both aesthetics and symbolic values. Additional shade structures or

shelters would further improve comfort, particularly in open grassy areas. Similar to Tibang Urban Forest, Trembesi Urban Forest was originally conceived to promote environmental sustainability, maintain a balance between green and non-green open spaces, and enhance the city's ecological health. In terms of Islamic garden design parameters, Trembesi Urban Forest fulfils 26 out of 42 criteria, resulting in a compliance rate of 61.90% (Table 1), placing it in the middle of the five evaluated parks.

4. Krueng Neng Park

Krueng Neng Park is the most recently developed urban park and green open space in Banda Aceh. Located in Lamjamee Village, Jaya Baru District, the park covers an area of 15,202 m² and includes several tree species, a children's play area, parking facilities, an information building, a mushalla, signage, toilets, pedestrian paths, park lighting, a plaza amphitheatre, a park sign, a basketball court, and an educational building for children (Figure 4).

The park's spatial configuration is asymmetrical, with a centrally positioned meunasah (prayer pavilion) connected by pedestrian paths, although the pathway network remains partially disconnected. Overall, the facilities accommodate a wide range of visitor activities. The children's play area is particularly well equipped and heavily used. In terms of Islamic architectural principles—Habluminallah, Habluminannas, and Habluminal'alam—the park shows mixed performance. The Habluminallah principle is relatively well fulfilled through the spacious and centrally located meunasah, which acts as the visual and spiritual focal point of the park. The Habluminannas dimension is supported by plazas, stages, open spaces, and an educational centre that facilitate social interaction.



Figure 4: Krueng Neng Park – *the centrally located meunasah reinforces Habluminallah, but universal Islamic geometric patterns and limited shading indicate weak performance in the "form" and "light" indicators.*
Source: Researcher Documentation, 2023.

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Despite these strengths, the park lacks key design characteristics typically associated with Islamic gardens. Form-related elements such as chahar bagh layouts, curved domes, arabesques, and calligraphy—which are hallmarks of traditional Islamic aesthetics—are not yet integrated into the wider spatial or architectural composition. There is also no clear application of Islamic or Middle Eastern stylistic patterns in flooring, façades, or site furniture. In addition, shading remains insufficient, reducing comfort for daytime use and affecting performance under the "light" indicator.

To improve Krueng Neng Park's alignment with Islamic garden principles, a more deliberate and comprehensive design concept is required. This should include the incorporation of chahar bagh formations, domes, horseshoe arches, arabesques, calligraphy, mashrabiya, and pillars in key architectural and landscape elements. The use of vibrant decorative tiles on buildings, pavements, and seating featuring Islamic, Arabic, or Middle Eastern motifs would help reinforce the park's cultural identity. The installation of additional shade structures or gazebos is also strongly recommended to enhance user comfort and overall spatial quality. Among the five parks evaluated, Krueng Neng Park ranks lowest in terms of compliance with Islamic garden parameters, fulfilling 16 out of 42 parameters, or 38.09% (Table 1).

5. Putroe Phang Park

Putroe Phang Park is a historically significant urban park with an area of 24,461 m². Located in Peuniti Village, Baiturrahman District, it contains 29 tree species, a children's play area, parking facilities, park signage, an information building, gazebos, a plaza amphitheatre, a suspension bridge, a mushalla, the historic Pintoe Khop monument, toilets, pedestrian paths, park lighting, pergolas, a bird enclosure, access to the Krueng Daroy River, and a main gate.

The park's landscape arrangement features an asymmetrical layout, with spatial emphasis placed on the central element, Pintoe Khop (Figure 5). The architectural principles of Habluminallah, Habluminannas, and Habluminal'alam are strongly expressed. Worship facilities, contemplative historical structures, and well-maintained natural elements together reinforce the relationship between humans, God, and the environment. The Habluminannas principle is particularly well represented through the amphitheatre-style plaza and a well-equipped children's play area, both of which support social interaction and community activities.

The design draws from a distinct Acehnese architectural concept, integrating Pintoe Khop forms and floral motifs such as bungong seulanga and bungong jeumpa. These motifs are consistently applied across hardscape elements, including garden fences, barriers, gazebos, gates, pergolas, and the

suspension bridge, thereby strengthening local identity and aligning with the "pattern" and "garden elements" indicators.



Figure 5: Putroe Phang Park – *Acehnese motifs (Pintoe Khop, seulanga/jeumpa flowers) strongly reinforce local identity, while opportunities remain to integrate broader Islamic geometric forms, supporting high compliance with "pattern", "garden elements", and Islamic architecture principles.*
Source: Researcher Documentation, 2023.

Nonetheless, several interventions could further enhance the park's Islamic architectural character. These include the introduction of more universally recognisable Islamic design elements, such as chahar bagh patterns, domes, horseshoe arches, arabesques, calligraphy, mashrabiya, and colourful tiled flooring inspired by Islamic or Arabic/Middle Eastern aesthetics, particularly in areas undergoing refurbishment or new development. While existing Acehnese forms and patterns already provide a strong sense of place, broadening the design vocabulary to include these additional Islamic references would enrich both the park's cultural resonance and its educational role in conveying Islamic garden concepts.

Overall, Putroe Phang Park demonstrates excellent compliance with Islamic garden design principles. Its strong performance is closely linked to its heritage status, where preserved historical structures continue to inform new interventions grounded in traditional Islamic architectural values. Among all the parks studied, Putroe Phang Park ranks highest, fulfilling 35 out of 42 parameters, with a compliance rate of 83.33% (Table 1).

The complete results of the tabulated observations conducted across five urban forest and parks in Banda Aceh are presented as follows:

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Table 1: *Table of observation of Urban Parks in Banda Aceh based on Islamic Garden Design Concepts*

Variables & Parameters of Islamic Gardens	Urban Parks				
	Tibang Urban Forest	Busta-nussa-latin	Trembesi Park	Krueng Neng Park	Putroe Phang Park
1. Order					
1) The garden site plan exhibits geometric forms with specific patterns.	√	√	√	√	√
2) Landscape design is typically symmetrical and centralised.	-	√	-	-	√
3) Circulation routes within the park are well-structured, enhancing both orientation and functionality.	√	-	√	-	√
2. Space					
4) The garden accommodates a large number of visitors simultaneously.	√	√	-	-	-
5) Clearly defined zoning separates different activity areas.	√	-	√	-	√
6) A proportional balance between green and non-green areas creates a harmonious spatial composition.	√	-	-	-	√
3. Form					
7) The garden excludes sculptures depicting living beings, such as humans or animals.	√	√	√	√	√
8) Repetitive elements like fountains, rocks, or trees symbolise eternity and timelessness.	√	√	√	√	√
9) Islamic architectural motifs include repeated arches (domes, horseshoe arches, *mashrabiya*) and colourful tiles.	-	√	-	√	√
4. Texture					
10) The texture of paving materials are natural and comfortable underfoot.	√	-	√	-	√
11) Building materials possess natural finishes that enhance aesthetic comfort.	√	-	√	-	√
12) Vegetation and water features contribute natural textures, enriching sensory experiences.	√	-	√	-	√
5. Pattern					
13) Abstract geometric patterns, such as arabesques and continuous circles or rectangles, are present.	-	√	-	-	√

Variables & Parameters of Islamic Gardens	Urban Parks				
	Tibang Urban Forest	Busta-nussa-latin	Trembesi Park	Krueng Neng Park	Putroe Phang Park
14) Plant- or floral-inspired abstract patterns, including calligraphy, are included.	-	√	-	-	√
15) Patterns avoid depiction of humans, animals, or objects associated with worship or idolatry.	√	-	√	√	√
6. Light					
16) Shade is provided through natural (trees) or artificial (gazebos, shelters) means to ensure thermal comfort.	√	√	√	-	√
17) Artificial lighting is aesthetically integrated to complement the park's ambiance.	-	√	-	√	-
18) Natural lighting from the sun, moon, or stars is harmoniously utilised.	√	√	√	-	√
7. Movement					
19) The park is easily accessible via adjacent, well-maintained road networks.	√	√	-	√	√
20) Pedestrian pathways are interconnected, facilitating smooth circulation and a dynamic experience.	√	-	√	-	√
21) Flowing water or tree-lined avenues (streams, rivers, canals, lakes, or aligned trees) enhance spatial rhythm.	√	-	-	-	√
8. Islamic Garden Elements					
8.1 Softscape Elements;					
22) Islamic softscape elements include lakes, canals, ponds, or fountains.	√	√	-	-	√
23) Landscapes incorporate vegetation, mounds, or hills planted with flowers and fruit-bearing flora.	√	-	√	-	X
24) Birds and fish represent symbolic soft elements in line with Islamic aesthetics.	√	-	√	-	√
8.2 Hardscape Elements;					
25) Pathways and flooring utilise coloured natural stone or marble.	√	√	√	√	√
26) Doors, gates, pillars, gazebos, and pergolas are employed as architectural hardscape features.	√	√	-	-	√
27) Traditional accessories such as rugs, cots, cups, vessels, goblets, plates, or jars reflect cultural identity.	-	√	-	-	√
8.3 Design Elements;					

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Variables & Parameters of Islamic Gardens	Urban Parks				
	Tibang Urban Forest	Busta-nussa-latin	Trembesi Park	Krueng Neng Park	Putroe Phang Park
28) Dominant colours such as green, gold, silver, white, and red, are used either individually or in combination.	√	√	√	√	√
29) Fragrance is introduced through the scent of musk, floral blooms, or fruits.	√	-	√	-	-
30) Auditory design prioritises tranquillity, with an emphasis on peaceful, noise-free environments.	√	-	√	-	-
9. User					
31) Visitors are expected to dress modestly, aligning with Islamic values.	√	√	√	√	√
32) Recreational activities avoid acts prohibited in Islam, such as immoral behaviour.	-	-	-	√	√
33) Facilities like toilets, prayer rooms, and seating areas are gender-segregated (non-*mahram*) and supervised.	√	-	√	-	√
10. Islamic Architecture Principles through *Habluminallah* (Human-Allah Relationship)					
34) Worship facilities like mosques, *mushalla*, prayer rooms, or suraus, are available within the park.	√	√	√	√	√
35) Memorial features, such as tombs or graves, serve as contemplative reminders of mortality.	√	√	√	√	√
36) Natural elements (trees, water, rocks, soil, mountains) symbolise the divine creation of nature.	√	-	√	-	√
11. Islamic Architecture Principles through *Habluminannas* (Human-Human Relationship)					
37) Open communal spaces, such as plazas, amphitheatres, performance stages, or recreation areas, are provided.	√	√	√	√	√
38) Facilities for social engagement, such as meeting rooms, halls, canteens or libraries, encourage community interaction.	-	√	-	√	-
39) The park and its amenities function as public assets, reflecting the value of *waqf* and social welfare.	√	√	-	-	√
12. Islamic Architecture Principles through *Habluminal'alam* (Human-Nature Relationship)					
40) Structures prioritise the use of environmentally friendly materials that minimise ecological harm.	√	-	√	-	√

Variables & Parameters of Islamic Gardens	Urban Parks				
	Tibang Urban Forest	Busta-nussa-latin	Trembesi Park	Krueng Neng Park	Putroe Phang Park
41) Facilities promote a clean, waste-free, and pollution-free environment.	√	-	√	-	√
42) The design adopts sustainable and energy-efficient approaches, such as LED lighting or solar panels.	-	-	-	√	-
Total	**33/42**	**23/42**	**26/42**	**16/42**	**35/42**
Percentage	**78,57 %**	**54,76 %**	**61,90 %**	**38,09 %**	**83,33 %**

Source: Researcher observation and analysis, 2024

Description:
√: Met
-: Not Met

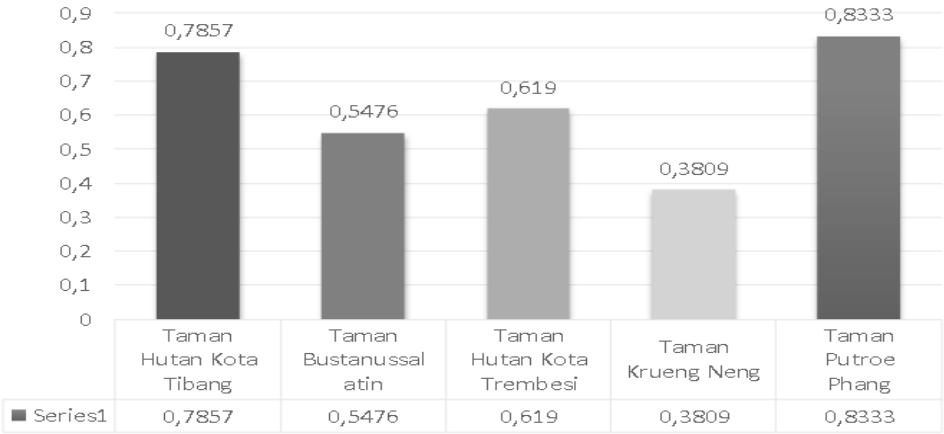


Figure 6: *Level of Compliance with Islamic Garden Design Principles across Urban Parks*
Source: Researcher analysis, 2024

Based on compliance percentages, the park rankings are: Putroe Phang (83.33%) > Tibang (78.57%) > Trembesi (61.90%) > Bustanussalatin (54.76%) > Krueng Neng (38.09%). There is a clear performance gap between the upper

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cluster (≥78%) and the lower cluster (≤55%). Qualitatively, parks with strong historical heritage or Islamic architectural elements tend to achieve higher scores. With more detailed numerical data at the sub-indicator level, future research could apply simple comparative statistics such as rank-order consistency tests or correlations between indicator groups (e.g. form, movement, user) and overall compliance scores, thereby adding further robustness to the findings.

A number of governance and contextual factors contribute to lower performance: (i) maintenance and funding constraints that reduce the quality of hard/vegetation elements; (ii) the absence of standardized guidelines for the application of Islamic patterns/components in green spaces; (iii) space allocation that emphasizes stage/commercial structures, thereby reducing communal space and circulation continuity; (iv) inadequate thermal comfort and pedestrian accessibility; and (v) tension between local Acehnese motifs and universal Islamic forms, causing symbolic inconsistency. These governance and contextual issues provide an important backdrop for interpreting the park scores and form the basis for the more analytical discussion that follows.

DISCUSSION

The evaluation of five urban parks in Banda Aceh reveals a broad range of compliance with Islamic garden design principles, with scores ranging from 83.33% (Putroe Phang Park) to 38.09% (Krueng Neng Park). This significant variation indicates a clear opportunity for improving the application of Islamic garden concepts across the city's urban parks. Putroe Phang Park, which achieved 35 out of 42 points, exemplifies a successful integration of Islamic garden elements within a contemporary urban context. This finding is consistent with research by Mohammad Sabri and Ponrahono (2024), who emphasise the importance of small urban parks in enhancing urban resilience while simultaneously providing cultural and social benefits.

The results align with recent literature demonstrating that strengthening heritage elements and green infrastructure contributes to resilience, socio-cultural functions, and well-being in urban spaces. The Islamic Green City approach, for example, highlights the role of green spaces in fostering social cohesion and public health in Muslim-majority cities (Hatta et al., 2024). Similarly, studies on Urban Green Infrastructure (UGI) underscore the importance of designs that harmonise ecological performance and user well-being (Santos et al., 2021). Within the discourse of Islamic urbanism, the integration of Islamic values into public spaces is viewed as essential for reinforcing identity, everyday practice, and spatial governance (Maneval, 2019). In this regard, the parks that score higher in this study tend to be those where Islamic architectural and cultural narratives are more coherently expressed through space, form, and programme.

The assessment also shows that parks with stronger historical connections and better maintenance, such as Putroe Phang Park and Tibang Urban Forest (78.57%), tend to perform better in terms of Islamic garden design. This correlation suggests that preserving historical features while deliberately incorporating Islamic design principles can foster more meaningful and culturally resonant urban spaces. This observation echoes the work of Riechers et al. (2019), who highlight the cultural ecosystem services provided by urban green spaces in enhancing community well-being and urban liveability. Furthermore, integrating Islamic garden design in these parks contributes to the broader goal of creating multifunctional urban spaces that accommodate environmental, social, and spiritual functions, as advocated in contemporary planning frameworks (Zuraidi et al., 2020).

In contrast, the relatively lower scores of Bustanussalatin Park (54.76%) and Krueng Neng Park (38.09%) highlight the need for targeted improvements in the implementation of Islamic garden design principles. In both cases, governance and design decisions have prioritised large built structures—such as stages, commercial or institutional buildings, and visually dominant architectural volumes—over coherent spatial patterns, communal circulation, and shade provision. This emphasis weakens the expression of Islamic garden values related to order, space, movement, and thermal comfort. Limited and fragmented maintenance budgets further affect the quality and continuity of softscape and hardscape elements, particularly vegetation, water features, and decorative components that are central to Islamic aesthetics.

The absence of clear municipal guidelines on how Islamic patterns, forms, and principles should be translated into public green space design also contributes to inconsistent outcomes. Bustanussalatin Park, for instance, still incorporates human figurative imagery on prominent structures, which conflicts with key Islamic garden parameters regarding representation and form. Krueng Neng Park, meanwhile, places strong emphasis on a large meunasah that anchors the habluminallah (human–God) relationship but does not incorporate broader Islamic geometric spatial concepts such as the chahar bagh. These choices reflect a partial translation of Islamic values—focusing primarily on worship facilities or symbolic monuments—rather than a holistic application that also attends to movement, shade, ecological integration, user comfort, and everyday behaviour. This finding underscores the need for planning instruments and design guidelines that explicitly link Islamic urbanism, green infrastructure standards, and detailed design decisions at the park scale.

Recent planning literature on green infrastructure and climate resilience further supports this argument. Policy and design analyses in Kuala Lumpur and Shah Alam show that retrofitting green infrastructure and formalising it within planning instruments can strengthen both climate resilience and urban liveability

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(Nizarudin & Zakariya, 2025; Abd Razak, Ponrahono, & Mohammad Sabri, 2025). Likewise, simulation studies in tropical coastal environments demonstrate that tree cover, shading structures, and surface material choices significantly influence microclimate performance and thermal comfort in public open spaces (Widyasamratri et al., 2025). These insights directly relate to the "light" and "movement" indicators used in this study and suggest that Islamic garden design criteria can be aligned with contemporary sustainability and comfort considerations in urban planning.

From a methodological perspective, the ranking of parks presented in this study is based on descriptive scoring of 12 indicators and 42 sub-indicators. The clear separation between a higher-performing cluster (Putroe Phang and Tibang) and a lower-performing cluster (Bustanussalatin and Krueng Neng) suggests underlying structural and governance differences that merit further investigation. With more granular numerical data at the sub-indicator level, future research could apply simple comparative statistics—such as rank-order consistency tests or correlations between indicator groups (e.g. form, movement, user) and overall compliance scores—to add robustness to these findings. Such analyses would complement the qualitative insights presented here and enable a more precise understanding of which aspects of Islamic garden design most strongly influence overall park performance.

Overall, the findings indicate that Islamic garden principles can serve as more than a symbolic or historical reference; they can provide an operational framework for contemporary urban park planning and design in Banda Aceh. By aligning spatial structure, vegetation, shading, circulation, and user facilities with Islamic architectural and ethical values, planners and designers can create urban green spaces that support cultural identity, social cohesion, ecological performance, and spiritual well-being. This perspective is consistent with emerging debates on Islamic urbanism, sustainability, and green infrastructure, and offers a context-specific yet transferable model for other Muslim-majority cities seeking to integrate religious and cultural values into their urban planning practice.

CONCLUSION

The findings of this study reveal varying levels of compliance with Islamic garden design principles across the urban parks in Banda Aceh. Putroe Phang Park stands out as a prime example of successfully integrating historical and Islamic architectural elements, serving as a model for future developments. In contrast, other parks, such as Bustanussalatin and Krueng Neng, require significant improvements to better align with these principles. By adopting the recommendations outlined in this study, the Banda Aceh Urban Government can enhance the quality and cultural significance of its urban parks. This approach

will not only ensure that these spaces reflect Islamic values but also foster social interaction and spiritual well-being, enriching the urban landscape for all users.

Beyond the empirical ranking of parks, this study's main contribution lies in operationalising Islamic garden principles into a replicable evaluation tool for planners and designers. The 12-indicator and 42-sub-indicator framework can be adapted to other Sharia-based or Muslim-majority cities seeking to align urban green space design with Islamic values, thus bridging the gap between heritage discourse and contemporary planning practice in Banda Aceh and beyond.

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IMPLEMENTATION OF THE MALAYSIAN GARDEN CONCEPT CRITERIA TO URBAN PUBLIC PARKS

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Abstract

The Malaysian Garden Concept (MGC), introduced by the National Landscape Department (NLD) in 2009, intends to integrate cultural heritage, ecological values, and aesthetic design into urban parks. However, implementing MGC has faced challenges, with many parks prioritising modern aesthetics over cultural and ecological principles. This study aims to assess the level of MGC implementation in two (2) public parks developed by the NLD. The objectives are to evaluate the effectiveness of MGC criteria and identify the challenges in their application. The research employs an observational method, using the MGC guidelines to assess the parks. Findings reveal that both parks partially adhere to the MGC criteria, with significant gaps in cultural and heritage integration. The discussion highlights the need for better enforcement and stakeholder education. Recommendations include enhancing awareness and implementing MGC guidelines more strictly. This study makes a novel contribution to the Malaysian planning literature by translating MGC policy guidelines into measurable, on-site design assessments, thereby linking conceptual frameworks to real-world implementation. Future studies should address long-term sustainability and promote a more proactive approach to MGC implementation in park development.

Keywords: The Malaysian Garden Concept, Urban Parks, Cultural Heritage, Landscape Architecture, Park Design Implementation

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INTRODUCTION

The Malaysian Garden Concept (MGC), established by the NLD in 2009, seeks to embed Malaysia's cultural heritage, ecological values, and aesthetics into urban parks. Despite significant potential, its implementation is hindered by a disconnect between guideline intentions and park realities. Modern aesthetics often override traditional values, diminishing local identity. The main issue is inconsistent enforcement and limited stakeholder awareness of MGC guidelines, which this study examines by evaluating the depth and barriers of MGC application in park design.

This study provides an empirical, site-based evaluation of MGC implementation by analysing two NLD-developed parks. Using field observations, it demonstrates the gap between policy and real-world application, offering insight into both challenges and opportunities. This approach advances planning scholarship by critically connecting theory, policy, and practice within Malaysia's evolving cultural landscape.

LITERATURE REVIEW

The MGC aims to integrate cultural, ecological, and social well-being elements in park designs. However, challenges remain in its consistent application, as many parks prioritise modern aesthetics over traditional and ecological principles. Studies highlight gaps in stakeholder education and enforcement, resulting in parks that fail to reflect Malaysia's cultural identity. The lack of integration of local plants, architectural elements, and cultural heritage undermines the MGC's objectives. Future efforts must focus on enhancing awareness, education, and enforcement to achieve a balanced, sustainable approach to park design.

Public Parks

According to the Town and Country Planning Department of Peninsular Malaysia (2013), "open space" is defined as land for public use, fully or partially. The term "park" is often used as a synonym for open space and is an area intended primarily for aesthetic enjoyment, reserved for the public (Abu Bakar, 2002). A public park is a location for public recreation built by a government agency, designed to meet the size, use, and specific needs of an area, whether in a residential area, city, or region.

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Table 1: Development of Public Parks in Malaysia 2010-2022 by the NLD

Type of Park (Hierarchy)	Total Area (Acres)	Total Parks (Nos)
Playground Lot	5951.28	9080
Play Field	5229.65	2083
Neighbourhood Park	3867.14	421
Local Park	5794.76	151
Urban Park	3518.34	25
Regional Park	8594.16	13

Source: NLD, 2022

The Malaysian Garden Concept (MGC)

In this guideline book, the MGC outlines eight (8) design criteria that must be prioritised in the development of public gardens (NLD, 2009). The design criteria are as follows:

1. *Genius Loci* – Its unique spirit and cultural atmosphere determine the style, meaning, and cultural quality, harmonising them within architecture.
2. *Local Plants* – This criterion guarantees the plant selection reflects the region's indigenous flora.
3. *Architectural Structure and Local Elements* – Incorporating traditional Malaysian architectural elements and structures into garden designs helps to maintain cultural continuity and celebrate local craftsmanship.
4. *Cultural and Heritage* – To incorporate cultural and historical context into the garden design, reflecting Malaysia's rich diversity and making visitors proud of their culture.
5. *High Intrinsic Value* – Gardens should be designed to provide high aesthetic, ecological, and recreational value.
6. *Adaptability to Local Weather* – Garden designs must consider local climatic conditions so that the plants and materials reflect regional weather patterns and adapt to this natural environment.
7. *Elements of Security* – Providing a garden layout and lighting, offering visitors an assuredly splendid, comfortable stay.
8. *Manageable and Comfortable* – Creating spaces that are easy to maintain and provide comfort to visitors, including adequate seating, shading, and accessibility features.

During World Forestry Day in 1997, the former Director-General of the NLD announced that such a concept would be developed, emphasising harmony with nature. It would include native trees and flora that reflect our lives, spiritual values, and cultural heritage, which is also Malaysia's.

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Designing the Malaysian garden

In conjunction with World Forestry Day, FAEZAH ISMAIL finds out about the National Landscape Department's plan to turn Malaysia into a garden nation in eight years, and the evolving concept of a uniquely Malaysian garden.

20 March 1997
New Straits Times

LANDSCAPING BASICS ... "We want to create our own garden based on our tropical rainforest," says Ismail. Picture by ALFRED C.L. QUEK

Figure 1: Newspaper article "Designing the Malaysian Garden"
Source: New Straits Times, 1997

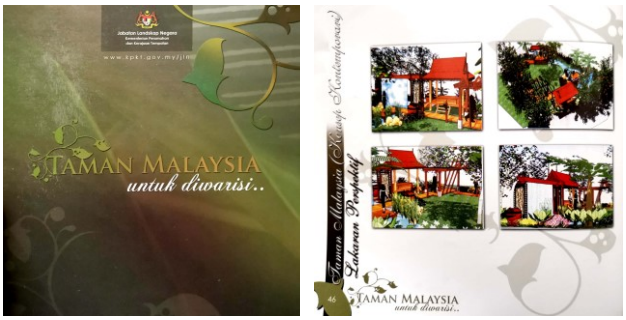


Figure 2: The NLD successfully published a guidebook of the MGC in 2009
Source: NLD, 2009

Cultural Identity and Heritage Preservation

The MGC aims to integrate cultural heritage and local identity in park designs, reflecting Malaysia's diversity. Landscape identity, linking parks to their cultural context, is crucial for meaningful spaces (Zakaria et al., 2021). However, modern design often overlooks traditional elements, weakening cultural representation. Incorporating traditional architecture is vital for cultural continuity (Stobbelaar & Pedroli, 2011). Modern trends compromise MGC's goal, leaving parks lacking cultural depth (Zakaria et al., 2020).

Ecological and Environmental Considerations

The MGC emphasizes using local plants and materials suited to Malaysia's tropical climate to enhance ecological value. Native plants preserve biodiversity, reduce maintenance costs, and improve park aesthetics (Rosli et al., 2020). However, many parks use non-native species, compromising ecological value (Zakaria et al., 2020). The Town and Country Planning Department (2013) highlights the need to better integrate ecological factors for sustainable urban parks.

Social Engagement and Well-being

Parks with clear cultural and ecological features promote social engagement and well-being, encouraging longer visits and deeper interactions (Chen et al., 2024). The MGC aims to create parks with recreational facilities, such as jogging tracks and playgrounds, to encourage active lifestyles (Anuar et al., 2018). However, many parks lack these elements, reducing engagement and physical activity.

Challenges in MGC Implementation

Despite MGC's benefits, its implementation faces challenges. Zakaria et al. (2020) note that many parks prioritize modern design over traditional elements, undermining MGC's goals. Lack of stakeholder awareness and education leads to inconsistent application (Zakaria et al., 2021). Modern design trends overshadow cultural and ecological aspects (Stobbelaar & Pedroli, 2011). Resource limitations and weak policy enforcement further hinder MGC integration (NLD, 2022).

Awareness and Education

Effective implementation of the MGC depends on stakeholder awareness and education. However, studies (Zakaria et al., 2021; Abu Bakar, 2012) reveal a limited understanding among practitioners and authorities, leading to inconsistent application. The NLD (2022), therefore, calls for continuous professional training to ensure uniform compliance with MGC guidelines.

METHODOLOGY

This study was conducted to obtain data through observation of the implementation of the selected public park. The study's objective is to determine the extent of implementation of the MGC criteria in the design of public parks funded by the NLD. In this study, two (2) public parks were sampled, and all were developed by the NLD in 2019. This study employed a qualitative observational method, which allows for a direct, contextual assessment of the physical and spatial characteristics within each park. The observational checklist was structured around the eight MGC criteria to ensure systematic data capture while maintaining interpretive flexibility. This qualitative approach is suitable for examining the visual and design-based dimensions of MGC implementation. However, the method focuses primarily on what is observed rather than why it occurs. Therefore, while the approach is valid for exploratory assessment, this study acknowledges that deeper interpretive insights, such as stakeholder decision-making and user experience, could be further explored through complementary qualitative methods, including interviews or document analysis, in future research. This study focused on public parks within the urban park category as case studies. The following section provides information on the two selected public parks.

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Table 2: Parks Information

Park Name	Area (Acres)	Completed (Year)
Taman Awam Bandar Puteri Jaya, Sungai Petani (P1)	29.4	2019
Taman Rimba Bandar Proton, Tanjung Malim (P2)	37	2019

Source: NLD, 2022



Figure 3: Taman Awam Bandar Puteri Jaya, Sungai Petani, Kedah

Figure 3 shows a site view of Taman Awam Bandar Puteri Jaya, Sungai Petani, Kedah. The design exhibits limited integration of native flora and traditional architectural motifs, reflecting a neutral level of MGC compliance (Authors' field observation, 2020).



Figure 4: Taman Rimba Bandar Proton, Tanjung Malim, Perak

Figure 4 shows Taman Rimba Bandar Proton, Tanjung Malim, Perak. The park's modern layout prioritises functionality and safety features but demonstrates weak incorporation of local cultural and heritage elements (Authors' field observation, 2020).

Eight (8) criteria of the MGC have been consistently used to evaluate the implementation level of park design. The study used a Likert-scale framework to guide the assessment of MGC design criteria. As noted by Jacoby and Matell (1971), a three-point scale may be sufficient in specific situations, as it captures both directional tendencies and neutral positions among respondents. The

observation method was chosen for this study because the researchers are familiar with landscape design and its evaluation using indicators, as shown in Table 3.

Table 3: The indicators in assessing the use of MGC design criteria

Point	Satisfaction
36 - 40	follows
32 - 35	a bit follows
20 - 31.6	neutral
12 - 19	weak
0 - 11	not follow

Description	Value	Symbol
It's there and dominant	4-5	ED
It's there, but a bit	1-3	H
None	0	X

Source: Authors

These sites were purposefully selected as they represent benchmark projects implemented after the introduction of the MGC guidelines in 2009. While this purposive selection allows for in-depth contextual understanding, it also limits the extent to which findings can be generalized across all urban parks in Malaysia. Therefore, the results are best interpreted as indicative rather than representative, highlighting patterns and issues that may recur in other parks with similar planning backgrounds.

FINDINGS AND DISCUSSION

The findings indicate that both public parks must fully comply with the MGC design criteria. P1 falls under the "Neutral" category, meaning they do not fully meet the MGC design criteria but does not significantly deviate from them. Surprisingly, the P2 had the lowest score among the parks.

Observational study using MGC Design Criteria

Table 4 provides an in-depth analysis of the adherence of P1 and P2 to the MGC design criteria. This study used the MGC design criteria to evaluate two public parks developed by the NLD. The MGC guidelines have eight criteria: Genius Loci, Local Plants, Architectural Structure & Local Elements, Culture & Heritage, High Intrinsic Value, Local Weather Compatibility, Elements of Security, and Manageable & Comfortable (NLD, 2009). The parks were assessed based on how well they adhered to these criteria.

The findings revealed that both parks partially met the MGC standards. P1 scored well on environmental criteria, including Adaptability to Local Weather and Elements of Security, with scores indicating extensive compliance. However, it scored poorly on Culture & Heritage and Local Plants, with significant gaps in cultural and ecological integration (Zakaria et al., 2020). P2 similarly showed weaknesses in the same areas, particularly with Local Plants, and Architectural Structure & Local Elements, which scored very low. Both parks failed to adequately integrate local flora and traditional Malaysian architectural features, undermining their cultural identity. These results confirm the need for a

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more comprehensive approach to applying the MGC guidelines, with a focus on cultural heritage and ecological sustainability in future park designs (Zakaria et al., 2021).

Table 4: Observational study using MGC Design Criteria for selected NLD-funded public parks

No	Garden Project (Funded by the NLD)	The Malaysian Garden Design Criteria									
		Criteria (1)	Criteria (2)	Criteria (3)	Criteria (4)	Criteria (5)	Criteria (6)	Criteria (7)	Criteria (8)	TOTAL (Point)	STATUS
1	P1 (2019)	ED (4)	H (3)	X (0)	X (0)	X (0)	ED (5)	ED (5)	ED (4)	**21**	**Neutral**
2	P2 (2019)	ED (4)	H (3)	X (0)	X (0)	X (0)	ED (5)	H (2)	H (2)	**16**	**Weak**

Source: Authors

Note: *The MGC Design Criteria, referring to the guideline published by the NLD*

1) Genius Loci
2) Local Plants
3) Architectural Structure & Local Elements
4) Culture & Heritage
5) High Intrinsic Value
6) Local Weather Compatibility
7) Elements of Security
8) Manageable & Comfortable

An overview of the site assessments

Table 5 presents a detailed assessment of two public parks (P1 and P2) developed by the NLD, identifying several gaps in adherence to the MGC guidelines. The evaluation was conducted based on the NLD's eight key MGC criteria.

P1, located in a residential area, had the potential for cultural integration but did not fully capitalize on it. While it reflected some local characteristics, it received a "neutral" score for Genius Loci, suggesting it did not fully embrace the cultural and environmental essence outlined in the MGC. P1 also struggled with integrating Local Plants, with a prevalence of non-native species, earning a "weak" score for this criterion. The park lacked significant traditional architectural elements, resulting in a low score for Architectural Structure & Local Elements.

In contrast, P2, situated near natural features such as forests and rivers, had an advantage in terms of surroundings. However, it also received a "weak" score for Genius Loci, indicating missed opportunities to integrate local cultural elements. Like P1, the use of native plants was minimal, and the park faced challenges in incorporating both Local Plants and Cultural Heritage, earning low scores in these areas. The absence of traditional Malaysian architecture further undermined P2's cultural identity, as noted by Stobbelaar & Pedroli (2011).

Both parks demonstrated adequate compliance with environmental aspects, including climate adaptation and visitor safety. However, these strengths were overshadowed by the absence of cultural and heritage integration core

components of the MGC that distinguish Malaysian landscape identity from generic park design. The site assessments stress the need for stronger cultural and ecological integration in park designs.

Despite performing well on environmental factors, neither park fully adheres to MGC's cultural and ecological guidelines. These findings underscore the need to better implement MGC principles to create parks that reflect Malaysia's unique cultural and environmental identity (Zakaria et al., 2020).

Table 5: An overview of the site assessments for selected public parks developed by the NLD after the existence of the MGC Guidelines

No.	The MGC Criteria	Site Assessments
1	Criteria (1): Genius Loci	P1: The park is located between residential areas. It can be categorized as a neighbourhood park in a residential area. The park's users are mostly local people.
		P2: The park is a bit further away from the development area. However, this site's advantage is its proximity to natural elements such as forests, hills, and rivers. The park lacks visitors due to being a bit far from residential and quiet areas.
2	Criteria (2): Local Plants	P1: There is little use of endemic plants in design. Non-native plants are widely used in planting design. In a selection of plants, indigenous plants are less prevalent.
		P2: There is not a significant number of endemic plants used in design. Non-native plants are widely used in planting design. However, their location in the natural element has balanced the population of indigenous plants and introduced plants.
3	Criteria (3): Architectural structure & local elements	P1: This does not imply that the park was built strongly to emphasize Malaysian civilization's architecture and use local construction materials.
		P2: It does not imply the park was built, emphasizing Malaysian civilization's architecture and local construction materials.
4	Criteria (4): Culture & Heritage	P1: It does not show superior characteristics to the inherited culture.
		P2: It does not show superior characteristics to the inherited culture.
5	Criteria (5): High Intrinsic Value	P1: The authenticity of local art does not have an intrinsic worth.
		P2: The authenticity of local art does not have an intrinsic worth.
6	Criteria (6): Local Weather Compatibility	P1: The use of building materials in the park's design aligns with the tropical climate. Most elements use cement and stone for long-lasting.
		P2: The use of building materials in the park's design is in tune with the tropical climate. Cement is mainly used for long-lasting.
7	Criteria (7): Elements of Security	P1: There are safety features regarding construction materials and design specific to park visitors.
		P2: Construction materials have minimal safety features, and unique designs for park visitors are highlighted. The park's location, with a river, forest, and bush elements, could endanger visitors.
8	Criteria (8):	P1: The park's surroundings are easy to maintain for visitors' convenience as it is only a local attraction.

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No.	The MGC Criteria	Site Assessments
	Manageable & Comfortable	P2: Because of its location close to the forest, it is not easy to ensure that the park's surroundings are maintained for the convenience of park visitors.

Note: Taman Awam Perbandaran Bandar Puteri Jaya (P1), Taman Rimba Bandar, Tanjung Malim (P2) *Source: Authors*

Table 5 shows that both parks lacked traditional architectural elements. This may reflect design priorities that favour modern aesthetics over cultural symbolism. Despite introducing the MGC guidelines in 2009, significant gaps remain in their implementation in public parks, as shown in Tables 4 and 5. Both parks, P1 and P2, failed to fully meet the MGC criteria, particularly in cultural heritage, local plant use, and the incorporation of traditional Malaysian architecture. The observational study in Table 4 reveals that both parks scored poorly in Cultural Heritage and Architectural Structure & Local Elements (scoring 0), reflecting a lack of cultural identity integration. While both parks performed reasonably well in Adaptability to Local Weather (scoring 5), this environmental success does not compensate for the absence of cultural depth.

Table 5 further emphasizes these shortcomings by assessing the parks' site characteristics. The Genius Loci criterion, which focuses on incorporating local cultural identity, further highlights the gap in both parks. P1, situated in a residential area, had the opportunity to integrate local cultural elements but failed to do so, missing a chance for community engagement. P2, located near natural features such as forests and rivers, also failed to utilize its environment to incorporate cultural elements. The concept of Genius Loci, representing the spirit of a place, could have enhanced the visitor experience and connection to the park, but this was not achieved in either park.

Both parks also struggled with integrating culture and heritage. P1 lacked local plants and cultural elements, while P2 faced challenges with accessibility and safety, further preventing adherence to the MGC standards. This inconsistency in cultural integration undermines the parks' ability to promote national identity through landscape design. Despite adequate environmental performance, both parks failed to integrate cultural and heritage elements, resulting in generic design outcomes.

In conclusion, while P1 and P2 met some environmental and functional aspects of the MGC, such as weather adaptability and security, they lack cultural and architectural depth. The findings suggest that an overreliance on modern design features has hindered the MGC's implementation, failing to sufficiently integrate local culture and heritage. To address these gaps, the NLD must play a more active role in enforcing MGC guidelines and ensuring that future parks reflect Malaysia's cultural, ecological, and architectural identity. Future developments must integrate cultural and ecological elements, creating public

spaces that serve as landmarks of national identity and reflect Malaysia's unique heritage.

Challenges in Implementing the MGC

Figure 5 illustrates the key challenges in implementing the MGC across public parks. The challenges outlined are critical in understanding why the MGC has not been fully integrated into park designs.

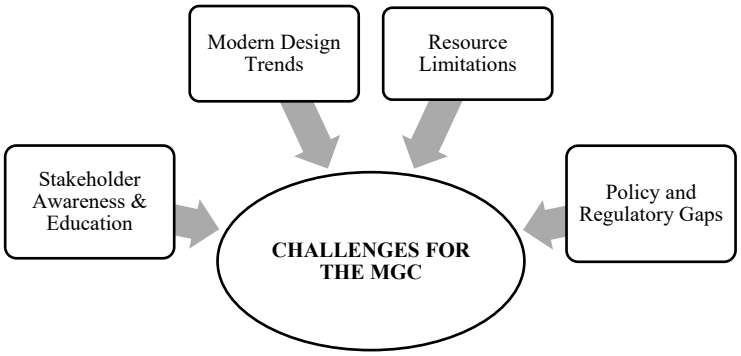


Figure 5: Challenges faced in implementing MGC criteria

These challenges align with the issues highlighted in the Literature Review, particularly stakeholder awareness, modern design trends, resource limitations, and policy gaps.

1. *Stakeholder Awareness and Education*
   Effective implementation of MGC requires greater awareness and education among stakeholders, including landscape architects and local authorities. Zakaria et al. (2021) emphasize that understanding MGC principles is essential for consistent application. Abu Bakar (2012) highlights the need for professionals and the public to understand MGC's cultural and ecological significance.
2. *Modern Design Trends*
   Modern design trends often overshadow traditional cultural and ecological elements in park development. Zakaria et al. (2020) and Rosli et al. (2020) highlight that parks frequently prioritize contemporary aesthetics, which results in a loss of cultural identity and ecological relevance, undermining the goals of the MGC.
3. *Resource Limitations*
   Limited resources, including funding and materials, impede the full implementation of MGC. Zakaria et al. (2021) and Anuar et al. (2018) note that financial constraints often prioritize basic functionality over cultural and

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ecological elements, resulting in park designs that lack the depth and sustainability intended by the MGC guidelines.

4. *Policy and Regulatory Gaps*
   The lack of clear enforcement frameworks and policy gaps hinders MGC implementation. Zakaria et al. (2020) and NLD (2009) emphasize the need for stronger regulatory oversight to ensure consistent application of MGC guidelines, as inadequate enforcement leads to parks that do not fully reflect Malaysia's cultural and ecological values.

Figure 5 summarises the main challenges hindering MGC implementation according to low stakeholder awareness, dominance of modern design trends, limited resources, and weak policy enforcement. These systemic issues, consistent with literature findings, highlight the need for improved education, funding, and regulation to ensure cultural-ecological integration in future park designs.

Framework for Implementing the MGC Design Criteria

Figure 6 is a proposed five-phase framework for MGC implementation, including Assessment, Design, Implementation, Monitoring, and Maintenance, developed from the empirical findings of this study (P1 and P2) and informed by NLD (2009) guidelines. The framework integrates cultural, ecological, and managerial aspects to address observed weaknesses in current park designs. This approach ensures consistent application of MGC guidelines in urban parks, addressing gaps identified in the Literature Review.

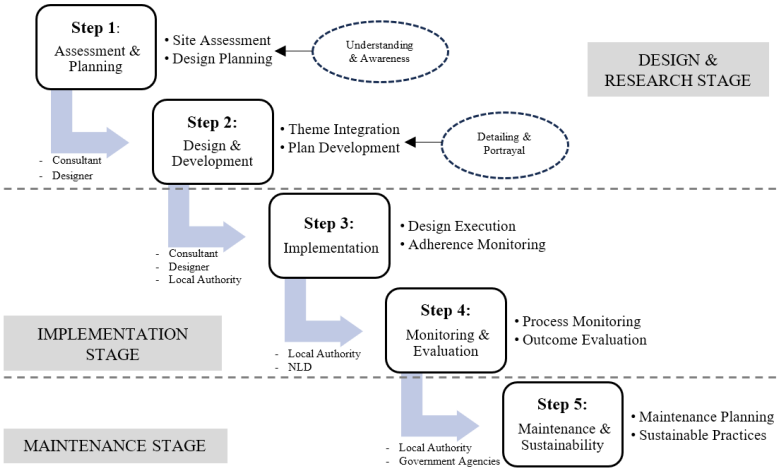


Figure 6: Proposed Framework for Implementing the MGC Design Criteria

1. *Assessment and Planning*
   The first step in implementing the MGC is a thorough site assessment and planning. Zakaria et al. (2020) emphasize understanding local cultural, ecological, and climatic factors to create parks that reflect Malaysia's identity. This phase helps identify opportunities to integrate MGC criteria, such as local plants and cultural heritage, into park designs. By incorporating these elements early in the planning process, designers can ensure the park meets its functional and cultural goals, creating spaces that reflect Malaysia's heritage and ecological values (Zakaria et al., 2021).
2. *Design and Development*
   In the design and development phase, the MGC's key elements, such as local architecture and native plants, must be integrated into park designs. Zakaria et al. (2020) stress the importance of reflecting local culture and ecological values through traditional architectural elements and indigenous flora. This phase ensures that parks meet functional needs and embody cultural identity. By adhering strictly to the MGC guidelines, designers can create parks that celebrate Malaysia's heritage and contribute to environmental sustainability (Zakaria et al., 2021).
3. *Implementation*
   The implementation phase focuses on translating the design into reality, following the MGC guidelines. Zakaria et al. (2024) emphasize the importance of ensuring that construction practices align with the prescribed criteria, including using local materials and traditional architectural features. This phase ensures that the park's physical space reflects both cultural heritage and ecological sustainability. Adhering to MGC during implementation guarantees that the park will represent Malaysia's identity and offer a space that is both functional and culturally significant (Zakaria et al., 2021).
4. *Monitoring and Evaluation*
   The implementation phase focuses on translating the design into reality, following the MGC guidelines. Zakaria et al. (2024) emphasize the importance of ensuring that construction practices align with the prescribed criteria, including using local materials and traditional architectural features. This phase ensures that the park's physical space reflects both cultural heritage and ecological sustainability. Adhering to MGC during implementation guarantees that the park will represent Malaysia's identity and offer a space that is both functional and culturally significant (Zakaria et al., 2021).
5. *Maintenance and Sustainability*
   The maintenance and sustainability phase ensures that parks remain functional and culturally relevant. Zakaria et al. (2020) and Rosli et al. (2020) highlight the importance of using native plants and sustainable

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practices to preserve ecological integrity. This phase involves maintaining the park's cultural and environmental features, ensuring long-term relevance. By focusing on sustainable management and regular upkeep, parks can continue to reflect Malaysia's heritage while promoting ecological sustainability, aligning with MGC guidelines (Zakaria et al., 2021).

Figure 6 translates the observational findings into a strategic framework. The five-phase approach directly addresses the weaknesses identified in Figures 3–5, providing a structured pathway to operationalise the MGC more consistently in urban park design. Implementing MGC criteria in public park designs requires a more structured and systematic approach. The proposed framework in Figure 6 provides clear guidelines to ensure that developed parks meet design criteria and reflect Malaysia's national identity. Following these steps will enhance the quality of public parks in Malaysia, helping to introduce Malaysia's culture and heritage to visitors while making the parks more meaningful and attractive as recreational spaces.

NEW DIRECTION FOR FURTHER RESEARCH

Future research should explore the long-term sustainability and impact of parks developed using MGC guidelines. This study could assess visitor engagement, cultural preservation, and environmental sustainability. Zakaria et al. (2022) suggest that understanding how MGC-designed parks affect social well-being and local economies is crucial. Research could also examine the role of native plants and climate-adapted designs in promoting sustainable green spaces. Additionally, attractive, well-designed, beautiful, diverse, and sequential park landscapes can positively influence participants, as mentioned by Chen et al. (2024). These findings could refine MGC guidelines for future park developments, ensuring long-term success and relevance (Zakaria et al., 2021).

LIMITATION

This study acknowledges several methodological limitations. Firstly, the research is based on only two case studies of urban parks developed by the National Landscape Department, which restricts the breadth of comparison. The parks were chosen purposefully for their relevance to the MGC policy context, but they may not capture the full diversity of park typologies, management practices, or regional variations in Malaysia.

Secondly, the exclusive use of qualitative observational methods means that findings are derived solely from visible design characteristics and contextual interpretation. While this approach is appropriate for exploring physical and cultural expressions of the MGC, it does not include stakeholder or user perspectives that could offer deeper explanatory insight.

Consequently, the findings should not be viewed as statistically generalizable. Instead, they provide *analytical transferability* insights that may inform understanding of similar urban park contexts where MGC guidelines are applied. The study's strength lies in offering an interpretive, site-based perspective that can serve as a foundation for future research involving broader samples and mixed qualitative approaches such as interviews or policy document analysis.

CONCLUSION

The implementation of the MGC in urban parks, as explored in this study, reveals significant gaps in integrating cultural, ecological, and aesthetic principles. Despite the MGC's introduction by the NLD in 2009, many parks still prioritize modern design elements over the prescribed guidelines, resulting in a loss of local identity and cultural relevance. The study concludes that the two examined parks only partially fulfilled MGC requirements, particularly in cultural and heritage integration. These findings underscore the need for stronger policy enforcement and continuous professional awareness among designers and local authorities. The proposed framework for implementing MGC, comprising assessment, design, implementation, monitoring, and sustainability, provides a systematic approach to enhance adherence to the MGC in future park developments. It is recommended that future studies focus on evaluating the long-term sustainability and impact of MGC-designed parks, particularly in terms of cultural preservation, ecological benefits, and public engagement. By addressing the identified challenges and ensuring a more substantial commitment to the MGC guidelines, the concept can better achieve its goal of creating parks that reflect Malaysia's rich cultural heritage while promoting environmental sustainability and enhancing public well-being. The novelty of this study lies in its direct observational analysis of MGC implementation, providing an initial empirical benchmark for future research. This qualitative baseline highlights how landscape identity is expressed in built environments and encourages further studies that integrate stakeholder perspectives to deepen analytical insight. This approach contributes uniquely to planning literature in Malaysia by demonstrating how qualitative, site-based evaluations can inform more culturally responsive and sustainable park planning strategies.

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GOVERNMENT LAND PROTECTION IN THE CONTEXT OF LEGAL PLURALISM: EVIDENCE FROM INDONESIA'S INDIGENOUS AND PERIPHERAL REGIONS

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Abstract

Government land is a strategic public asset whose safeguarding is particularly complex in regions with strong customary land tenure systems. In Eastern Indonesia, especially Papua, land is embedded not only in administrative and legal frameworks but also in indigenous social and cultural structures. This study examines the safeguarding of government land in Jayapura City using a qualitative legal-empirical approach grounded in a post-positivist paradigm. Data were collected through in-depth interviews with local government officials, customary leaders, academics, and land authorities, complemented by document analysis and field observations. The findings show that legal insecurity constitutes the most fundamental and systemic challenge. The absence or contestation of customary land release documents undermines formal land certification, weakens administrative registration, and exposes government land to recurring disputes and encroachment. These conditions reflect persistent tensions between formal state law and customary land governance rather than isolated administrative failures. This study argues that safeguarding government land in Papua requires a hybrid land governance framework that recognizes legal pluralism as an operational reality, supported by the institutional integration of customary mechanisms, participatory mapping, and strengthened inter-agency coordination. This study contributes to land governance literature by positioning legal pluralism not as a constraint but as an operational governance variable.

Keywords: government land, legal pluralism, land governance, indigenous land rights, Papua

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INTRODUCTION

The safeguarding of Local Government Assets (*Barang Milik Daerah/BMD*) in Indonesia is formally governed through comprehensive control mechanisms encompassing physical, administrative, and legal dimensions. Physical safeguarding generally includes protective measures such as fencing and boundary demarcation, administrative safeguarding focuses on systematic documentation covering ownership certificates, acquisition records, proof of payment, and survey reports while legal safeguarding aims to ensure protection through dispute resolution and litigation processes to prevent encroachment, seizure, or third-party claims. These mechanisms are designed to provide legal certainty and support effective public asset governance.

Nevertheless, empirical evidence indicates that the existence of formal regulatory frameworks does not necessarily translate into effective land asset security. Following administrative territorial expansion, local governments frequently encounter intensified challenges in securing land assets, particularly in newly formed urban areas. In Jayapura City, Papua Province established through the administrative expansion of Jayapura Regency government owned land has become a persistent source of dispute involving indigenous communities and private claimants. These disputes reveal a structural gap between normative legal arrangements and their practical implementation, suggesting that asset insecurity cannot be explained solely as an administrative deficiency.

In the Papuan context, land occupies a distinctive socio-legal position that extends beyond its function as an economic or administrative asset. Indigenous communities in Jayapura continue to recognize customary land rights (*hak ulayat*) as socially authoritative, shaping land governance practices at the local level. *Hak ulayat* is understood as a collective and hereditary right embedded in kinship structures and territorial boundaries governed by customary leaders (*ondoafi*), rather than as an individual proprietary entitlement. This understanding is consistent with Constitutional Court Decision No. 35/PUU-X/2012, which affirms the recognition of indigenous peoples' customary rights as constitutionally protected and distinct from state-controlled land. Consequently, land transactions or transfers that bypass customary deliberation and approval are often perceived as illegitimate, even when supported by formal legal instruments issued by the state. As noted by Simarmata (2019) and Boelaars (1986), in Papuan societies land functions as a socio-cultural foundation tied to identity, history, and collective survival, placing government land governance within a plural legal order that requires mediation between state law and customary authority to achieve legitimacy and effectiveness.

Within this plural legal setting, formal land certification and administrative registration by the government often lack social legitimacy in the absence of customary land release documents endorsed by traditional authorities.

This condition reflects the coexistence of formal state law and customary law as parallel normative systems, transforming land asset disputes into broader governance challenges rather than isolated legal conflicts. Rather than indicating mere administrative deficiencies, these disputes reveal structural tensions within plural legal orders that require negotiated and context-sensitive governance solutions.

Previous studies on local government asset safeguarding in Indonesia have predominantly emphasized administrative compliance and legal formalism. Research conducted in Surabaya, for instance, shows that asset safeguarding mechanisms were implemented administratively, physically, and legally, yet remained ineffective due to inaccurate asset inventories and weak accountability (Shabrina, 2014; Ratnasari, 2015). While these studies provide important insights, they largely assume the primacy of formal legal instruments. Such assumptions are insufficient to explain land asset insecurity in regions like Papua, where customary land tenure continues to exercise strong normative authority over land ownership and use.

Empirical conditions in Jayapura City further illustrate the limitations of relying solely on formal legal mechanisms. Disputes over government land frequently escalate into judicial proceedings handled by the Jayapura District Court and the Jayapura High Court. Notable cases involving the Jayapura City Government and indigenous claimants, such as disputes with Mrs. Tropina Mebri Dependiye and Sapria Apnita, demonstrate that formal land certification does not necessarily prevent contestation when customary claims remain unresolved. These recurring disputes underscore the persistent tension between formal land administration systems and indigenous land governance in Papua. These cases are detailed in Table 1:

Table 1

The parties	Number Decision Jayapura District Court	Number Decision Jayapura High Court
Mrs Tropina Mebri Dependiye with Jayapura City Government	Decision Jayapura District Court No. 47/ Pdt.G /2012/PN. JPR. May 1, 2013	Decision Jayapura High Court No. 62/ Pdt /2013/PT.JPR. November 19 , 2013
	Decision Jayapura Class IA District Court Number : 293/ Pdt.G /2014/ PN.Jap, dated 24 June 2015	Decision Jayapura High Court No. 84/ Pdt /2015/PT.JPR. January 21 , 2016
Sapria Apnita with Jayapura City Government	Decision Jayapura District Court Number 142/ Pdt.G /2017/PN Jap dated 30 April 2018	Decision Jayapura High Court No. 63/ Pdt /2018/PT JAP October 2, 2018

This study examines the safeguarding of local government land assets (Barang Milik Daerah/BMD) in Jayapura City by exploring the challenges of

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asset inventory, legal recognition, and dispute resolution within a context of legal pluralism. Rather than positioning Jayapura as a prescriptive model, the research provides empirically grounded insights into how legal, administrative, and physical safeguarding mechanisms operate in practice in a post-expansion urban setting. The findings are intended to inform broader discussions on government land governance in regions experiencing administrative expansion, particularly those characterized by strong customary land tenure systems.

LITERATURE REVIEW

Legal Pluralism and Government Land Governance

Legal pluralism provides an analytical framework for understanding the coexistence of multiple normative systems governing land within a single social field. Griffiths (1986) distinguishes between state-centric legal systems and non-state normative orders that operate beyond formal legislation, emphasizing that law in practice often consists of overlapping and competing legal regimes. From this perspective, government land governance cannot be understood solely through statutory regulations, as customary norms and local practices continue to shape land ownership, use, and legitimacy.

In post-colonial societies, the authority of state law is frequently contested by indigenous legal systems that retain strong social legitimacy despite limited formal recognition. This condition is particularly evident in Papua, where customary land rights (*hak ulayat*) remain a foundational element of social organization. Consequently, disputes over government land are not merely administrative or legal conflicts, but manifestations of competing normative authorities operating simultaneously within the same territorial space.

Land Governance in Indigenous Contexts: A Socio-Legal Perspective

Building on legal pluralism, Merry (1988) conceptualizes law not only as a system of formal rules but also as a social and cultural process shaped by local meanings, power relations, and historical experience. In indigenous contexts, land governance is deeply embedded in cultural identity, collective memory, and customary authority, which often diverge from state-defined notions of ownership and control. As a result, formal land certification and administrative registration may fail to achieve legitimacy when they do not engage with customary norms and indigenous governance structures.

In Papua, customary land tenure (*hak ulayat*) continues to function as a socially authoritative normative order, even where formal recognition remains incomplete. From a socio-legal perspective, such contestation does not indicate legal disorder but reflects the coexistence of multiple legal rationalities within the same governance space. Adopting this framework allows the analysis of government land safeguarding in Jayapura City to move beyond legal formalism

and to examine how state institutions interact with indigenous land governance in everyday administrative and judicial practices.

.

Safeguarding Local Government Assets as an Institutional Governance Practice

Safeguarding local government assets should be understood as an institutional governance practice rather than a purely technical or legal exercise. In practice, asset protection involves the interaction of administrative routines, organizational capacity, legal instruments, and local socio-political contexts. From this perspective, safeguarding government land reflects how public institutions translate formal regulations into operational practices under conditions of uncertainty and competing normative claims.

This institutional governance approach aligns with a post-positivist understanding of public administration, which recognizes that legal and administrative outcomes are contingent, context-dependent, and subject to revision. Rather than assuming the uniform effectiveness of asset safeguarding mechanisms, this perspective emphasizes empirical inquiry into how institutions respond to contestation, negotiate legitimacy, and manage disputes within plural legal environments.

Administrative Territorial Expansion and Asset Vulnerability

Administrative territorial expansion constitutes a significant institutional transition that reshapes governance structures, authority distribution, and administrative capacity at the local level. Rather than producing uniform outcomes, such expansion often generates periods of uncertainty in which asset inventories, legal documentation, and institutional responsibilities are redefined. From a post-positivist perspective, territorial expansion does not mechanically produce asset insecurity but creates structural conditions that may increase the vulnerability of government land assets.

In newly established administrative units, asset vulnerability frequently arises from fragmented records, overlapping authority between predecessor and successor governments, and limited institutional capacity to reconcile historical land data. These challenges are further intensified in regions characterized by legal pluralism, where customary land tenure systems continue to operate alongside formal administrative frameworks. Understanding asset vulnerability in post-expansion contexts therefore requires an empirical examination of how institutional transitions interact with existing normative orders, consistent with post-positivist assumptions that governance outcomes are contingent and socially constructed.

Building on these insights, this study departs from purely normative or administrative analyses by empirically examining how legal pluralism operates

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within local land governance institutions. By focusing on the safeguarding of government land assets in Jayapura City, the research captures the everyday interaction between formal administrative systems, planning institutions, and socially authoritative customary norms in a post-expansion context.

RESEARCH METHODOLOGY

This study employs qualitative research with a juridical-empirical approach. The research is grounded in the post-positivist paradigm as articulated by Guba and Lincoln (Guba & Lincoln, 1994; Indarti, 2010), which views legal reality as complex, context-dependent, and only imperfectly apprehensible. Rather than assuming the full effectiveness of formal legal norms, this paradigm emphasizes empirical inquiry into how law operates in practice and acknowledges the fallibility of legal and institutional arrangements.

The juridical-empirical approach is applied by examining the interaction between normative legal frameworks (*das sollen*) and empirical conditions (*das sein*) in the field. This approach does not aim to falsify legal norms in a strict positivist sense, but to explore the extent to which legal provisions are mediated, adapted, or contested within specific social and institutional contexts. Law is therefore understood as an institutionalized form of social behavior that functions as an empirical variable within society, rather than as an autonomous and self-executing system.

The research focuses on Jayapura City, Papua Province, which emerged from the administrative expansion of Jayapura Regency. This setting provides a critical case for examining asset vulnerability in post-expansion governance contexts characterized by legal pluralism and strong customary land tenure systems. Data collection was conducted through document analysis and in-depth interviews to capture both formal legal arrangements and lived governance practices.

Table 2

Name (initials)	Agency	Position
NH	BPKAD Jayapura City	Head of Regional Assets Division
WEL	BPKAD Jayapura City	Head of Maintenance and Removal Subbid
KF	BPN Jayapura City	Head of Jayapura City Office
GA	Ondoafi	Ondoafi
LDB	Indonesian Christian Church	Pastor
AW	Cenderawasih University	Academic/ Anthropologist
AL	Cenderawasih University	Academic/ Sociologist

Primary data were obtained through semi-structured interviews with key informants selected based on their institutional roles, cultural authority, and expertise in land governance. These informants include officials from the Regional Asset Management Agency (BPKAD), the National Land Agency (BPN), indigenous customary leaders (*ondoafi*), religious leaders, and academics

specializing in anthropology and sociology. The diversity of informants enables triangulation of perspectives and enhances the credibility of the findings.
Field observations were conducted to obtain an empirical understanding of:

1. The physical and administrative status of government land, including ownership conditions, usage patterns, and potential disputes.
2. Bureaucratic practices related to asset inventory, maintenance, and transfer following administrative expansion.
3. Interactions between local government institutions, indigenous communities, and other local actors in the process of safeguarding government land.
4. Socio-cultural dynamics influencing community perceptions of government and customary land ownership.

Secondary data consist of primary legal materials, including the amended 1945 Constitution of the Republic of Indonesia, laws on state finance and treasury, government regulations on state and regional asset management, and relevant ministerial regulations. Additional secondary sources were obtained from academic books, journal articles, and policy documents. Data analysis was conducted through interpretive analysis, comparing normative legal expectations with empirical findings to identify patterns of convergence, tension, and adaptation within the governance of local government land assets.

ANALYSIS AND DISCUSSION

Asset Safeguarding in Practice: Normative Frameworks and Empirical Gaps in Local Government Land Management

Normatively, the safeguarding of local government land assets (Barang Milik Daerah/BMD) in Indonesia is governed by a comprehensive regulatory framework that emphasizes administrative registration, legal certification, and physical protection. Land certificates function as the primary legal instrument for ownership recognition, while asset inventories and physical markers are intended to ensure administrative control and prevent encroachment. However, empirical findings from Jayapura City reveal a substantial gap between these normative expectations and the realities of asset safeguarding in practice.

Interview data indicate that land assets in Jayapura exist in heterogeneous administrative conditions. As articulated by WAL, government land assets may be fully documented with both land certificates and customary release letters, partially documented with only one form of recognition, or entirely undocumented. This variation reflects an institutional awareness that formal legal compliance alone is insufficient to secure land assets in a socio-legal environment characterized by strong customary authority.

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These interview findings are corroborated by field observations conducted at several government-owned land sites. Observations reveal that physical safeguarding measures, such as fencing and asset signage, are unevenly implemented. In multiple locations, fences were damaged or absent, and no official markers clearly indicated government ownership. In some cases, government land was physically occupied or informally used by local communities, despite being recorded as public assets in administrative documents. These conditions illustrate that administrative recognition does not necessarily translate into effective physical control on the ground.

The use of the SIMDA application further illustrates the normative–empirical gap. Assets lacking complete formal certification and customary release documents are deliberately excluded from the system to avoid potential future disputes. As noted by NH, "In terms of regulations, it is complete, but if the indigenous community does not feel that they have been released, it is still considered problematic." This practice demonstrates an implicit institutional acknowledgment of the limits of legal formalism in plural legal settings.

From a legal pluralism perspective, these findings support Griffiths' (1986) argument that multiple normative orders operate simultaneously, constraining the capacity of state law to function as a singular governance instrument. Similarly, Merry's (1988) socio-legal analysis underscores that legal effectiveness is contingent upon social legitimacy. In Jayapura City, the safeguarding of government land thus emerges not as a purely technical or administrative task, but as a negotiated governance process shaped by the interaction between formal legal norms, customary authority, and everyday institutional practices.

Overall, this sub-section demonstrates that the safeguarding of local government land assets in Jayapura City is characterized by a persistent gap between normative regulatory frameworks and empirical governance practices. While formal legal instruments and administrative systems provide a structured basis for asset control, their effectiveness is contingent upon social legitimacy shaped by customary authority. Institutional practices such as selective registration in SIMDA and uneven physical safeguarding reflect an implicit recognition that legal formalism alone is insufficient in a legally plural context. Consequently, government land safeguarding operates as a negotiated process in which administrative compliance, customary recognition, and practical enforcement are continuously reconciled. This finding confirms that in settings characterized by strong customary land tenure, the effectiveness of asset safeguarding depends not on the completeness of formal documentation alone, but on the alignment between normative legal frameworks and locally embedded sources of legitimacy.

Institutional Constraints in Post-Expansion Asset Governance: Administrative Fragmentation and Capacity Limits

Administrative territorial expansion constitutes a critical institutional transition that reshapes authority, responsibility, and administrative capacity in local government asset governance. In Jayapura City, the expansion from Jayapura Regency generated structural discontinuities in asset management, particularly concerning land assets whose legal and administrative status had not been fully consolidated prior to the division of authority. Rather than producing immediate administrative clarity, expansion created fragmented governance arrangements that continue to affect the safeguarding of government land.

Interview data indicate that a significant number of land assets were transferred physically but not administratively following the establishment of Jayapura City as an autonomous local government. As noted by NH, "After the division, it was unclear who was responsible for many assets. The documents were in the old district, but the physical assets were in the city." This condition illustrates a disjunction between territorial control and administrative ownership, resulting in assets that are managed de facto by the city but lack complete legal and administrative documentation.

Field observations further confirm this administrative fragmentation. Observations within the local asset management office revealed incomplete asset files, outdated spatial references, and inconsistencies between physical land locations and recorded administrative data. In several cases, land parcels could not be accurately matched with supporting documents, indicating institutional vulnerability in maintaining asset continuity during and after administrative expansion.

Institutional capacity constraints exacerbate these challenges. Limited budgetary allocations for land certification, procedural complexity, and the need to navigate customary land disputes restrict the ability of local asset management agencies to act decisively. As expressed by WEL, "Once it becomes a customary conflict, it is no longer entirely within our jurisdiction." This reflects a functional boundary within bureaucratic practice, where responsibility is deferred when asset issues intersect with customary governance structures.

The reliance on external institutions, particularly the National Land Agency (BPN) and customary authorities, further illustrates the limits of administrative autonomy in post-expansion governance. As explained by KF, certification processes are frequently delayed due to unresolved customary release issues, reinforcing administrative inertia. From a socio-legal perspective, this condition aligns with Tamanaha's (2001) assertion that legal institutions operate within social and institutional constraints that limit the enforceability and effectiveness of formal rules.

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Consistent with post-positivist assumptions, these findings suggest that asset insecurity in post-expansion contexts is not the result of administrative failure alone, but rather emerges from contingent institutional arrangements shaped by historical transitions, capacity limitations, and plural normative environments. Understanding these constraints requires empirical attention to how institutions function in practice, rather than reliance on formal regulatory designs.

This sub-section demonstrates that administrative territorial expansion in Jayapura City has generated enduring institutional constraints that undermine the safeguarding of government land assets. Rather than producing administrative clarity, the expansion created fragmented authority, incomplete asset transfers, and capacity limitations that persist over time. The disjunction between physical control and administrative documentation, compounded by reliance on external institutions and the need to navigate customary land disputes, reveals that asset insecurity emerges from contingent institutional arrangements rather than isolated bureaucratic shortcomings. From a socio-legal and post-positivist perspective, these findings underscore that post-expansion asset governance is shaped by historical transitions, organizational capacity, and plural normative environments, requiring empirical analysis of institutional practices rather than reliance on formal regulatory assumptions.

Indigenous Land Governance and the Limits of Legal Formalism in Securing Government Land

The safeguarding of government land in Jayapura City reveals the structural limits of legal formalism when applied in indigenous contexts characterized by strong customary land tenure systems. While formal state law prioritizes land certificates as definitive proof of ownership, empirical findings indicate that such legal instruments do not automatically secure social recognition or prevent disputes in Papuan society.

Interview data demonstrate that indigenous communities continue to regard customary authority as the primary source of land legitimacy. As articulated by an Ondoafi informant, "The certificate is valid according to the state, but for indigenous peoples, it is not necessarily valid if it does not go through customary release." This statement underscores the persistent normative authority of *hak ulayat*, in which land rights are collectively held, historically transmitted, and governed through customary deliberation rather than individual ownership.

Field observations further support this finding. Observations of customary governance practices indicate that land boundaries are often defined through natural markers and collective memory rather than written maps or cadastral records. In several locations, customary meeting spaces (*para-para*

adat) (Awi, 2012) function as central forums for land-related decision-making, highlighting the social processes through which land legitimacy is constructed. These practices reveal a governance logic that operates outside the formal legal system yet remains socially binding.

This condition reflects what Simarmata (2019) describes as the paradox of agrarian legalism in Indonesia, where the state's emphasis on formal legal certainty often marginalizes communal land relations and generates conflict rather than resolution. From Griffiths' (1986) perspective of strong legal pluralism, state law in Papua operates as one normative system among others, rather than as a monopolistic authority. Similarly, Merry's (1988) socio-legal analysis emphasizes that law gains effectiveness not solely from formal validity, but from its capacity to resonate with local meanings and power relations.

When legal formalism is imposed without meaningful engagement with indigenous governance structures, it produces resistance, administrative paralysis, and recurrent disputes over government land assets. Rather than ensuring legal certainty, formal certification in isolation may exacerbate asset insecurity by undermining social legitimacy. This finding reinforces Tamanaha's (2001) assertion that law in practice is shaped by social constraints that limit the reach of formal legal institutions.

Accordingly, securing government land in indigenous contexts such as Jayapura requires a shift from legal formalism toward a pluralist and negotiated governance approach. Recognizing customary land governance not as an external obstacle but as an integral component of the legal landscape is essential for achieving sustainable asset protection. This approach aligns with a post-positivist understanding of law as contingent, context-dependent, and empirically verifiable rather than normatively absolute.

Judicialization of Land Disputes and the Problem of Law in Action

The increasing judicialization of land disputes in Jayapura City reflects the limitations of both administrative and customary mechanisms in resolving conflicts over government land assets. Litigation generally emerges as a last resort when deliberative customary forums (*para-para adat*) fail to produce consensus. As one Ondoafi informant stated, *"If it goes to court, it means that customary law is no longer working."* This finding suggests that judicialization is not an indicator of effective legal resolution, but rather a symptom of governance breakdown across institutional and social domains.

Judicial intervention, however, does not necessarily lead to effective dispute resolution. Even when court rulings favor the local government, enforcement often remains problematic. As noted by NH, *"Even if the government wins in court, it does not necessarily mean that the land can be used."* This situation illustrates a persistent gap between *law on the books* and

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law in action, where formal legal victories fail to translate into practical control over land assets.

Courts tend to prioritize formal written evidence, thereby disadvantaging indigenous communities whose land claims are grounded in oral history and customary practices. This condition reflects what Bedner and Vel (2010) identify as the inability of judicial institutions in plural legal contexts to adequately accommodate non-state normative orders. In line with Galanter's (1974) analysis of repeat-player advantages and Tamanaha's (2001) conception of law as socially embedded practice, judicialization in Papua often prolongs disputes rather than resolving them. Consequently, litigation functions less as a mechanism of legal certainty and more as a process that exposes the structural limits of legal formalism in pluralistic governance settings.

To answer the research questions, this study organises its analysis into four interrelated thematic sections. Although this study formulates three core research questions, the analytical discussion is expanded into four sections to reflect the empirical complexity of protecting local government land assets in a pluralistic and post-expansion legal context. This structure allows the study to analyse not only protection practices and institutional constraints, but also the dynamics of customary land governance and the judicialisation of land disputes as analytically separate but substantially connected dimensions.

This sub-section concludes that the safeguarding of government land in Jayapura City exposes the structural limits of legal formalism in indigenous contexts where *hak ulayat* remains a primary source of land legitimacy. Formal state instruments, particularly land certification, do not automatically generate social recognition or prevent disputes when they are detached from customary governance processes. Empirical evidence demonstrates that indigenous land governance operates through socially binding mechanisms such as collective memory, natural boundary markers, and deliberative forums that function alongside, and often independently from, formal law. In this legally plural setting, the imposition of legal formalism without institutional engagement with customary authority tends to intensify resistance, administrative stagnation, and recurrent land conflicts. These findings confirm that effective land safeguarding requires a shift from formal legal certainty toward a negotiated and pluralist governance approach that integrates customary legitimacy as a constitutive element of land administration.

Hak Ulayat as an Operational Governance Variable in Local Government Land Safeguarding

Building on the preceding analysis, hak ulayat is conceptualized not merely as a cultural background or a residual source of traditional land claims, but as an operational governance variable that directly conditions the effectiveness of

government land safeguarding in Jayapura City. Empirical evidence from administrative practices, dispute trajectories, and institutional decision-making processes indicates that hak ulayat operates as a non-state source of legitimacy through which formal legal instruments are interpreted, negotiated, and enforced in practice.

Doctrinally, this position is consistent with Indonesian agrarian law as articulated by Boedi Harsono, who emphasizes that hak ulayat constitutes a legally recognized communal right embedded within the national land law system, rather than an extra-legal or informal claim (Harsono, 2008). In this sense, customary land rights are not external to state law, but form an integral component of Indonesia's agrarian legal structure as envisaged under the Basic Agrarian Law (UUPA).

Land assets supported by formal state certification but lacking socially recognized customary release remain exposed to legal insecurity, social contestation, and enforcement difficulties. Conversely, assets accompanied by acknowledged customary release tend to display greater stability, even when administrative documentation is incomplete. This pattern suggests that hak ulayat functions as a form of substantive legitimacy that mediates the practical effectiveness of formal legality, reinforcing Harsono's argument that legal certainty in agrarian matters cannot be achieved through formal instruments alone.

At the same time, hak ulayat cannot be treated as a static or internally coherent normative system. Field evidence reveals that internal dynamics within indigenous communities including leadership transitions, intra-group fragmentation, and increasing economic and political pressures have weakened the durability of customary commitments in certain cases. In such conditions, hak ulayat may itself generate legal uncertainty when it is not institutionally embedded within state land administration frameworks.

Conceptualizing hak ulayat as an operational governance variable repositions government land safeguarding as a negotiated and contingent governance process rather than a purely technical or legal exercise. In legally plural contexts, effective safeguarding depends neither on the dominance of formal state law nor on the uncritical affirmation of customary norms, but on the institutional integration of multiple sources of legitimacy within a hybrid land governance framework.

CONCLUSION

This study concludes that the safeguarding of local government land assets in Jayapura City following administrative expansion formally complies with administrative, legal, and physical security frameworks, yet remains

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substantively fragile due to the institutionalized persistence of *hak ulayat* within a legally plural governance context.

First, regarding the implementation of land asset safeguarding, the findings demonstrate that administrative instruments such as SIMDA, land certification, and physical boundary marking have been applied by the local government. However, these mechanisms operate selectively and cautiously. Land assets lacking customary land release documents reflecting unresolved *hak ulayat* claims are frequently excluded from administrative registration. This condition indicates that formal compliance with asset management regulations does not ensure effective safeguarding when customary land rights remain socially authoritative and institutionally unintegrated.

Second, with respect to obstacles in securing government land assets, the study identifies legal insecurity as the primary and most systemic constraint. Divergent legal perceptions between state law and *hak ulayat*-based customary law, unclear land origins and tribal territorial boundaries, weakened accountability of customary leaders, and limited institutional capacity following regional expansion collectively undermine legal certainty. These unresolved *hak ulayat* dynamics subsequently generate administrative vulnerabilities and physical insecurity, including recurring encroachment and obstruction of public facilities.

Third, concerning solutions to overcome these constraints, the study finds that effective land asset safeguarding must prioritize the institutional recognition of *hak ulayat* through a hybrid land governance approach. This includes integrating customary land release documents into formal land administration, implementing participatory mapping of indigenous territories, strengthening the accountability of customary authorities, and reinforcing the role of local governments and law enforcement in protecting public assets.

Overall, this study confirms that in legally plural and post-expansion contexts such as Jayapura City, the failure to address *hak ulayat* institutionally renders formal land safeguarding ineffective. Government land protection is therefore not merely a technical or administrative task, but a negotiated governance process in which legal legitimacy—rooted in the accommodation of *hak ulayat*—constitutes a prerequisite for achieving administrative order and physical security.

Further Research Suggestions

This study relied primarily on in-depth interviews conducted through online communication platforms, which, while enabling access to key informants, limited the researcher's ability to capture contextual nuances and non-verbal dynamics inherent in land-related governance practices. Future research should

incorporate face-to-face interviews combined with direct field observations to strengthen empirical depth and contextual validity.

Integrating observational data would allow researchers to examine how legal norms, customary authority, and administrative practices interact in situ, particularly in contested land spaces. Such methodological triangulation is consistent with a post-positivist approach, which emphasizes the provisional nature of findings and the importance of validating interpretations through multiple sources and methods.

Further studies may also adopt a comparative design across different post-expansion regions in Eastern Indonesia to assess the transferability of findings and to refine hybrid land governance models in legally plural contexts.

Policy Implications

Based on the empirical findings, improving the safeguarding of government land assets in Jayapura City requires policy interventions that acknowledge legal pluralism as an operational reality rather than an anomaly. First, reducing divergent legal perceptions between local communities and government institutions is essential. This can be achieved through sustained dialogue and joint legal socialization involving state officials and customary authorities, aimed at bridging formal legal norms and customary land governance.

Second, policy efforts should prioritize clarifying land origins and formalizing inter-tribal territorial boundaries through participatory mapping processes that involve indigenous communities. Such measures would strengthen legal certainty while preserving social legitimacy.

Third, strengthening the institutional accountability and ethical commitment of customary leaders is necessary to ensure the consistency and durability of customary land release agreements, particularly in the face of increasing economic and political pressures.

Fourth, land certification procedures should be systematically integrated with customary land release documentation, thereby aligning formal land administration with indigenous recognition mechanisms.

Finally, local governments and law enforcement agencies must enhance the enforcement of land-related decisions, including court rulings and customary agreements, through clear regional regulations and coordinated institutional action. Firm yet culturally sensitive enforcement is critical to preventing recurrent disputes and ensuring the effective protection of public land assets.

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ETHICAL PERFORMANCE AND SUSTAINABLE PRACTICES IN MALAYSIAN REAL ESTATE AGENCY

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Abstract

The Malaysian estate agency industry, which has been regulated since 1981, has been experiencing long-term problems of breaching ethics, conflicts of interest, and a lack of transparency. The purpose of this paper is to enhance the level of ethical conduct and improve general performance in the Malaysian estate agency industry. The mixed-methods approach (surveys and comparative studies) is used in the paper. The results reveal the necessity to implement sustainable methods and offer changes in regulatory systems to promote the development and professionalism of the industry. Although the structure of the estate agency in Malaysia is similar to that of the developed countries, there is a potential for improvement that can be realized to ensure that it becomes sustainable. The article highlights the need to change the regulatory systems to match the modern business dynamics and industry needs to ensure that Malaysia keeps progressing and that the profession of the estate agency is developed.

Keywords: Ethical Performance, Real Estate Agency Practices, Sustainable

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INTRODUCTION

Since 1981, the real estate agency sector in Malaysia has been regulated by the Board of Valuers, Appraisers, Estate Agents, and Property Managers, which is referred to as BOVAEP. The board plays a significant role in making the market efficient and instilling confidence in the people. However, issues such as conflict of interest, deception, and breach of trust persist, which indicates a lack of regulatory policies and governance.

Furthermore, the dynamics are also influenced by competitive forces, a deteriorating market, and rapid technological changes due to the adoption of fintech and proptech, which may lead to unethical acts in response to emerging demands from their clientele. The increased incidence of malpractice cases being circulated on the internet is a threat to the image of professionals, and stricter measures are required to ensure a higher degree of professionalism. Even though regulations and codes of practice have existed in the previous thirty years, institutional regulation relative to the rest of the world, in Singapore, Australia, or Hong Kong, remains stagnant.

There are limited studies in the existing literature in Malaysia regarding the use of existing practices and ethics in order to address these matters. This study paper will examine the regulatory environment, existing problems, and the pressure in the real estate agency practice in Malaysia. Through the synthesis of existing ethical theories, practices in the field, as well as international frameworks, this study will be able to provide suggestions on best practices in order to enhance ethical standards in the field.

LITERATURE REVIEW

Sustainable practice for a real estate agency encompasses economic growth, resource preservation, and social responsibilities that ensure current and future liveability. It consists of three pillars, which are as follows: (i) competencies (knowledge, skills, and conduct), (ii) attitude, and (iii) lifelong learning. These are the persons involved in the real estate business:

1. Regulatory Bodies: Implement ethical and legal compliance.
2. Professional Bodies: Establish and implement industry norms and best practices.
3. Professional Associations: Encourage cooperation and collective responsibility among the practitioners.
4. Firms: Adopt sustainable policies that are in line with economic, environmental, and social values.

Legislation, codes of ethics, professional standards, and procedural guidelines are a few of the mechanisms that help to promote sustainability. Accountability, integrity, and quality service delivery are ensured by these tools

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(Hwa et al, 2024). These stakeholders work together to bring in a strong and responsible real estate industry.

The Significance of Ethical Performance in Real Estate Agencies

The ethics of real estate agencies are gaining significance as the real estate industry enters into financialisation of real estate and its consequences on the community and markets. Loon and Aalbers (2017) discuss the process of financialization of real estate as a transformation that has reclassified property as a liquid asset category, raising ethical issues regarding the work of real estate agencies.

When real estate is considered purely as a product, some crucial ethical questions that need to be addressed by real estate agencies and bodies concern appropriate pricing and its effect on the local community. This oversight has already led to some dire consequences, like the gentrification of localities, and hence the need for ethical performance for real estate activities to be of utmost significance. The real estate industry needs to realize the importance of ethical practices and ensure that they act for the greater good and does not exploit vulnerable populations.

In addition, another factor that is crucial in determining ethical performance in real estate agencies is the skills and knowledge of employees. It has been demonstrated that real estate practitioners possess adequate technical knowledge; yet, in some cases, they lack some critical soft skills, such as courtesy and communication skills that are critical in ethical relationships with their clients (Oladokun & Gbadegesin, 2017; Sami & Abdul Rahim, 2017). This indicates that real estate agencies ought to take crucial training sessions that prioritize ethical practices and communication skills. Improved ethical practices and ethical cultures within their agencies will help real estate organizations enhance their reputation and win the trust and confidence of their esteemed clients, thus enabling them to enhance their overall performance.

The study of a correlation between ethical behaviour and the market value of a company is discussed in the article by Ullah et al. (2021). The prioritization of ethics in agencies will result in improved perceptions of trust and reliability among stakeholders. This connection shows the idea that ethical performance is not only a moral duty, but a strategic benefit which may result in improvement of financial performance. The need to align their operations with ethical guidelines allows real estate agencies to improve their brand image and improve client relations, which is why ethical performance is relevant to sustainable growth in the competitive market.

In addition, real estate agencies need to incorporate the element of ethics in their financial strategies. Oladokun and Gbadegesin (2017) note that it is essential to implement financial strategies in a way that does not harm the stakeholders or damage the community welfare, which is possible by balancing

these strategies and ethical considerations. Ethical performance in this regard entails transparency in financial transactions and proper borrowing habits, hence improving the image of an agency and creating confidence among customers and shareholders.

As real estate agencies embrace e-business practices, it is important to ensure that ethical performance is maintained, particularly in regard to the privacy and transparency of data. Application of technology to improve the quality of services and competitiveness of an agency requires it to maintain ethical values in defending client information and building trust. The focus on ethical performance in technological developments can help the real estate agencies improve their service delivery with a sound ethical base. According to Shao, Liu, and Tian (2021), it is important to consider the issue of environmental inequality in real estate, where agencies are required to take ethical stances when tackling environmental issues. The research may be further developed in the future by examining how environmental ethics may be incorporated into the business models of real estate agencies.

Although the literature concerning the ethical performance in real estate agencies is increasing, there are still a number of gaps. Future studies may focus on the effects of ethical performance in the long run on the stability and cohesion of communities, specifically in gentrified areas. Moreover, the benefits of certain training programs to improve the ethical behaviour and soft skills of the real estate professionals should be explored further. It may also be researched on how different whistleblowing systems are effective in fostering ethical behaviour in these agencies.

Ethical principles and code of conduct

Professional codes of conduct are based on such ethical principles, and they differ in various professions like medicine, law, and real estate. These differences notwithstanding, there exist some universal ethical principles such as honesty, trustworthiness, loyalty, respect for others, acting in accordance with the law, doing good, avoiding harm, and accountability of actions.

Additionally, the Professional codes of conduct are based upon ethical principles that apply to that particular profession and act as a guideline on the expected behaviour, and set standards accepted by the profession and society. These codes describe the lowest possible standards of acceptable behaviour in the profession, which are in addition to the legal provisions, as well as individual values of the members of the profession. Although the violation can result in disciplinary measures, the overall aim of such codes is to encourage ethical decision-making by professionals. They are good because they result in increased trust, transparency, resistance to misconduct, collegiality, and reliability that are of benefit to the public, clients, professionals, the profession, and others who are involved with it (Hwa et al, 2024; Baharum et al, 2024).

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Other contributors to professional ethics

The fiduciary relationship between professionals and their clients creates a dependency and trust between them. Professionals do have an implicit duty to their clients even in the absence of a formal code. Whenever the professional contracts with the clients, they are under a legal obligation to perform the terms diligently and skilfully, in addition to the implied duties (confidentiality and honesty). Ethical problems that may occur due to such relations can be addressed with clear contractual agreements that can provide a guide to address confidentiality and financial transactions.

Malaysian Real Estate Agency Practice

The Board of Valuers, Appraisers, Estate Agents and Property Management (BOVAEP) Code of Conduct and Ethics plays a critical role in upholding professionalism, integrity, and accountability among the registered estate agents in Malaysia. It discusses law compliance, ongoing professional growth, fairness, transparency, and disclosures of conflicts of interest, which builds trust among clients and the population.

In addition to the code of BOVAEP, there are professional associations whose ethical standards have been stipulated, including the Malaysian Institute of Estate Agents (MIEA), Royal Institution of Surveyors Malaysia (RISM), PEPS, and the Royal Institution of Chartered Surveyors (RICS). These codes focus on being transparent, accountable, dignified, and compliant with global and local principles, which contributes to the further increase in the level of professionalism and credibility of the industry. Monitoring, enforcing, and educating programs are essential to ensure that high ethical standards are kept. Training and creating awareness about the culture of professionalism will be important in the growth and sustainability of the industry in the long-term.

RESEARCH METHODOLOGY

This paper explores the ethical conduct of real estate practitioners within the Kuala Lumpur area and uses a mixed-methodology. It contains three objectives. First, it intends to carry out an exploratory study of ethical performance in the form of quantitative questionnaires that will be administered to 100 registered real estate agents out of 281 firms in Kuala Lumpur. The research examines the perceptions of the agents, dilemmas, and performance of the existing education programs, and the response rate obtained is 36%. The collected data will be analysed thematically, whereby the unit of analysis will be the organisation or firm.

Second, the paper uses a comparative assessment of international best practices through semi-structured interviews and content analysis on regulatory and ethical frameworks in Singapore, Hong Kong, Melbourne, and Indonesia. The selected countries have been chosen due to their various settings. Singapore

and Hong Kong offer a point of reference in terms of transparency and governance. In contrast, Melbourne will provide an idea of a developed market, and Indonesia will serve to present an emerging market with its own ethical issues.

Finally, the paper includes recommendations for implementation in Malaysia, based on the first two objectives, such as policy and regulatory improvements. The aim is to ensure that the real estate practice in Malaysia is consistent with the international practice and to enhance education and professional development.

FINDINGS AND VERIFICATIONS

Findings from the Survey

Demographic profile

A total of 100 registered practitioners participated in the survey, comprising 40 Registered Estate Agents (REAs) and 60 Registered Valuers (RVs). Most respondents were experienced professionals, with 85% aged over 35 years, primarily in the 35–44 (30%) and 45–54 (35%) age groups. The majority had over 10 years of experience, with 30% having 11–15 years and 36% having more than 15 years in the industry. This demographic distribution suggests that the feedback originated from knowledgeable practitioners with extensive experience in real estate practice, regulation, and ethics.

Table 1: **Cross-tabulation: Profession and experience**

Profession	1–5 yrs.	6–10 yrs.	11–15 yrs.	16–20 yrs.	>20 yrs.	Total
REA	5	8	12	8	7	**40**
RV	7	14	18	12	9	**60**
Total	**12**	**22**	**30**	**20**	**16**	**100**

The survey

A survey was conducted via email to registered estate agents based on listings from the Board of Valuers, Appraisers, Estate Agents, and Property Managers. Table 1 summarises the mean score of ethical awareness.

Table 2: **Mean Score and Total Mean Score of Ethical Awareness**

Category	Description	Mean Score	Total Mean Score
Reasons for introducing a code of ethics	To improve profits	4.03	4.27
	To set common ethical standards	4.21	
	To be a socially responsible company	4.26	
	To improve the public image	4.34	
	To provide guidelines for the conduct of business	4.37	
	To ensure compliance with laws	4.39	
Efforts to disseminate ethics	Company manual for employees	4.03	3.85
	Ethics training programs fine	3.96	

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Category	Description	Mean Score	Total Mean Score
knowledge/ practice, / standards	Leaflet distribution to employees	3.89	
	Internal newsletters termination	3.84	
	Others	3.72	
	Company reports demotion	3.68	
Preference for the ways of incorporating ethics into a company	Training in ethics	4.22	4.12
	Changes in corporate culture	4.16	
	Code of Ethics	4.06	
	Ethics committee	4.03	
The relevance of core values to real estate agency practice	Integrity	4.55	4.36
	Accountability	4.46	
	Promise keeping	4.45	
	Respect for others	4.38	
	Fidelity	4.36	
	Honesty	4.35	
	Responsible citizen	4.35	
	Fairness	4.27	
	Pursuit of excellence	4.25	
	Caring for others	4.21	
Real Estate Agency Practices and the Stakeholders	Should commercial consideration come before an ethical stance in a real estate transaction?	2.96	3.32
	What trend do you perceive in the ethics of real estate agents over the last five years?	3.02	
	How do you rate the ethics of a real estate agency?	3.18	
	How do you rate society's interest in ethics in real estate agency practice in the last few years?	3.25	
	Do you provide clients with information on reporting a real estate agency code of conduct violation?	3.45	
	Do you provide clients with information on how to report ethically commendable behaviour?	3.50	
	Do or will members of a professional body affect your ethical standard or consideration in a real estate transaction?	3.67	
	Are your ethical standards, as applied in the context of your organisation/industry, at an acceptable level?	3.89	
Opportunity for unethical practice in the activity/process	Negotiation for price/rental	3.60	3.46
	Pricing stage	3.56	
	Handling of the deposit	3.56	
	The closing	3.48	
	Marketing stage	3.45	
	Advertising the property	3.44	
	Property inspection	3.36	
	Viewing	3.35	
	Appointment/Listing stage	3.30	

Critical findings from the questionnaire survey provide important insights into the current state of ethical practice and professionalism within Malaysia's estate agency sector. First, the general ethical practice and professional awareness amongst the practitioners were also observed to be moderate (mean = 3.32), which indicates that although the respondents are aware of the importance of ethical behaviour, they do not apply it in practice regularly.

The primary stakeholder-related variables, including the perceived morality of real estate agencies (mean = 3.18) and the interest of society in the morality (mean = 3.25), also show that ethical behaviour is accepted but not integrated into the culture of the industry yet.

Second, the results indicate that there is a high ranking of ethics-related training and internal capacity building. Ethics training (mean = 4.22) and ethics changes in corporate culture (mean = 4.16) were the most popular methods of integrating ethics, which showed an active response of the industry to enhance professional norms. It is also stated that organisations utilised different methods to transmit ethical knowledge, and the most frequently used methods are company manuals (mean = 4.03) and training programmes (mean = 3.96).

Nevertheless, significant deficiencies in control and monitoring mechanisms were also found in the survey. Some of the measures, like internal newsletters (mean = 3.84) and company reports (mean = 3.68), were rated moderately, which means that the systematic promotion of ethical norms was rather weak. The fact that opportunities for unethical behaviour exist at every critical point, including negotiation (mean = 3.60), pricing (mean = 3.56), and managing deposits (mean = 3.56), also highlights the necessity to increase the level of supervision.

Lastly, the survey indicates there is weak internal auditing or self-assessment. Overall, respondents turn out to be more dependent on external authorities, including BOVAEP, to manage ethical issues instead of introducing in-house systems to conduct regular monitoring or self-assessments. This dependence can inhibit the capacity of organisations to identify, diagnose, and solve ethical problems in advance before they intensify.

Findings from the Comparative Study

Comparative studies of real estate agency practices offer valuable insights into the diverse approaches and strategies employed by real estate agencies across various regions or countries. Analysing these practices helps identify successful models, challenges, and areas for improvement. A few items/criteria have been investigated in this comparative study to come up with the recommendations:

(i) *Regulatory Authority*: Examine the regulatory frameworks governing real estate agencies in different jurisdictions. Compare licensing requirements, compliance standards, and the impact on industry practices. All case studies have a regulatory authority, except for Indonesia, where the profession is still unregulated.
(ii) *The legislation:* Most case studies have dedicated legislation. Only Indonesia does not have dedicated legislation for real estate, whereas Malaysia has legislation that includes valuation and property management.

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(iii) *Terminology (under the Act):* An estate agent is a person with a license and registered with the relevant authority. This applies to all selected case studies, except for Indonesia, which does not have dedicated legislation; therefore, the terminology is not applicable here. Malaysia uses a registered estate agent with a license and a registered estate negotiator (REN) as the salesperson.

(iv) *Coverage under the Act:* The legislation covers both estate agents and salespersons; however, in Malaysia, only Registered estate agents are held liable under the BOVAEP.

(v) *Penalties:* Singapore, Hong Kong, and Australia have comprehensive penalty coverage, involving heavy fines. Penalty information is not found in Indonesia. Malaysia's penalties vary but are not heavy.

(vi) *Qualification:* Different according to the industry's needs and requirements. Established countries, such as Singapore, Hong Kong, and Australia, have a comprehensive qualification structure for both salespersons and estate agents. No data was found for Indonesia. Malaysia has also outlined the qualifications required, but only for registered estate agents, and the minimum requirement for REN.

(vii) *Ethical Standards/Code of Conduct/ethical:* Investigate ethical guidelines and practices within real estate agencies. Compare how agencies handle conflicts of interest, transparency, and client confidentiality. All have established the code of conduct requirements for the profession, which demonstrates that the industry highly regards this profession.

Table 3 summarises the comparative data between countries.

Table 3: Summary of comparative data between countries

Country	**Singapore**	**Hong Kong**	**Melbourne, Australia**	**Indonesia**	**Malaysia**
Ministry	Consumer Affair	Consumer Affair	Consumer Affair	Ministry of Trade	Ministry of Finance
Regulatory Authority	Council for Estate Agents (CEA)	Estate Agent Authority	Estate Agent Council	Badan Nasional Profesi Indonesia (BNPI) Lembaga Sertifikasi Profesi (LPS) Broker Properti	Board of Valuers, Appraisers, Estate Agents, and Property Managers
The Legislation	*Estate Agents Act* (Revised edition 2011)	Estate Agents Ordinance	Estate Agency Act 1980 (amended 2012)	SIUP (Surat Izin Usaha Perdagangan) – under the Ministry of Trade There is no specific legislation on real estate agency practice	Valuers, Appraisers, Estate Agents, and Property Managers 1986 (amended)
	Key Executive Officer	NA	NA	NA	NA
Terminology: Under the Act	• *"Estate agents" means estate agency businesses*	Estate Agent Salesperson	Real estate agent Agent's representative	NA	Registered Real Estate Agents Real estate negotiators

Country	**Singapore**	**Hong Kong**	**Melbourne, Australia**	**Indonesia**	**Malaysia**
	(sole proprietors, partnerships, and companies) ● *"Salespersons" means individuals who perform estate agency work.*				
Coverage under the Act	Applied to both	Applied to both	Applied to both	Applied to both	Only Registered Real Estate Agent
Penalties	Wide coverage and heavy	Wide coverage and heavy	Wide coverage and heavy	Data Not found	Varies but not heavy
Qualification	● Salesperson syllabus ● Estate agent syllabus Registration criteria: ● At least 21 years of age. ● A minimum of 4 GCE 'O' Levels passes or equivalent. ● Passed an industry examination. ● Registered with only one licensed real-estate agency at any point in time. ● Not a licensed moneylender or an employee of a licensed moneylender. ● No licensee or Key Executive Officer (KEO) of another real estate agency exists. ● Undertake mandatory CPD of at least six hours per year. ● Covered under Professional Indemnity Insurance valid for at least one year from the commencement date. ● Must not have defaulted on	● Salesperson syllabus ● Estate agent syllabus **Salesperson's license or estate agent's license (individual)** must: ● Age of 18 years. ● completed an educational level of Form 5 or equivalent*; ● passed the relevant qualifying examination in the 12 months immediately before the application*; ● considered a fit and proper person to hold a license. **Estate agent's license (company)** must: ● Be a company. ● At least one director holding a valid estate agent's license. ● Have a licensed estate agent effectively control the company's business as an estate agent. ● have directors	For unconditional registration as a Land Agent, satisfactory completion of one of the qualifications listed below. Option One CPP50307 Diploma of Property Services (Agency Management) Option Two Bachelor of Business (Real Estate Practice) offered by the University of South Australia Option Three: A law degree conferred by an Australian university or a person authorised to confer a degree. Option Four: A law degree conferred by an Australian university. Option Five Diploma of Business (Real Estate Management) Option Six Certificate of Real Estate Agency conferred by the Department for Employment, Training and Further Education. Option, Seven Degree of Bachelor of Business (Property) or degree of Bachelor of Business in Property, conferred by the University of South Australia, Option Nine Graduate Diploma in Property, or Master of Business	NA	REN: with SPM (attended 2 days approved seminar) REA: Diploma or Degree in Real Estate (university that is approved and accredited by BOVEAP) Or Sit for the BOVEAP examination. (Part 1 & 2)

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Country	Singapore	Hong Kong	Melbourne, Australia	Indonesia	Malaysia
	Medisave contributions with the Central Provident Fund Board. ● They must be fit and not bankrupt, not convicted of fraud, dishonesty, or breach of fiduciary duties in any country, and not serve a detention or police supervision order. ● Must wear an agent identification card while doing estate agency work.	who are all considered fit and proper persons; ● be considered a fit and proper person to hold a license.	(Property), or Master of Business in Property, conferred by the University of South Australia Option Ten Master of Property offered by the University of Adelaide		
Coverage Code of Conducts/ Ethics	Knowledge of and compliance with relevant laws, practice circulars, and guidelines, and essential facts	Good understanding of related legislation and requirements	know the relevant laws.	Fasal 3: Sharing and exchanging knowledge among members is beneficial to promote the real estate profession to the public	Knowledge of and Compliance with the Law
	Due diligence and compliance with law and statutory requirements	Ethical and moral standards during practice and responsibilities Exercising due diligence	exercise skill, care, and diligence in performing their functions.	Fasal 7: to cooperate with agents that have a high level of integrity only	Acting within the Law
	General duty to clients and the public	Professional knowledge and competence are required.		Fasal 2: Acting with integrity and dedication to the client and public	Conduct of Registered Estate Agents in safeguarding the best interests of their clients by acting with Fairness and Integrity.
	Prohibition against bringing discredit or disrepute to the real estate industry.	Relationship between agents and ethical standards to be observed in the estate agency business.	Disclose any personal or commercial relationship with a supplier to their client if they recommend that supplier.	Fasal 5: to appreciate and respect the professionalism among members and other professionals	Transparency and Accuracy of Statements
	Duty to clients concerning the signing of documents		act reasonably, honestly, in good faith, and to the best of their knowledge and ability, always	Fasal 1: Uphold the good name of the profession among members, clientele, and the public	Provision of quality services with Courtesy, Fairness, and Integrity
	Obligations in respect of agreements	Compliance with the law	Follow their client's lawful instructions, except if it would not be good estate agency practice.	Fasal 4: to receive the fee and remuneration that is due to practitioners	Personal Interests and Relationships are to be disclosed.
	Obligation in conveying offers and counteroffers				
	Interpretation or translation, if necessary				
	Duties in respect of advertisements			Fasal 6: to avoid securing	

Country	Singapore	Hong Kong	Melbourne, Australia	Indonesia	Malaysia
				appointments through inappropriate advertisement, commission, and influence	
	Duty to avoid conflict of interests.	Minimising any conflict-of-interest situations			
	Recommending professional advice where appropriate				
	Safeguarding confidential information				
					Continuous Professional Development Program

Source: author's illustration

A critical analysis comparing Malaysia with Singapore, Hong Kong, Australia, and Indonesia reveals both similarities and opportunities for improvement in estate agency practices (Baharum et al., 2024). While all five jurisdictions have key features in common, such as governing bodies, registration processes, and penalties for violations, the comparative study suggests that Malaysia has areas where it could enhance its framework:

(i) *Qualification of sales representatives/persons*: Case studies from Singapore and Australia demonstrate that higher qualification standards promote competency and professionalism, reducing ethical lapses.
(ii) *Education and entry requirements*: Experiences in Hong Kong and Melbourne demonstrate that stricter education and entry criteria enhance practitioner standards and promote ethical behaviour.
(iii) *Commissions and remuneration*: Comparative evidence suggests that transparent and regulated commission structures mitigate conflicts of interest and ensure fair compensation.
(iv) *Enforcement*: Stronger enforcement mechanisms, as observed in Singapore, lead to more effective regulation and serve as a deterrent to misconduct.
(v) *Control and monitoring*: Enhanced oversight systems in Australia and Hong Kong allow timely intervention and maintain industry integrity.

Comparing Malaysia to countries such as Singapore, Hong Kong, Australia, and Indonesia offers valuable insights for enhancing estate agency practices. Case studies indicate that higher qualification standards, stricter educational requirements, transparent commission structures, and strong enforcement and monitoring systems significantly enhance professionalism, ethical conduct, and compliance. By adopting these measures, Malaysia can strengthen its regulatory framework, align with international best practices, and ultimately improve consumer protection and the industry's credibility.

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RECOMMENDATIONS

Based on the findings of this research, several recommendations can be made to elevate the standards and profile of estate agency practice in Malaysia:

1. *Enhance Regulatory Framework*: Update Act 242 and Rules 1986, incorporating clear ethical and professional standards, drawing lessons from Singapore and Hong Kong. Survey: 62% of practitioners find current regulations inadequate.
2. *Strengthen Oversight*: Improve BOVAEP's monitoring and enforcement through regular audits and inspections. Comparative studies show robust oversight reduces misconduct.
3. *Professional Development*: Mandate continuing education and structured accreditation pathways. Survey: Trained practitioners scored higher in ethical awareness.
4. *Transparency & Accountability*: Standardise fees, commission disclosures, and grievance mechanisms. Survey: 47% perceive complaint handling as slow; Hong Kong examples show transparency builds trust.
5. *Promote an Ethical Culture*: Implement ethics campaigns, training programs, and recognition schemes. Evidence suggests that organisations with strong ethical cultures report higher rates of ethical decision-making.
6. *Engage Stakeholders*: Include consumers, industry bodies, and government in reforms. Comparative insights from Indonesia suggest that stakeholder involvement improves compliance in emerging markets.
7. *Monitor International Best Practices*: Benchmark and adapt successful global practices from Singapore, Hong Kong, and Melbourne to strengthen professionalism and consumer confidence.

Survey findings and comparative lessons from Singapore, Hong Kong, Australia, and Indonesia highlight key recommendations for Malaysia's estate agency sector. To enhance the industry, it is essential to strengthen regulations and oversight, mandate continuing education and structured accreditation, and ensure transparency in the areas of fees, commissions, and complaint resolution. Additionally, fostering an ethical culture and actively engaging stakeholders in reform initiatives are crucial. It is advisable to benchmark against international best practices to improve professionalism, ethical conduct, consumer trust, and the overall credibility of the industry.

CONCLUSION

This study demonstrates that ethical performance is central to achieving sustainable estate agency practices in Malaysia. An analysis of regulatory structures, professional bodies, legislative provisions, technological advancements, and stakeholder expectations reveals both strengths and critical

gaps. While Malaysia's framework aligns in part with international standards, deficiencies persist in qualifications, education, enforcement, transparency, and stakeholder engagement.

To improve industry credibility and consumer trust, it is crucial to address these gaps through targeted reforms. This can be achieved by strengthening regulatory oversight, enhancing professional development, fostering a culture of accountability, and promoting transparency. Taking immediate action is essential to mitigate ethical lapses and align Malaysian practices with global standards. By embracing these measures, the estate agency sector can evolve into a more professional, trustworthy, and sustainable industry that meets the expectations of practitioners, consumers, and society as a whole.

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THE HOUSING AMENITIES PREFERENCES BY GENERATIONS IN MALAYSIA

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Abstract

Housing preferences differ between age groups or populations (i.e. the generations). Housing amenities preferences are one of the essential factors influencing housing decisions. Therefore, this study aims to provide an in-depth examination of housing amenities preferences among generations in Shah Alam, Selangor. The objectives of this study are (i) to categorise the generations, (ii) to determine the housing amenities preferences, and (iii) to analyse housing amenities preferences among generations in Shah Alam. This study focused on the housing amenities preferences of four (4) generations: Baby Boomers, Generation X, Generation Y, and Generation Z. This study adopts a mixed-method research strategy combining qualitative (interviews) and quantitative (questionnaire survey) methods. The main housing amenities preferences derived from the study are (1) accessibility, (2) proximity, (3) safety, and (4) others (parks, green spaces, car parks, playgrounds, places of worship, sports centres, and restaurants). Accessibility appeared as the strongest overall preference, with Baby Boomers, Gen X, and Gen Y prioritising access to town, work, and public transport, while Gen Z placed higher importance on access to universities. Understanding the generational housing preferences is crucial in narrowing the Malaysian real estate market mismatch gap. The main findings are significant in providing information to the public (local authorities) and private (developers) sectors for better housing provisions that enhance long-term liveability and quality of life in Malaysia.

Keywords: Housing amenities preferences, Baby Boomers, Generation X, Generation Y and Generation Z.

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INTRODUCTION

According to Ansell (2019), housing plays a significant role in shaping contemporary political preferences as a direct measure of individuals' wealth and welfare and as a proxy for the relative fortunes of different places. Buying a housing property can reflect the most significant milestone in an individual's life. Some individuals may purchase housing properties only for investment purposes, while others aim to upgrade their lifestyles (Hassan et al., 2021). The housing decisions are made based on different needs and preferences. Housing preferences conceptualise expressing a desire or 'want' for a particular form of housing (Preece et al., 2019). Housing or residential preferences are a complex and sometimes inconsistent set of factors that are related to, among other things, the house itself (tenure, price, size, etc.), its place (and all the social and symbolic construction of that place) and how it provides access to amenities such as schools, but also how it facilitates social interaction with friends and family (Booi & Boterman., 2020).

The influence of socio-demographic characteristics on housing preference is prone to change and differs for each individual in the population (the generations). Housing preferences can change with age, as with the advancement in age, more convenient and supportive housing is preferred or necessary (Anderson et al., 2019). Among the socio-demographic variables, age defines the target population as a proxy for many components (Kim, 2020). The age of the household remains an essential determinant of housing preferences (Bloch et al., 2023). The population's age cohort also refers to the terminology of the generations. Substantially, generations are influenced by their generational characteristics, beliefs, experiences, lifestyles, ideals, and demographic backgrounds (Ismail et al., 2023). A lack of knowledge about what the science of generations tells us leads to misunderstandings of the evidence about generations, their existence, and their purported impact (Rudolph et al., 2021).

There are a few previous studies in Malaysia that have studied housing preferences within specific population segments. For instance, Ismail et al. (2025) investigated elderly-friendly neighbourhood features across generations, but their scope was limited to ageing-related contexts. In addition, Ismail et al. (2021) examined housing preferences among Malaysian youths, providing insights into affordability and lifestyle factors, yet without comparative analysis across multiple generations.

Therefore, understanding each generational housing preference has become increasingly important due to the changing demographic profiles and evolving market expectations. Housing developers, urban planners, and policymakers rely on these insights in designing housing developments, reducing housing mismatch, and ensuring long-term neighbourhood liveability. Therefore, this study aims to provide in-depth housing amenities preferences among

generations, using Shah Alam, Selangor, as a case study. The objectives of this study are (i) to categorise the generations, (ii) to determine the housing amenities preferences, and (iii) to analyse housing amenities preferences among generations in Shah Alam.

The Generations

Generations are different types of populations distinguished based on their age group or birth year. The elderly (senior) generation, also known as the Baby Boomers generation, is a population of 60 years and above. The year born of this generation is the Baby Boomers - born between 1946 and 1961; Generation X (Gen-X) - born between 1962 and 1976; Generation Y (Gen-Y) - born between 1977 and 1999; and Generation Z (Gen-Z) - born after 1992 (Ismail et al., 2019). These generation groups shared values and preferences influenced by external factors present when they were growing up.

The Housing Amenities Preferences

House price is a summary measure of the desirability of a location based on a bundle of nearby amenities (Herath, 2021). The price of land and house or residential property is higher if the residential property is in a strategic location or area near local amenities such as shopping centres, schools, and public transport. Most homebuyers will choose their house near some amenities (Thanaraju et al., 2019).

Accessibility to amenities is a crucial preference for house purchasers or house occupants. Mulyano et al. (2020) state that one vital factor in housing placement is accessibility, the ease with which a person may reach and depart a particular region utilising a transportation system and land-use pattern. The main highway, toll road, and homebuyers 'accessibility to a station or public transport are the factors that affect their decision. Urban development aims to integrate housing and transit as driving a private car in a city is getting harder.

Proximity to amenities is a key element in the transition to more urbanised environments is related to the extent to which urban amenities have a role in residents' perceptions of quality of life (Mbazor et al., 2024). The term' ease of accessibility' refers to the availability of several entry and exit points for the real estate property. Accessibility will enable users to reach their destination more quickly and go through their journey in less time. Due to the availability of public transit and other forms of transportation, jobs, schools, markets, and other community centres must be close by. Customers should also consider how accessible the property is since travelling to different locations from their homes is essential.

Safety to amenities preferences is also one of the significant aspects of housing amenities preferences. Safety and aesthetics are important to consider

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within the context of access to services and amenities (McCormack et al., 2020). The safety of a neighbourhood is also considered as another aspect during the selection of a property (Thanaraju et al., 2019). For those who live in residential areas, safety is paramount. According to de Graaff (2021), safety and security influence property prices. Thus, a high degree of security will encourage confident home purchases. This confidence is because they will live safely without worrying about issues like crime or anything else. In relevance, people who consider "health" or "natural environment" to be important in their lives were shown to have a relative preference for living in places that were safer from natural disasters. Thus, educating people to take more interest in their health and the surrounding natural environment could be effective as a means to increase the number of people preferring to live in safer places (Takabatake & Hasegawa, 2022). Safer amenities are vital in ensuring that the residents enjoy the amenities of the housing neighbourhood.

In addition, there are also other amenities preferences according to each individual's needs for the neighbourhood, which are also a dream or desire for property buyers to live in the area. Previous studies in Malaysia indicate that the housing environments that incorporate adequate neighbourhood amenities contribute significantly to residents' comfort, convenience, and satisfaction with their living environment (Figure 1) (Ismail et al., 2020). They can use the provided facilities without obstacles, such as playgrounds, car parking sites, etc. Open space creates amenities that enhance the appeal of neighbouring regions, altering the spatial pattern of demand for development (Tajibaeva et al., 2008). Buyers' present and future needs and preferences are fundamental in purchase evaluation and psychological cost-benefit analysis. Therefore, the priority and significance of green space for individuals and positioning among those needs will play a role in the output of customer evaluation (Zalejska-Jonsson et al., 2020).

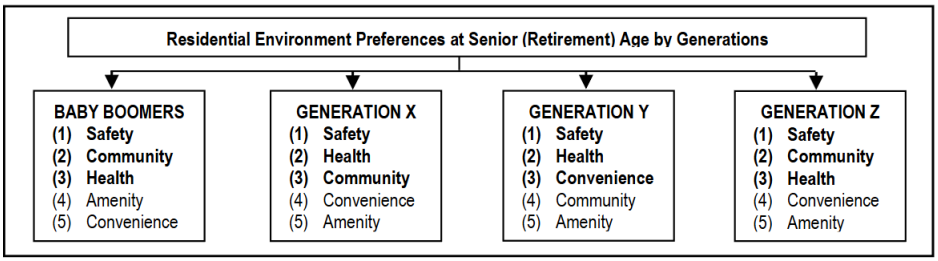


Figure 11: The Residential Environment Preferences at Senior Age (Retirement) Age by Generations
Source: Ismail et al. (2020)

By promoting immigration to (or emigration from) the metropolitan region, open space designation may cause changes in overall demand and demand in different locations within a particular metro area. There is a need to realise that the standard of public spaces and other amenities affects the quality of living in the city (Błoch et al., 2023). For this study, Figure 2 shows the Housing Amenities Preferences that were derived from the literature review.

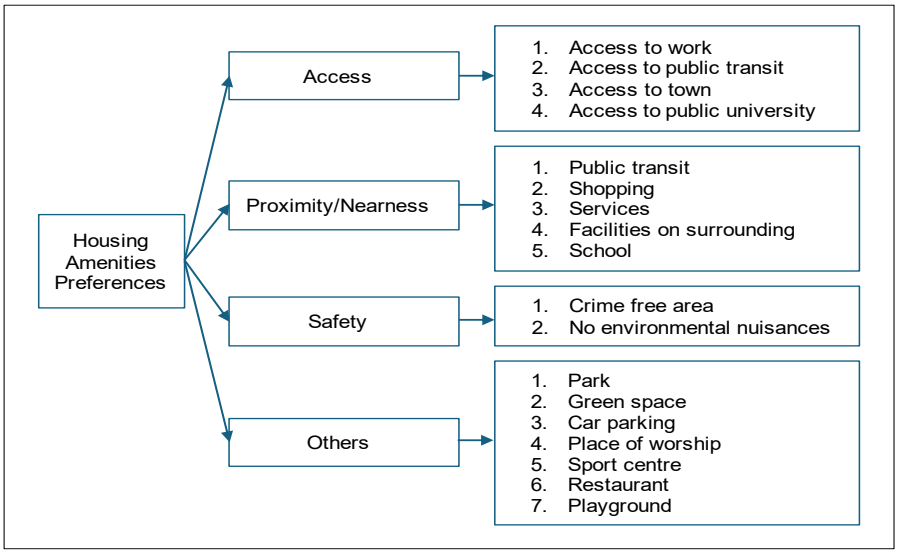


Figure 2: Housing Amenities Preference
Source: The Authors (2024)

RESEARCH METHODOLOGY

Shah Alam has been chosen as the case study due to its status as one of the City Councils in Selangor. The status of the City Council is due to its large population, which also consists of a large multi/intergenerational population. This study utilises a mixed-method research strategy. Combining both data in a convergent design will allow a researcher to understand the one provided by the quantitative or qualitative results (Dawadi et al., 2021). Employing mixed methods in each study gives a more profound knowledge of research challenges than alone (Ismail et al., 2020). Thus, research that adopts both qualitative and quantitative data collection will produce substantial results.

For qualitative data, two experts from the industry (i.e. Registered Valuer and Real Estate Negotiator) were interviewed (12th May 2024 and 17th May 2024) by using a purposive sampling strategy. Participants were selected based on their professional expertise and experience in property valuation and real estate practice (inclusion criteria). Individuals without professional and

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insufficient industry experience, or roles unrelated to property and housing, were excluded from selection (exclusion criteria). The collected qualitative data were analysed using thematic analysis. This interview was essential in validating the preference derived from the literature reviews (Figure 1).

As for the quantitative data, 122 samples/responses were collected from the distributed Google Forms (16th May 2024 to 16th June 2024) by using the convenience sampling strategy. Subsequently, the collected data were analysed using descriptive statistics to rank overall housing amenities preferences and ANOVA to examine differences across generations in the Statistical Package for Social Science (SPSS) software. In this paper, only the quantitative data findings will be presented and discussed.

FINDINGS AND DISCUSSION

This study's main findings focus on the structured arrangement of questionnaire sections: Section A gathers demographic profiles, Section B compiles current housing details, and Section C explores housing amenities preferences across generations.

Demographics Profile

Table 1 shows the demographic profiles of the respondents. The majority of the respondents were Gen-Y (32%), followed by Gen-Z (26.2%) and Gen-X (23.8%). The lowest responses come from the Baby Boomers (18%). This distribution reflects the dominance of younger age cohorts commonly found in the case study. Most respondents were male (54.1%), followed by females (45.9%). In terms of ethnicity, most of the respondents were Malays (68%), followed by Chinese (21.3%), Indian (9.8%) and Others (0.8%). The majority of the respondents were married (64.8%), followed by single (32.8%) and Others (2.5%). Most of the respondents are government sector employees (32%), followed by non-working (students) (23.8%) and private sector employees (19.7%). These demographic trends show that housing demand in Shah Alam is primarily driven by younger households, civil servants, and students.

Table 1: Demographic Profiles of the Respondents

Demographic Categories	Details	No. of Respondents	Percentage (%)	Total (%)
Generations	Baby Boomers (born between 1943-1960)	22	18.0	122 (100%)
	Gen-X (born between 1961-1980)	29	23.8	
	Gen-Y (born between 1981-1996)	39	32.0	
	Gen-Z (born from 1997 onwards)	32	26.2	
Gender	Male	66	54.1	122 (100%)
	Female	56	45.9	

Demographic Categories	Details	No. of Respondents	Percentage (%)	Total (%)
Ethnicity	Malays	83	68.0	122 (100%)
	Chinese	26	21.3	
	Indian	12	9.8	
	Others	1	0.8	
Marital Status	Single	40	32.8	122 (100%)
	Married	79	64.8	
	Others	3	2.5	
Occupation	Employer	2	1.6	122 (100%)
	Government sector employee	39	32.0	
	Private sector employee	24	19.7	
	Self-employed	17	13.9	
	Retiree	11	9.0	
	Non-working (Students)	29	23.8	

Current Housing Details

Table 2 below shows the findings on the current housing details. The majority of the respondents were house owners (owner-occupied) (38.5%), followed by family housing (35.2%), and the least were house renters (26.2%). Most of the respondents come from the M40 group (42.6%), and the B40 (41.8%), whilst the least are the T20 (15.6%). Most respondents had 4-6 people per household (55.7%). Next were 1-3 persons per household (32.8%), and the least were seven (7) or more persons per household (11.5%).

Table 2: Current Housing Details

Current Housing Details		No. of Respondents	Percentages (%)	Total (%)
Housing Ownership Status	Owner	47	38.5	122 (100%)
	Rental	32	26.2	
	Family housing	43	35.2	
Household Income	B40	51	41.8	122 (100%)
	M40	52	42.6	
	T20	19	15.6	
Household Number	1-3	40	32.8	122 (100%)
	4-6	68	55.7	
	7 and above	14	11.5	
Types of Households	Single	23	18.9	122 (100%)
	Couple without children	10	8.2	
	Couple with children	64	52.5	
	Single parents with children	3	2.5	
	Extended family	22	18.0	
Types of Housing	Landed	71	58.2	122 (100%)
	Strata	51	41.8	

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The Housing Amenities Preferences by Generations in Malaysia

Table 3 below displays the overall ranking of the amenities housing preferences based on the 122 responses. Most respondents choose accessibility to the amenities (Rank 1) as the most significant preference. Accessibilities here include access to work, public transit, town, and public universities. This preference is an essential indicator of overall preferences, and many respondents may be committed to their careers and lifestyles. Accessibility significantly plays a role in residential location decisions, as households often prioritise locations that provide convenient access to jobs, education, and other essential services to improve quality of life (Raza et al., 2022). Therefore, accessibility will make it easier for everyone to reach the facility easily without any obstacles.

Table 3: Overall Ranking of Housing Amenities Preference

Preference/ Ranking	Frequency	Percentage (%)	Mean Score	Overall Ranking
Accessibility to the amenities	93	76.23	1.2869	1
Proximity/Nearness to the amenities	45	36.89	1.4508	2
Safety of the amenities	34	27.87	1.8770	4
Other amenities preferences (i.e. mosque, park, lake, restaurant, sports centre, car park)	35	28.69	2.6475	3

Apart from accessibility, proximity/nearness to amenities is the second most crucial factor the respondents chose, affecting their housing selection. Proximity or nearness to the amenities (Rank 2) becomes the second most important factor in the preferences for housing amenities. Distance to the main public amenities such as schools, public transit, services, shopping, and facilities in the surrounding area, and others, are some of the critical factors to consider due to urban traffic issues. Proximity to public amenities significantly influences residential location decisions by reducing travel time and improving daily convenience (Rajabi et al., 2024)**.** Thus, this factor of preferences resulted in high priority for housing purchasers and consumers of all ages or generations. The third significant preference (Rank 3) is other amenities preference (i.e. parks, green spaces, lakes, car parks, worship areas, and restaurants). Public halls, playgrounds and recreational facilities facilitate social interaction among residents, fostering community and neighbourhood spirit. The presence of local amenities such as grocery stores, schools and restaurants within walking distance can increase the walkability of neighbourhoods, reduce traffic-related pollution and increase community participation. Research has shown that walkability and proximity to amenities are interlinked with higher levels of social activities and participation, highlighting the role in strengthening social interaction and community engagement (Bollenbach et al., 2023). Therefore, it becomes one of

the essential lists in the selection of each generation to choose amenities for their own home.

The fourth ranking (Rank 4) of the housing amenities' preferences is safety, are regarded as essential and significantly impacts the choice of housing. The security preference is necessary due to having confidence in terms of safety when using the amenities in the housing neighbourhood, which includes being away from disturbances that can cause environmental instability. Safety of the residential area is a major factor considered when making housing decisions, underscoring that perceived neighbourhood safety strongly influences housing choice preferences (Ismail & Shaari, 2020). These preferences are vital not only for themselves as housing consumers but, most importantly, for their family members' safety.

ANOVA analysis was conducted to determine whether there were significant differences between the generations in terms of these housing amenities preference. Table 4 shows the findings reveals a similar perception of the respondents across these four (4) housing amenities preferences (accessibility, proximity, safety and others). Ratings are consistent across age groups. This indicates that the generational factor may not be a primary determinant of differences in perceived housing environment preferences among the sample.

Table 4: ANOVA analysis of Housing Amenities Preference Across Generations

Preferences		**Sum of Square**	**df**	**Mean Square**	**F**	**Sig (p value)**
Accessibility to the amenities	Between groups	1.687	3	.562	.650	.585
	Within groups	102.096	118	.865		
	Total	103.783	121			
Proximity/Nearness to the amenities	Between groups	1.396	3	.465	.552	.648
	Within groups	99.530	118	.843		
	Total	100.926	121			
Safety of the amenities	Between groups	1.327	3	.442	.401	.753
	Within groups	130.214	118	1.104		
	Total	131.541	121			
Other amenities preferences (i.e. mosque, park, lake, restaurant, sports centre, car park)	Between groups	3.163	3	1.054	1.295	.279
	Within groups	96.074	118	.814		
	Total	99.237	121			

In addition, Table 5 details the preferences for housing amenities by generation. Housing preferences include accessibility to amenities, proximity to amenities, safety of amenities, and other amenities.

As for accessibility to amenities, the Baby Boomers and Gen-X have similar preferences, such as access to town (Rank 1), access to work (Rank 2),

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access to public transport (Rank 3) and access to university (Rank 4). This perceived importance of preferences is also the same for Gen-Y, and the only difference is that Gen-Y perceived access to work as first importance (Rank 1) and access to town as second importance (Rank 2). Similar to Baby Boomers and Gen-X, Gen-Z also perceived access to town as the first importance (Rank 1), access to public transport as the third importance (Rank 3) and access to work as the fourth importance (Rank 4). Gen-Z regard access to the university as their second (Rank 2) most important preference for access to amenities. The findings on the accessibility to amenities preferences show that the older generation, as the retirees (Baby Boomers) and working generations (Gen-X and Gen-Y), are still active and signify signs of preference to age-in-place with requirements of easy access to town, work and public transport. Access to amenities is vital for these generations' convenience and, most importantly, remaining active. As for Gen-Z, as the youngest generation, the preference for access to university is relevant to enable them to enjoy their educational life and journey. The accessibility of amenities preferences is crucial for the quality of life of the younger generations.

Table 5: Housing Amenities Preference Across Generations

Preferences	Baby Boomers			Gen-X			Gen-Y			Gen-Z		
	Mean	Std. Deviation	Rank	Mean	Std. Deviation	Rank	Mean	Std. Deviation	Rank	Mean	Std. Deviation	Rank
Accessibility to amenities												
Access to work	4.22	1.15	**2**	4.39	1.17	**2**	4.21	1.25	**1**	4.13	1.00	**4**
Access to public transport	4.00	1.02	**3**	4.27	1.09	**3**	4.08	1.36	**3**	4.26	0.78	**3**
Access to town	4.40	0.50	**1**	4.42	1.06	**1**	4.18	1.22	**2**	4.40	0.67	**1**
Access to university	3.40	0.95	**4**	3.81	1.07	**4**	3.86	1.43	**4**	4.33	0.71	**2**
Proximity/Nearness to amenities												
Public transit	4.00	0.97	**3**	4.30	1.10	**2**	4.27	1.28	**1**	4.40	0.81	**3**
Shopping	4.00	0.81	**4**	4.42	1.03	**1**	4.00	1.35	**4**	4.36	0.76	**4**
Services	4.63	0.49	**1**	3.81	0.98	**5**	4.13	1.39	**3**	4.50	0.68	**2**
Facilities	4.27	0.70	**2**	4.20	1.04	**3**	4.16	1.25	**2**	4.60	0.56	**1**
School	3.72	0.93	**5**	4.12	1.08	**4**	3.97	1.40	**5**	3.96	1.06	**5**
Safety of the amenities												
Crime-free area	4.77	0.42	**1**	4.48	1.00	**1**	4.13	1.39	**1**	4.40	0.81	**1**
No environmental nuisances	4.45	0.85	**2**	4.42	1.00	**2**	4.08	1.40	**2**	4.36	0.80	**2**
Other preferences of amenities												
Recreational Park	3.77	0.81	**3**	4.00	1.00	**3**	3.81	1.32	**6**	3.96	0.85	**5**
Green space	3.45	1.14	**4**	3.84	1.22	**5**	3.91	1.32	**4**	3.8	0.84	**6**
Car park	3.95	0.95	**2**	4.30	1.01	**2**	4.10	1.26	**2**	4.0	0.87	**4**
Playground	3.31	0.94	**5**	3.75	1.06	**6**	3.78	1.29	**7**	3.7	0.87	**7**

Preferences	Baby Boomers			Gen-X			Gen-Y			Gen-Z		
	Mean	Std. Deviation	Rank	Mean	Std. Deviation	Rank	Mean	Std. Deviation	Rank	Mean	Std. Deviation	Rank
Worship	4.86	0.46	**1**	4.57	1.06	**1**	4.37	1.27	**1**	4.16	0.91	**2**
Sport center	3.04	1.21	**7**	3.63	1.11	**7**	3.89	1.19	**5**	4.13	0.93	**3**
Restaurant	3.28	0.64	**6**	3.90	1.10	**4**	3.97	1.34	**3**	4.23	0.72	**1**

Next, generational preferences are quite divergent for proximity/nearness to amenities. The three (3) essential preferences of proximity/nearness to amenities for the Baby Boomers are services (Rank 1), facilities (Rank 2), and public transit (Rank 3). As for Gen-X, shopping (Rank 1), public transit (Rank 2) and facilities (Rank 3). Next, for Gen-Y, public transit (Rank 1), facilities (Rank 2) and Services (Rank 3). Finally, for Gen-Z, facilities (Rank 1), services (Rank 2), and public transit (Rank 3). This dissimilarity of preference for proximity/nearness to amenities shows that the divergence of willingness to commute to the amenities differs between generations. This sign is crucial to the local authorities and housing developers in planning to place the amenities that can be tailored based on the density of different age groups (generations) in each housing location.

For safety in the amenities, the findings show similar preferences across generations (Baby Boomers, Gen-X, Y and Gen-Z), which ranked preference for crime-free (Rank 1) and no nuisance (Rank 2). This preference shows that safety from crime in the amenities areas is crucial for housing amenities.

Baby Boomers, Gen-X and Gen-Y show similarities in preferences for other amenities preferences, worship (Rank 1) and car park (Rank 2). This preference for worship amenities indicates the importance of the availability of worship places/centres, which can also be places for inter-generational gatherings and social interactions with each other. Enough parking spaces are also vital in each housing neighbourhood for the convenience of the housing community.

CONCLUSION

The role of urban amenities in assessing urban residents' quality of life is growing (Błoch et al., 2023). Each generation is unique as they come with different needs and preferences. Different generations are given with their own needs and preferences, including their housing decision-making (Ismail et al., 2024). Studies on generational differences and housing are vital in understanding generational housing decision-making. Determining the housing preferences of other generations is crucial in narrowing the gap in the real estate market mismatch. Besides the housing preferences, identifications of the housing amenities preferences by generations will assist the local authorities and housing

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developers in implementing better housing provisions and a better quality of life in the housing neighbourhood.

This study reveals four (4) main housing amenities preferences by generations, such as (1) accessibility, (2) proximity, (3) safety, and (4) others (parks, green spaces, car parks, playgrounds, places of worship, sports centres, and restaurants). Although the analysis focuses specifically on housing amenities preferences, the generational patterns hold wider implications for long-term urban development and sustainable city planning in Malaysia. Understanding generational differences in housing environment can help urban planners, developers, and local authorities in future market behaviour and housing design that remain resilient and adaptable over time.

Future studies on generational differences and housing preferences can be expanded by integrating other features, such as the factors of ageing-in-place (AIP), active and healthy ageing, and Quality of Life (QoL), to derive a comprehensive framework of multi/inter-generational housing environments to support sustainable cities.

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UNDERSTANDING THE ATTRACTIVENESS OF TRANSIT-ORIENTED SHOPPING CENTRE

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Abstract

The integration of shopping centres with rapid transit stations is a growing trend in urban development. This study examines how proximity to rapid transit affects shopping centre attractiveness in Klang Valley, Malaysia. A mixed-methods approach was adopted. Firstly, spatial analysis was conducted using Quantum Geographic Information System (QGIS) to measure distances between rapid transit stations and nearby shopping centres. The analysis identified 54 shopping centres within walking distance of rapid transit stations, with a maximum distance of 636 metres. Secondly, customer satisfaction and preferences were assessed through a structured questionnaire survey, yielding 258 valid responses. Findings indicate that proximity to rapid transit enhances customer satisfaction and influences shopping centre choice. Younger respondents (18–29 years) valued rapid transit mainly for avoiding traffic congestion and parking difficulties, while female respondents placed greater emphasis on transit availability when selecting shopping centres. Cost savings were important across all demographic groups, although carrying purchases remained a key limitation. This study contributes to the literature by offering new insights into how rapid transit proximity shapes shopping centre attractiveness in Malaysian urban context. The findings provide valuable insights for property valuers, shopping centre managers, and leasing professionals, indicating that shopping centres located closer to rapid transit stations benefit from enhanced customer perceptions and overall attractiveness.

Keywords: Real Estate, Shopping Centre Attractiveness, Rapid Transit System, Spatial Analysis

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INTRODUCTION

A growing trend in urban planning is the integration of shopping centres with rapid transit stations, where passengers can exit directly into shopping centres. This design improves convenience, enhances walkability, and contributes to more vibrant urban environments (Rao & Pafka, 2021). Transit proximity also increases foot traffic and strengthens shopping centre attractiveness, particularly in densely populated areas where public transport is widely used (Abutaleb et al., 2020; Dzulhijwandari et al., 2021).

Although these benefits are well documented globally, limited research has examined how transit proximity shapes customer perceptions of shopping centre attractiveness in Malaysia. Rapid transit systems in Malaysian urban regions, particularly the Klang Valley, have expanded significantly in recent years. However, empirical evidence on how these developments influence consumer behaviour and retail performance remains scarce (Blanco & Wikstrom, 2018). This gap is important because transit-oriented accessibility has substantial implications for urban planning, retail management, and property valuation in Malaysia.

This study addresses this gap by examining the relationship between transit proximity and shopping centre attractiveness. The research objectives are: (i) to identify shopping centres located near transit stations, and (ii) to assess customer satisfaction and preferences related to transit accessibility. Spatial analysis is used to calculate distances between shopping centres and transit stations, providing insights into how accessibility influences customer perceptions.

The findings are expected to offer valuable insights for property valuers, shopping centre managers, and leasing professionals. By understanding how proximity to transit stations affects customer perceptions, they can make more informed decisions about property valuation and leasing strategies.

LITERATURE REVIEW

Transit-Oriented Development (TOD)

A growing body of research positions Transit-Oriented Development (TOD) as an urban development strategy that integrates mixed land uses with rapid transit systems and pedestrian-friendly networks (Dzulhijwandari et al., 2021). Malaysia reflects this direction through the expansion of MRT, LRT, and BRT systems (Kwan et al., 2017; PLANMalaysia, 2018). TOD is intended to enhance accessibility, reduce car dependency, and support more sustainable mobility (Abutaleb et al., 2020).

Empirical studies commonly assess TOD environments using walkable distances of 400–800 metres. A previous study by Ramlan et al. (2021) evaluated TOD performance of stations within a radius of 400–800 metres. This distance

aligns with the recommendations of PLANMalaysia (2018), as it represents comfortable walking distances of 5 to 10 minutes. Similar thresholds appear in TOD definitions of mixed-use communities located within 600–800 metres of transit stations (Sohoni et al., 2017). Studies on Transit-Oriented Shopping Mall Developments (TOSMDs) also identify transit-integrated shopping centres within an 800-metre walkable radius (Abutaleb et al., 2020), while Khaderi et al. (2021) highlight pedestrian accessibility within 400–800 metres as shaping activity patterns around transit-oriented retail spaces.

Overall, these studies establish that walkability and transit catchment areas significantly influence how people move within transit environments. However, they provide limited insights into how such proximity influences consumer behaviour towards shopping centres, which is the gap that this study seeks to address.

Shopping Centre Attractiveness

Shopping centre attractiveness is shaped by a range of features that influence consumers' visitation decisions. Key factors commonly identified in the literature include location, tenant mix, amenities, and the overall shopping environment (Mohd Sapie et al., 2014). Environmental qualities such as accessibility, comfort, and design elements further shape users' perceptions and overall shopping experience. Shopping centres located near or integrated with public transport nodes generally attract higher footfall due to enhanced accessibility (Khalaf et al., 2022).

Despite recognising the importance of accessibility, most studies emphasise the presence of transport connections rather than examining how transit-linked proximity influences consumer behaviour. Past research also highlights uneven access to transit-linked shopping centres and limited understanding of how different user groups perceive and experience this accessibility (Abutaleb et al., 2020). Furthermore, while the link between transit infrastructure and retail activity is acknowledged, the specific factors shaping consumer behaviour around rail-linked shopping centres remain underexplored (Li et al., 2025).

Overall, these studies establish that the general determinants of shopping centre attractiveness are well recognised. However, they offer limited insights into how transit-based accessibility shapes consumer perceptions and behaviour towards shopping centres, which is the gap that this study seeks to address.

RESEARCH METHODOLOGY

This study employs a mixed-methods approach, combining spatial analysis and a questionnaire survey to examine the relationship between transit stations and

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shopping centres in Klang Valley. The region was chosen due to its rapid urbanisation and the highest concentration of shopping centres in Malaysia, with 169 shopping centres identified by NAPIC (2024). For the first research objective, data on transit stations were collected from route maps on the MyRapid website, while nearby shopping centres were identified using Google Maps. The coordinates of both transit stations and shopping centres were extracted using Geocode by Awesome Table and analysed using Quantum Geographic Information System (QGIS) to measure distances between them, with 800 metres (approximately a 10-minute walking distance) used as the benchmark in line with previous studies (Ramlan et al., 2021; Khaderi et al., 2021; Abutaleb et al., 2020; Sohoni et al., 2017).

For the second research objective, a questionnaire survey was conducted to collect data on customer satisfaction and preferences regarding transit accessibility to shopping centres. The survey was distributed online through social media and targeted outreach to UiTM students via institutional email. Although convenience sampling was applied, efforts were made to increase demographic diversity by reaching different faculties, age groups, and non-student networks. Responses were recorded via Google Forms and analysed using the Statistical Package for Social Sciences (SPSS) to identify patterns in consumer perceptions on the accessibility of transit stations and shopping centre attractiveness.

ANALYSIS AND DISCUSSION

Spatial Analysis

In relation to the first research objective, Table 1 summarises shopping centres in Klang Valley that are accessible via rapid transit, identified through spatial analysis using QGIS. The table presents the corresponding shopping centre names, transit lines, and transit stations. In total, 54 shopping centres were found to be accessible within a walkable distance of up to 636 metres, which is approximately a 10-minute walk.

Table 1: Identified shopping centres accessible via rapid transit in Klang Valley

Shopping centre	Transit line	Transit station
Pavilion KL Lot 10 Farenheit88 Starhill Plaza Low Yat Sungei Wang Plaza	MRT Kajang Monorail KL	Bukit Bintang
The Exchange TRX	MRT Kajang	Tun Razak Exchange (TRX)
Pavilion Damansara Heights DC Mall	MRT Kajang	Pusat Bandar Damansara
1 Utama	MRT Kajang	Bandar Utama

Shopping centre	Transit line	Transit station
MyTOWN IKEA Cheras	MRT Kajang	Cochrane
Sunway Velocity Mall	MRT Kajang	Cochrane
	LRT Ampang/Sri Petaling	Maluri
The Curve IPC Shopping Centre IKEA Damansara	MRT Kajang	Mutiara Damansara
Sunway Giza Mall Tropicana Gardens Mall	MRT Kajang	Surian
NU Sentral	MRT Kajang	Muzium Negara
	LRT Kelana Jaya Monorail KL	KL Sentral
Glo Damansara	MRT Kajang	Taman Tun Dr Ismail (TTDI)
EkoCheras Mall Cheras Leisure Mall	MRT Kajang	Taman Mutiara
Plaza Metro Kajang	MRT Kajang	Stadium Kajang
Suria KLCC Avenue K	LRT Kelana Jaya	KLCC
Mid Valley Megamall The Gardens KL Eco City	LRT Kelana Jaya	Abdullah Hukum
Berjaya Times Square	Monorail KL	Imbi
	LRT Ampang/Sri Petaling	Hang Tuah
Lalaport BBCC	Monorail KL LRT Ampang/Sri Petaling	Hang Tuah
Subang Parade Empire Shopping Gallery	LRT Kelana Jaya	Subang Jaya
KL Gateway Mall	LRT Kelana Jaya	Universiti
M3 Mall	LRT Kelana Jaya	Taman Melati
Main Place USJ	LRT Kelana Jaya	USJ21
The 19 USJ City Mall	LRT Kelana Jaya	Wawasan
Evolve Concept Mall	LRT Kelana Jaya	Ara Damansara
Amcorp Mall	LRT Kelana Jaya	Taman Jaya
Datum Jelatek	LRT Kelana Jaya	Jelatek
Wangsa Walk	LRT Kelana Jaya	Sri Rampai
Sunway Pyramid	BRT Sunway	Sunway Lagoon
IOI Mall Puchong	LRT Ampang/Sri Petaling	IOI Puchong Jaya
SS15 Courtyard	LRT Kelana Jaya	SS15
The LINC KL Intermark Mall	MRT Putrajaya LRT Kelana Jaya	Ampang Park
Sunway Putra	LRT Ampang/Sri Petaling	PWTC
Da Men Mall Summit USJ	LRT Kelana Jaya BRT Sunway	USJ7
SOGO KL	LRT Ampang/Sri Petaling	Bandaraya
Quill City Mall	Monorail KL	Medan Tuanku
Metro Mall	MRT Putrajaya LRT Ampang/Sri Petaling	Chan Sow Lin
Endah Parade	LRT Ampang/Sri Petaling	Bukit Jalil

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Shopping centre	Transit line	Transit station
SetiaWalk Mall	LRT Ampang/Sri Petaling	Pusat Bandar Puchong
Brem Mall	MRT Putrajaya	Sri Delima

Source: MyRapid Data, Google Maps Data and Author's Observation

Using QGIS for spatial analysis, the maximum walkable distance between shopping centres and transit stations in Klang Valley was approximately 636 metres (between Endah Parade and LRT Bukit Jalil), which falls within the generally accepted 800-metre or 10-minute walk range (Ramlan et al., 2021; Khaderi et al., 2021; Abutaleb et al., 2020; Sohoni et al., 2017). Figure 1 illustrates the straight-line distances between shopping centres and their nearest rapid transit stations in Klang Valley, calculated using the QGIS 'Hub Lines/Distances' function. This spatial analysis supports the first research objective by identifying shopping centres located within walkable proximity to transit stations, with distances ranging up to a maximum of 636 metres. Straight-line distance was adopted as a standardised measure to allow consistent comparison across all shopping centre–station pairs. While this method does not capture actual pedestrian routes, obstacles, or variations in walkability, it is widely applied in transit-oriented and retail accessibility studies as a practical indicator of spatial proximity. As such, the analysis provides a reliable basis for assessing the distribution and accessibility of transit-linked shopping centres.

	Shopping C	HubName	HubDist
1	Pavilion KL	MRT Bukit Bintang◆	249.895845393847651
2	Lot 10	Monorail Bukit Bintang◆	66.075593530010593
3	Farenheit88	MRT Bukit Bintang◆	112.061218630961179
4	Starhill	MRT Bukit Bintang◆	227.299771629403693
5	Plaza Low Yat	Monorail Imbi◆	162.541318592444838
6	Sungei Wang Plaza	Monorail Bukit Bintang◆	101.387427467651463
7	The Exchange TRX	MRT Tun Razak Exchange (TRX)◆	291.627557874139598
8	Pavilion Damansara Heights	MRT Pusat Bandar Damansara◆	407.130685667126954
9	DC Mall	MRT Pusat Bandar Damansara◆	283.103029645935067
10	1 Utama	MRT Bandar Utama◆	297.767007437837719
11	MyTOWN	MRT Cochrane◆	211.379669129632418
12	IKEA Cheras	MRT Cochrane◆	314.489882022234838
13	Sunway Velocity Mall	LRT Maluri◆	561.249063032707454
14	The Curve	MRT Mutiara Damansara◆	421.075387979959658
15	IPC Shopping Centre	MRT Mutiara Damansara◆	314.244964881250837
16	IKEA Damansara	MRT Mutiara Damansara◆	570.164789798572542
17	Sunway Giza Mall	MRT Surian◆	219.455192913601906
18	Tropicana Gardens Mall	MRT Surian◆	84.038859953885634
19	NU Sentral	LRT KL Sentral◆	151.086334044482783
20	Glo Damansara	MRT Taman Tun Dr Ismail (TTDI)◆	354.825856923190145
21	EkoCheras Mall	MRT Taman Mutiara◆	338.997990745228208
22	Cheras Leisure Mall	MRT Taman Mutiara◆	310.357732520637740
23	Plaza Metro Kajang	MRT Stadium Kajang◆	472.849307799481380
24	Suria KLCC	LRT KLCC◆	259.860358527313508
25	Avenue K	LRT KLCC◆	70.111764409869508
26	Mid Valley Megamall	LRT Abdullah Hukum◆	486.849378258171271
27	The Gardens	LRT Abdullah Hukum◆	312.591953944008310

	Shopping C	HubName	HubDist
28	KL Eco City	LRT Abdullah Hukum◆	123.678020290538498
29	Berjaya Times Square	Monorail Imbi◆	99.098735305865986
30	Lalaport BBCC	Monorail Imbi◆	229.807827562622521
31	Subang Parade	LRT Subang Jaya◆	442.422885514284417
32	Empire Shopping Gallery	LRT Subang Jaya◆	616.175427020965117
33	KL Gateway Mall	LRT Universiti◆	206.092582275643736
34	M3 Mall	LRT Taman Melati◆	433.773365011909846
35	Main Place USJ	LRT USJ21◆	380.246880446980072
36	The 19 USJ City Mall	LRT Wawasan◆	237.059893942954346
37	Evolve Concept Mall	LRT Ara Damansara◆	137.466311808662709
38	Amcorp Mall	LRT Taman Jaya◆	220.074693534032463
39	Datum Jelatek	LRT Jelatek◆	87.650369154406008
40	Wangsa Walk Mall	LRT Sri Rampai◆	520.712175231795527
41	Sunway Pyramid	BRT Sunway Lagoon◆	513.034336044852807
42	IOI Mall Puchong	LRT IOI Puchong Jaya◆	304.778678096390934
43	SS15 Courtyard	LRT SS15◆	182.398322240203044
44	The LINC KL	LRT Ampang Park◆	234.086521782327026
45	Intermark Mall	LRT Ampang Park◆	175.255515090546510
46	Sunway Putra	LRT PWTC◆	132.600504678181551
47	Da Men Mall	LRT USJ7◆	327.621144681193982
48	Summit USJ	LRT USJ7◆	592.598962981443719
49	SOGO KL	LRT Bandaraya◆	105.589653005596787
50	Quill City Mall	Monorail Medan Tuanku◆	141.4734846353601 65
51	Metro Mall	LRT Chan Sow Lin◆	197.759779946722489
52	Endah Parade	LRT Bukit Jalil◆	636.028704029448022
53	SetiaWalk Mall	LRT Pusat Bandar Puchong◆	276.123364872184482
54	Brem Mall	MRT Sri Delima◆	373.191389756769354

Figure 1: Straight-line distances between shopping centres and their nearest rapid transit stations in Klang Valley, derived from QGIS spatial analysis
Source: MyRapid Data (2024), Google Maps Data (2024) & QGIS Analysis (*2024)*

The analysis highlights strong connectivity between shopping centres and transit stations, particularly in Bukit Bintang (Pavilion KL, Fahrenheit88, Starhill) and Mutiara Damansara (The Curve, IPC Shopping Centre), where multiple shopping centres are located within close walking distance. This proximity enhances accessibility and the potential for higher foot traffic, contributing to a transit-oriented shopping environment. While the analysis is based solely on spatial data and does not capture pedestrian infrastructure or safety perceptions that may affect actual walking behaviour, findings suggest that Klang Valley has effectively developed a network of transit-oriented shopping centres, which may support sustainable urban mobility and contribute to a well-connected retail landscape.

Questionnaire Survey Analysis

For the second research objective, findings were obtained via data collection conducted through a questionnaire survey. The questionnaire survey is divided into two parts. Part A, titled "Respondent's Profile", gathers demographic information about the respondents. Part B, titled "Rapid Transit and Shopping Centre Attractiveness", delves deeper into the connection between rapid transit and shopping centre attractiveness, employing a 5-point Likert scale, respondents indicate their level of agreement with statements. Statements in Part B (a) evaluate customer satisfaction with aspects such as convenience, walking distance from transit stations to shopping centres, frequency of rapid transit, and comfort during the commute. Part B (b) examines how access to rapid transit influences shopping centre selection, addressing factors such as traffic avoidance, parking concerns, and cost savings. Finally, Part B (c) focuses on the sustainability aspects of using rapid transit to shopping centres.

Respondents

A total of 258 valid responses were obtained from respondents who completed the questionnaire. Analysis of respondent demographics revealed that 31.4% were male (N = 81), while the majority, 68.6%, were female (N = 177). The highest percentage of respondents fell within the 18–24 years category, comprising 49.2% (N = 127), followed by 25–29 years at 41.5% (N = 107). The remaining age groups, from 30 to above 50 years old, exhibited lower proportions. In terms of ethnicity, the majority identified as Malay, representing 82.9% (N = 214), followed by Chinese at 8.9% (N = 23), Indian at 5.8% (N = 15), and others at 2.3% (N = 6). Geographically, a significant portion of respondents, 63.6% (N = 164), resided in Klang Valley, while 36.4% (N = 94) resided outside Klang Valley. Moreover, an overwhelming majority, 89.9% (N = 232), responded having experienced using rapid transit, whereas only 10.1% (N = 26) indicated otherwise.

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Descriptive Analysis

This study applies descriptive analysis to examine the questionnaire survey responses. Descriptive statistics are used to summarise respondents' demographic characteristics, travel behaviour, and perceptions of rapid transit accessibility and shopping centre attractiveness. The findings are presented in terms of frequency, percentage, mean, and standard deviation to provide an overview of response patterns and variability. The mean indicates the average level of agreement or importance assigned to each variable, reflecting the central tendency of responses, while the standard deviation illustrates the degree of dispersion, with lower values suggesting greater consensus among respondents and higher values indicating more varied perceptions. Table 2 summarises the descriptive statistics for the 258 valid responses, forming the basis for analysing how rapid transit proximity influences customer satisfaction and shopping centre choice.

Table 2: Descriptive statistics of questionnaire survey responses on rapid transit satisfaction, shopping centre preference, and sustainability (N = 258)

Item / Scale	1		2		3		4		5		M	SD
	f	%	f	%	f	%	f	%	f	%		
Ba. Rapid Transit Satisfaction												
*1. Satisfied with the convenience of accessing shopping centres via rapid transit.	1	0.4	5	1.9	43	16.7	120	46.5	89	34.5	4.13	0.781
*2. Satisfied with the walking distance from the nearest transit station to shopping centres.	2	0.8	16	6.2	42	16.3	114	44.2	84	32.6	4.02	0.899
*3. Satisfied with the frequency of rapid transit availability.	3	1.2	11	4.3	48	18.6	110	42.6	86	33.3	4.03	0.893
*4. Satisfied with the comfort when commuting by rapid transit.	1	0.4	33	12.8	64	24.8	118	45.7	42	16.3	3.65	0.914
^5. Walking distance of 636 metres between shopping centre and transit station is manageable.	8	3.1	18	7.0	51	19.8	105	40.7	76	29.5	3.86	1.018

Item / Scale	1		2		3		4		5		M	SD
	f	%	f	%	f	%	f	%	f	%		
Bb. Shopping Centre Preference												
*1. Consider the availability of rapid transit when selecting a shopping centre to visit.	10	3.9	25	9.7	37	14.3	71	27.5	115	44.6	3.99	1.154
*2. Prefer using rapid transit to commute to shopping centres to avoid traffic congestion.	6	2.3	24	9.3	33	12.8	64	24.8	131	50.8	4.12	1.098
*3. Prefer using rapid transit to alleviate issues with finding parking at shopping centres.	8	3.1	20	7.8	25	9.7	77	29.8	128	49.6	4.15	1.079
*4. Save on costs by commuting via rapid transit to shopping centres compared to other transportation modes.	3	1.2	7	2.7	28	10.9	97	37.6	123	47.7	4.28	0.851
*5. Easy to transport shopping purchases back home using rapid transit.	30	11.6	92	35.7	64	24.8	52	20.2	20	7.8	2.77	1.133
Bc. Sustainability												
*1. Using rapid transit to commute to shopping centres is more environmentally friendly compared to other transportation modes.	0	0.0	7	2.7	19	7.4	99	38.4	133	51.6	4.39	0.741

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Item / Scale	1		2		3		4		5		M	SD
	f	%	f	%	f	%	f	%	f	%		
*2. Using rapid transit to commute to shopping centres reduces traffic congestion.	2	0.8	3	1.2	16	6.2	80	31.0	157	60.9	4.50	0.734
*3. Using rapid transit to commute to shopping centres improves air quality.	3	1.2	4	1.6	26	10.1	91	35.3	134	51.9	4.35	0.815
*4. Using rapid transit to commute to shopping centres reduces carbon footprint.	0	0.0	4	1.6	27	10.5	91	35.3	136	52.7	4.39	0.737
*5. Walking a reasonable distance from a transit station to a shopping centre reduces environmental impact.	2	0.8	5	1.9	34	13.2	95	36.8	122	47.3	4.28	0.823

Source: Questionnaire Survey Data and SPSS Analysis
**Scale values range from 1 ("strongly disagree") to 5 ("strongly agree")*
^Scale values range from 1 ("not manageable at all") to 5 ("very manageable")
M mean, SD standard deviation, f frequency

Respondents generally reported positive perceptions of rapid transit for accessing shopping centres. Convenience of access (mean = 4.13), walking distance from transit stations (mean = 4.02), and frequency of rapid transit availability (mean = 4.03) received relatively high scores, indicating general satisfaction. Comfort during commutes scored slightly lower (mean = 3.65), with greater variability (SD = 0.914), suggesting more diverse experiences. The majority of respondents (70.2%) considered the maximum walking distance of 636 metres manageable, consistent with prior studies that identify 400–800 metres as a walkable range for transit-oriented retail (Ramlan et al., 2021; Khaderi et al., 2021; Abutaleb et al., 2020; Sohoni et al., 2017). Key motivators for using rapid transit included avoiding traffic congestion, alleviating parking difficulties, and cost savings, whereas ease of carrying purchases was the least influential factor (mean = 2.77), consistent with other studies highlighting practical constraints as a limitation of transit use for shopping trips (Blanco &

Wikstrom, 2018). These findings reinforce that transit-based accessibility shapes consumer behaviour, but other practical factors may mediate its influence.

Cross-Tabulation Analysis

This study utilizes cross-tabulation analysis to explore the relationship between gender, age, and responses to Parts B (a) and (b) of the questionnaire, Part B (c) on 'Sustainability' are discarded due to consistent positive responses across all groups. Gender analysis includes both male and female respondents. Age analysis excludes the 45–49 age group due to a single respondent, aiming to prevent bias. Only the most prevalent age groups are examined to avoid bias from low response rates. This approach provides insights into demographic influences on rapid transit satisfaction and shopping centre preferences. Figure 2 illustrates the demographic variations in rapid transit satisfaction and shopping centre preferences across gender and age groups.

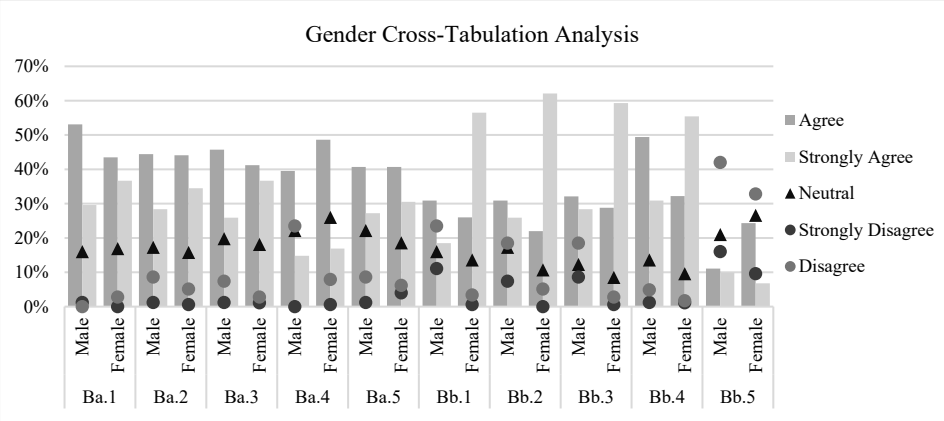


Figure 2: Cross-tabulation analysis of gender and age differences in rapid transit satisfaction and shopping centre preferences
Source: Questionnaire Survey Data (2024) & SPSS Analysis (2024)

Cross-tabulation analysis revealed demographic differences in satisfaction and transit preferences. Female respondents generally reported higher satisfaction with rapid transit frequency, comfort, and the influence of transit availability on shopping centre selection compared to males. Younger age groups (18–29 years) placed greater emphasis on convenience, frequency, and accessibility than older respondents, consistent with literature suggesting that younger, urban populations are more likely to use public transit (Rosni et al., 2025). Across all groups, cost savings were consistently valued, whereas transporting purchases remained a deterrent for transit use. These patterns align with prior research indicating that proximity and convenience are strong

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determinants of shopping centre choice, particularly in transit-accessible settings, while factors such as carrying capacity influence modality preference (Blanco & Wikstrom, 2018).

Collectively, the survey results provide empirical evidence for how transit accessibility affects consumer behaviour towards shopping centres, directly addressing the research gap identified in the literature review. Compared with previous studies, this research contributes new insights on Malaysian urban contexts, highlighting specific accessibility factors (walking distance, congestion avoidance, parking relief, and cost) that shape shopper decision-making in Klang Valley.

DISCUSSION

The findings of this study highlight the practical significance of transit accessibility in shaping shopping centre attractiveness. From an industry perspective, property developers and urban planners can appreciate that locating retail developments within walkable distances of rapid transit stations enhances customer inflow and satisfaction, particularly among younger and female demographics. This aligns with the operational insights often observed during market and feasibility studies, where proximity to transit is a key determinant in forecasting footfall and retail performance (Khalaf et al., 2022). For instance, when planning new shopping centres or retrofitting existing ones, understanding customer preferences for ease of access, avoidance of traffic congestion, and cost savings can guide site selection, tenant mix strategies, and connectivity improvements. Furthermore, this study underscores the need for planning policies that incentivise TOD in Malaysia, promoting integration between retail spaces and evolving rapid transit networks. These insights are particularly relevant in dense urban areas like Klang Valley, where enhancing pedestrian-friendly connections to MRT or LRT stations can support sustainable urban mobility while maximising commercial returns. Overall, this study provides guidance for industry practitioners, suggesting that investment decisions, property management strategies, and urban planning policies should systematically incorporate transit accessibility as a core criterion to optimise both customer experience and retail performance.

CONCLUSION

This study examined the influence of rapid transit integration on shopping centre attractiveness in Klang Valley, Malaysia. Spatial analysis identified 54 shopping centres within walking distance of transit stations, with the furthest at 636 metres. Complementing this, questionnaire survey findings showed that proximity to transit stations enhances customer satisfaction and shapes shopping centre preferences. Younger customers (18–29 years old) use rapid transit to avoid

traffic and parking difficulties, while female customers place stronger emphasis on transit availability when choosing which shopping centre to visit, and cost savings are valued across all demographics, although carrying purchases remains a key drawback.

Overall, this study demonstrates that transit accessibility plays a meaningful role in shaping customer perceptions of shopping centre attractiveness. The findings offer valuable guidance for property valuers, shopping centre managers, and leasing professionals, suggesting that closer proximity to rapid transit stations could improve customer perceptions, thereby enhancing shopping centre attractiveness and its perceived value. Beyond retail operations, these insights are relevant for urban planners and policymakers, as they highlight the importance of integrating commercial developments with transit networks to strengthen walkability, support sustainable mobility, and enhance urban competitiveness. As Malaysia's transit system continues to expand, coordinating retail development around transit stations will be increasingly important for shaping the city's layout and fostering vibrant commercial areas. Future research should explore valuation methods tailored to TOD to ensure more accurate market value assessments, reflecting the growing importance of transit integration in urban development.

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THE CO-LIVING CONCEPT IN MALAYSIA: ADOPTION BY DEVELOPERS AND USERS

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Abstract

The concept of co-living housing is a trendy housing concept that is making its way into the real estate business. However, this concept is considered a new housing concept in Malaysia, and limited studies have been conducted focusing on this concept. Therefore, the objectives of this study are to identify level of adoption among Malaysian property developers on co-living concepts in housing development as well as to study the benefits of applying the co-living concept to individuals working in urban areas particularly in Kuala Lumpur, Malaysia. This study employed a mixed-methods approach, utilizing both quantitative methods including online survey of co-living residents, and qualitative method which is an interview with Malaysian property developers. The data collected from the interviews were then analysed using narrative analysis, whereas the data obtained from the online survey method were then analysed using descriptive and cross-tabulation analysis. The results showed that majority property developers were familiar with co-living concepts, and they are motivated to implement this concept for future development. On the other hand, majority respondents or residents agreed that the co-living concept was the good initiative to provide affordable housing options through co-living concept implementations which are safe, comfortable, and accessible for those who live in the urban areas. Hence, implementing co-living concepts into new development is an environmental solution that addresses both the affordable housing crisis and environmental sustainability.

Keywords: Co-living, Community, Housing development, Sustainable

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INTRODUCTION

Malaysia's urban affordable housing issue has become a significant concern, with high- cost housing dominating the supply. As urbanization and populations grow, demand for affordable housing has increased (National Housing Department, 2018), leading to the introduction of various new trends of housing concepts as a solution to the housing shortages in urban areas which including co-living concept (Corfe & Salutin, 2019). Co-living is a new housing concept that is a modern housing arrangement in which individuals that share similar interests, aspirations, and values share a living space, almost like a family (Wycech, 2020; Mehl, 2021). The idea of this concept is not entirely new, but the millennial generation redefined the concept of co-living.

This concept has gained appeal in recent years as a solution to city life's issues, such as high living costs and social isolation (Shaharudin, 2022). To build a sense of community among residents, co-living places frequently include amenities such as housekeeping services, social activities, and co-working areas as well. Co-living concept nowadays has become a commercialized industry with private companies offering fully furnished apartments and shared facilities to young professionals and digital nomads. The concept of co-living continues to evolve and adapt to changing social and economic trends, with new models emerging that focus on sustainability, well-being, and intergenerational living (Vivarium, 2023).

However, Malaysians still have limited knowledge and understanding of co-living because this concept is new in Malaysia. Moreover, while relatively unheard of amongst Malaysians, it is a well and alive concept that is widely practiced abroad. In fact, the concept is gaining traction amongst the digital nomad/international community in Malaysia as an alternative lifestyle and it is only a matter of time before more Malaysians latch on to the trend too.

To apply a new concept to a place, particularly a country, the concept must be clearly conveyed so that the community understands the purpose and benefits of the concept. Furthermore, the community's acceptability of this new concept should be considered since community acceptability can have a significant impact on the implementation of a new concept. Therefore, this study focuses on the level of awareness among Malaysian property developers and co-living providers on co-living concepts in housing development and identifying the benefits of applying the co-living concept to individuals working in urban areas.

LITERATURE REVIEW

Co-living Concept

Co-living has recently become a trend in the real estate business, particularly among young professionals, digital nomads, students, and freelancers, however,

no specific conceptual definition of the term co-living has been established, although some researchers or the publics appear to describe the term without defining it (Steding, 2019). The concept of co-living is a housing concept that involves a shared living space where individuals or groups of people live together in a setting that is community-oriented, and this arrangement of living typically includes private bedrooms and shared common areas such as the kitchen, living room, and bathrooms (Corfe & Salutin, 2019). The young people who choose to move to new cities for career opportunities and want to meet as well interact with new people are the main reasons behind the increasing popularity of co-living spaces (Frank, 2018).

Previous models of co-living practiced providing a basic level of accommodation for bachelors, students, or freelancers. High-rise buildings provide an ideal setting for co-living spaces because these structures are designed to accommodate many people in a relatively small area. This allows efficient use of space especially in urban areas that have limited land for housing development. Co-living facilities usually aim at young adults who have recently left their family homes but are not yet entirely independent or have a solid idea of where they want to live. In recent times, co-living has been promoted to individuals who are not students as a unique style of living. This evolution has entailed not just providing the bare necessities of life, but also promoting it as a more luxurious option with modern design elements such as studios, restaurants, beautiful public rooms, or working spaces. Provides individuals with a desirable lifestyle and a chance that their current living situation requires (Ehrenberg & Keinonen, 2021).

Co-living In Malaysia and Overseas

The co-living trend in Malaysia gained momentum starting from 2016, with a focus on central locations, particularly in Kuala Lumpur (Yi, 2022), where co-living in Malaysia is a growing trend in shared apartment rentals, bringing together individuals from diverse backgrounds to live, work, and forge new friendships. It offers a cost-effective alternative to dorms, providing furnished rooms with individual leases and inclusive pricing.

The rise of co-living spaces in Malaysia is driven by several factors such as urbanization, evolving work patterns, and changing lifestyle preferences (The Next Six Sdn Bhd., 2023). It is primarily aimed at students, working adults, and couples, catering to the lifestyle preferences of the ambitious and innovative millennial and Gen Z generations. Although co-living is still in its early stages in Malaysia, there is a belief that the concept will gain momentum as the sharing economy continues to grow in popularity. Still, there is a demand in Malaysia for co-living because it provides a group of people who prefer a little higher end living experience. Co-living provides absolute convenience, an enjoyable experience, cheap leasing fees, and the chance to experience a communal lifestyle

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(Chan, 2020). In addition, co-living could address the issue of unsold properties in Malaysia by repurposing them into co-living spaces (Chan, 2020).

There are several co-living businesses that have already established their presence in the local market such as Travel Hub Kl, The Hatchery Place, Forward School, Hut Co-living, Co-Living @ Damai Residence, JL Co-living, The Bed KLCC, Insides Co-living, Nestz, Selborn Co-living, Cozylab, Commune Co-living, Upstairs Downstairs, Sunway House, Youtopia Co-living, Homax Co-living, Living Kl, Hom, Komune Living, and Utopia.

On the other hand, experience from Asian cities showed that co-living adapts to local housing pressures and lifestyle trends by combining private living spaces with shared communal facilities, offering more flexible leases and community-oriented living. While the specifics — from Singapore's growing, professionally run co-living market to Hong Kong's lifestyle-oriented communal spaces and Tokyo's blend of share houses and co-living formats — differ by context, the core idea remains focused on convenience, community, and adaptability in expensive urban housing markets.

Types of Co-living Arrangement

Communal living arrangements differ from typical single-family households because they involve individuals who share a living space or a group of living spaces based on their interpersonal relationships rather than primarily family relationships (Hilder, Edward, Sigle, & Metcalf, 2018). These different types of living arrangements are determined by significant similarities, including shared spaces, social interaction, resource sharing, cost- effectiveness, and a desire for a communal living experience. These elements foster a sense of belonging, social relationships, and a supportive atmosphere among residents.

Co-housing

Co-housing serves as a bottom-up movement initiated by residents, whereas co-living is a more top- down approach in which the building or flat is designed towards shared dwellings. The ideological motivation differs between both co-housing and co-living, which arguments for co-housing are often based in feminist interaction, for example making housekeeping services more visible, communal maintenance actions, and equality, whereas co-living is a market solution developed by business organizations or landlords who may offer similar services (Ehrenberg & Keinonen, 2021).

Shared Housing

Shared housing is when a group of people share a regular home or apartment, with private rooms and shared common areas. It lacks dedicated communal

spaces like co-living spaces, and utilities are divided equally among the roommates (Hossam, (2021).

Benefits And Challenges of Co-living Adoption

Table 1 and Table 2 below summaries the benefits and challenges of adoption co-living concept by property developers and co-living operators.

Table 10: Benefits of adoption co-living concept by stakeholders

Benefits	Details
Affordability	Co-living offers an affordable alternative in densely populated urban areas, with monthly rents comparable to similarly sized studio apartments. This is particularly beneficial as co-living arrangements often do not require a security deposit, which typically equals two to three months' rent. A further advantage is the inclusion of utilities, water, internet, and gym access in a single monthly bill, reducing the need for multiple contracts and simplifying expenses (Bott, 2021). Residents also benefit from private living spaces, usually including a personal bathroom, with many units fully furnished. This removes the need to purchase or dispose of furniture when relocating, increasing convenience and flexibility (Ehrenberg & Keinonen, 2021).
Sustainability	Co-living promotes sustainable living through efficient space use and shared resources (Coliwoo, 2022). Higher housing density reduces land consumption, helping to prevent deforestation and land degradation. Shared facilities such as kitchens, living areas, and laundry rooms improve resource efficiency and lower energy use. Additionally, the social structure of co-living encourages sustainable behaviors, including carpooling and bulk shopping, which reduce individual consumption and waste, resulting in a smaller ecological footprint (Wycech, 2020).
Community building	Living alone can limit social interaction, making it challenging to maintain a fulfilling social life. Co-living addresses this issue by fostering environments where residents can easily connect with like-minded individuals at similar life stages. These spaces meet the growing need for community by encouraging social interaction and meaningful relationships. Additionally, community guidelines and managers help maintain a harmonious living environment (Ehrenberg & Keinonen, 2021). As a result, co-living offers residents a sense of belonging and social support in an increasingly isolating society.
Flexibility	The rise of co-living has transformed accommodation by offering flexible, convenient housing options. The ability to book rooms online without long-term lease commitments empowers residents and reduces the administrative burden of traditional rentals (Christy & Tan, 2022). Additionally, the option to change rooms enhances comfort and personalization. For students and individuals with extended commitments, co-living provides a stable yet adaptable living environment (Ehrenberg & Keinonen, 2021).

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Benefits	Details
Accessibility	Co-living spaces promote accessibility while fostering a strong sense of community through shared facilities and services. Communal areas such as co-working spaces, TV rooms, kitchens, and recreational amenities encourage social interaction, collaboration, and sustainable living (Ehrenberg & Keinonen, 2021). Free access to these spaces supports inclusivity and a sense of belonging. Additionally, the shared principles of co-living and co-working enhance networking and engagement among like-minded individuals, particularly in urban areas with strong remote-working cultures (Inamdar, 2020). As demand for community-oriented housing grows, co-living spaces provide supportive environments where residents can thrive.

Table 2: Challenges of adoption co-living concept by stakeholders

Challenges	Details
Social interaction	Co-living is not primarily designed as an affordable solution to the housing crisis but rather reflects rising urban costs and consumption-driven demand for convenience (Coricelli, 2022). However, amid demographic shifts and worsening affordability in cities, it could play a meaningful role if thoughtfully integrated. While improving the co-living experience is important, it should not overshadow the need to address core challenges of affordability, flexibility, and convenience (Patel, 2020).
Affordable	Co-living is not primarily designed as an affordable solution to the housing crisis but rather reflects rising urban costs and consumption-driven demand for convenience (Coricelli, 2022). However, amid demographic shifts and worsening affordability in cities, it could play a meaningful role if thoughtfully integrated. While improving the co-living experience is important, it should not overshadow the need to address core challenges of affordability, flexibility, and convenience (Patel, 2020).
Privacy concern	Unlike traditional renting, co-living residents have limited control over access to their private spaces and must compromise on personal preferences within shared environments (Ehrenberg & Keinonen, 2021). Shared amenities can become crowded or untidy, reducing privacy and making it difficult to find quiet or clean spaces (Homes, 2023). While some residents value the social aspects of co-living, others may find the lack of personal space and privacy challenging.

SDG – Goal 11: Making Cities and Human Settlements Inclusive, Safe, Resilient, And Sustainable.

Over half of the global population currently resides in urban areas, however many of these cities are not ready for this rapid urbanization, and it outpaces the development of housing, infrastructure, and services, which led to many social issues. Co-living concepts is one of the alternatives to solve the social issues or problem of society through sustainable cities and communities. The fact is the sustainable development cannot be achieved without the way urban spaces are

built and managed, and without strong commitment by various institutions to make the cities and human settlement inclusive safe, resilient, and sustainable.

RESEARCH METHODOLOGY

This study employed a mixed-methods approach, utilizing both quantitative methods including online survey of co-living residents and qualitative method which is an interview with Malaysian property developers and co-living provider. The aim of this interview is to find out about the level of awareness among Malaysian property developers and co-living providers on co-living concept in housing development, as well as the benefits of adoption these concepts into property development. On the other hand, the survey aimed to obtain information related to the benefits of applying co-living concepts to individuals working in urban areas. The structured questionnaire for the online survey used a scale based on five (5) points, ranging from strongly disagree to strongly agree, where this scale helped analyse the trends and patterns. The questionnaire was blasted through online platforms including professional networks in LinkedIn, co- living communities, and WhatsApp for each co-living space within the research scope in form of Google Form and poster as well.

The study was conducted within Kuala Lumpur since the goal of the initiative is to provide affordable housing options through co-living concept implementations which are safe, comfortable, and accessible for those who live in the urban areas. This serves as a significant advantage in optimizing land use and management, especially in areas where demand for accommodation is high.

The respondents participated in this study were identified through a purposive sampling method. Purposive sampling entails the deliberate selection of people with relevant information and experiences related to the co-living concept. The most important was, the respondents selected for this study were actively participated in property development activities and get involved directly and indirectly in co living concept in housing development. Moreover, the respondents are willingly to share their information and experiences related to the issues being studied. Apparently, throughout the research procedure, ethical principles such as informed consent and privacy protection were strictly followed.

ANALYSIS AND DISCUSSION

Response Rate

The one-to-one in-depth interviews were successfully conducted with ten property developers and co-living providers, to ensure a diverse range of opinions and experiences, to allow a deeper understanding and motivations behind each respondent. Interviews were sufficiently well answered to allow a response rate of 100% to be obtained.

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On the other hand, from the total of 100 questionnaires were distributed to the respondents, only 82 questionnaires were returned, and resulted 82% response rate. Table 3 and Table 4 below present the demographic profile of the respondents participated in this study.

Table 3: Respondents' profile - interview

Respondents	Gender	Position	Department	Working experiences (Years)
R1	Male	Manager	Accounting & Finance	6 years
R2	Male	Project Manager	Project	>10 years
R3	Male	Executive	Project	10 years
R4	Female	Administrative executive	Human resource	8 years
R5	Male	Assistant Manager	Human resource	>10 years
R6	Female	Administrative executive	Finance	7 years
R7	Male	Project manager	Project	8 years
R8	Female	Administrative executive	Administrative	6 years
R9	Female	Financial Executive	Finance	6 years
R10	Male	Executive	Aset and Facility	5 years

Table 4: Respondents' profile – survey questionnaire

Variable	Frequency (N)	Percentage (%)
Gender:		
Male	35	42.7
Female	47	57.3
Age:		
18 - 25 years old	38	46.3
26 - 33 years old	43	52.4
34 - 41 years old	1	1.2
Above 41 years old	0	0
Race:		
Malay	38	46.4
Chinese	23	28
Indian	9	14.6
Others	12	11
Marital status:		
Single	81	98.8

Variable	Frequency (N)	Percentage (%)
married	1	1.2
Employment status:		
Public sector	14	17.2
Private sector	43	52.4
Self employed	25	30.5
Income level:		
Below RM 2000	14	17.1
RM 2001 - RM 3000	15	18.3
RM 3001 – RM 4000	24	29.3
RM 4001 – RM 5000	16	19.5
Above RM5000	13	15.9

The Level of Awareness Among Malaysian Property Developers on Co-Living Concepts in Housing Development

From the interviews it appears that all interviewees were aware of the co-living concept within housing development. Even though only small number of property developers had undertaken this concept within housing development projects, but the number of co-living projects in Malaysia is forecasted to be increased in future especially in urban areas. This finding was consistent with previous study which mentioned the co-living concept is one of the new trends in the housing development and has gained popularity in recent years as a solution to the housing shortages in urban areas (Corfe, & Salutin, 2019). In addition, Hsia, Chuan & Choong (2024) highlighted that the concept of co-living is emerging and feasible in Malaysia due to booming in technology and education along with the development of tourism.

Moreover, co-living concept provides individuals with a desirable lifestyle and a chance that their current living situation requires (Ehrenberg & Keinonen, 2021). Co-living developments have shown superior efficiency in using space when compared to the traditional housing developments. This serves as a significant advantage in optimizing land use and management, especially in areas where demand for accommodation is high (National Housing Department (2018). Hence, the co-living concept can encourage a sustainable way of living by promoting community-oriented living, space optimization, lower carbon emission and conserving resources (Vivarium, 2023).

However, until year 2023, there was no figure recorded that indicated co-living population for Malaysia, but findings from the study forecast that co-living project will be increased in the future. Therefore, the researcher would recommend identifying co-living population in Malaysia in future research.

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Identifying The Benefits of Adopting the Co-Living Concept to Individuals Working in Urban Areas

From the survey, they were asked about the benefits of adopting co-living concept to the individuals working in urban areas. Table 5 summaries the results.

Table 5: Benefits of adopting the co-living concept to individual working in urban areas

Variables	Mean Score
Affordable Housing	4.74
Accessibility	4.73
Community Building	4.34
Sustainability	3.98
Flexibility	3.84

Based on the findings, the result reveals that people choose co-living space because of its affordability factor and how it will benefit individuals working in urban areas where in this research, the researcher labels the variable as affordable housing. This analysis indeed aligned with the findings from National Housing Department (2018), the co-living space is a reasonably priced option for housing in major urban areas. Moreover, study conducted by Nor Suzylah (2022) was determined that the affordability issue clearly impacted the B40 group of young professionals the most, since their household income and expenditure margins were very tight, leaving them with little residual cash to pay for housing costs.

Next, the result demonstrates that the second highest benefits when applying this co-living concept is because of its accessibility factor. Co-living residents agreed that co-living spaces are more accessible, especially when this modern housing concept is located strategically in the heart of the city. Not just convenience in terms of the public transportation, co-living space also prioritizes accessibility through the multiple communal spaces and the services provided in the co-living space. From previous research, Ehrenberg & Keinonen, (2021) revealed that this public space's accessibility in co-living space arrangement enables residents (to interact with each other which leads to enhancing the individual's living experience in a busy place like the city. In addition, it is widely believed that co-living can provide living closer to the quality amenities (Hsia, Chuan & Choong (2024).

Community building was also identified as one of the benefits of applying the co-living concept to individuals working in urban areas with mean score = 4.34. It is evident that the development of co-living spaces aims to provide a focus on community building in which fellow residents are encouraged to connect and socialize with others. According to Ehrenberg & Keinonen (2021) the emergence of co-living spaces addresses the inherent need for community in

modern society, and this concept of housing also strongly emphasizes promoting social engagement, as stated by (Corfe & Salutin, (2019).

Furthermore, co-living is known for its significant environmental benefits. The concept promotes sustainable living through efficient space utilization which is in accordance with (National Housing Department, (2018) previous study highlighting its benefits in optimizing land use, especially in densely populated areas with high housing demand. As Vivarium, (2023) emphasizes that co-living spaces promote sustainability by encouraging residents to share facilities and resources, thereby developing sustainable habits in individuals.

Furthermore, co-living provides flexibility, which is a significant benefit for people who work in cities. Previous research indicates that the co-living concept has transformed the approach to accommodation by allowing individuals to easily book a room online without committing to a long-term lease, adding a layer of flexibility (Ehrenberg & Keinonen, 2021). Apparently, co-living allows people from diverse backgrounds to live in a supportive community without the need to invest in long-term rental or homeownership due to the concept's inherent flexibility.

RECOMMENDATION

The goal of co-living initiatives is to offer affordable housing options through the applications of these concepts in housing development while fostering a sense of community-building where residents can connect and share experiences. Besides, co- living space developments contribute to more sustainable and inclusive urban environments. Possible strategies include partnering with developers to build affordable co-living spaces, looking at alternative financing sources such as fundraising, and collaborating with local governments to encourage the development of affordable co-living spaces with proper regulation applied. Hence, these spaces should be safe, comfortable, and accessible to those living in urban areas.

CONCLUSION

This study aims to answer questions about the level of awareness of this co-living concept in housing development as well as the benefits of adopting co-living concepts within housing development by property developers and co-living providers. Based on the analysed results of the research, both established research objectives are successfully achieved. The growing urbanization and modern lifestyle lead to the introduction of many new ideas with co-living concepts are no exception. As a new modern housing concept that is recognized for its various benefits aligned with modern lifestyle while offering an affordable monthly rental rate, this concept should be further studied and developed into a large scale with

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a sufficient framework. Moreover, the stated limitations and suggested recommendations could be references for future study. In conclusion, an application of co-living concept within housing development with proper guidelines and legal regulation from local government authorities will potentially make co-living as a long-term lease solution for affordable housing options in urban areas.

LIMITATION

The co-living concept remains relatively new in Malaysia, with a focus on central locations, particularly in Kuala Lumpur, restricting the survey sample to individuals with prior co-living experience. Limited cooperation from some co-living operators due to cybersecurity concerns resulted in a smaller respondent pool, although an acceptable response rate of 82% was achieved. In addition, only 10 interviews were conducted, limiting the depth of qualitative insights.

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FACTORS INFLUENCING HOMEOWNERSHIP DECISIONS AMONG MALAYSIANS: A PRISMA REVIEW

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Abstract

Malaysia is widely regarded as a homeownership-oriented nation. However, homeownership rates in Malaysia have shown a declining trend in recent years, particularly in urban areas, largely due to challenges related to housing affordability. Previous studies indicate that the decline in homeownership is not driven by affordability constraints alone but is also shaped by a range of additional factors. Accordingly, this study aims to examine the factors influencing homeownership decisions in Malaysia. A systematic literature review was conducted using the four-step Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, drawing on studies published between 2008 and 2024 from two primary databases (Scopus and Web of Science) and one supplementary database (Google Scholar). In total, 31 papers were included for analysis, comprising 19 articles from Scopus and Web of Science and 12 articles from Google Scholar. The PRISMA-based synthesis identified eleven key factors influencing homeownership decisions. Among these, financial considerations, locational attributes, and building design and quality emerged as the three most frequently cited factors. This study contributes to the literature on the Malaysian housing market by providing a structured synthesis of determinants of homeownership, and the findings offer practical insights for policymakers in formulating housing policies and for developers in designing strategies that enhance housing marketability.

Keywords: Systematic literature review, Homeownership Decision, Malaysian housing market

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INTRODUCTION

Housing satisfies fundamental physiological and safety needs within Maslow's five-tier model of human needs, as it is essential for human survival and provides safety and stability (Maslow, 1943; Baqutayan et al., 2015). Beyond shelter, housing must be functional, comfortable, and secure, while also supporting privacy, social interaction with guests, and individuals' need for love and a sense of belonging (Baqutayan et al., 2015; Hassan, 2023).

Home ownership represents the preferred form of housing tenure in both developed and developing economies and is often regarded as a major life transition due to the substantial financial commitment involved. Consequently, individuals consider multiple factors when deciding to purchase a home. Prior studies indicate that homeownership decisions are influenced by physical and financial characteristics, environmental and behavioural factors, housing location, accessibility, security, and personal values (Kaynak et al., 2022; Abidoye et al., 2021; Aziz et al., 2022; Hu et al., 2016).

In Malaysia, homeownership is widely perceived as a significant life achievement and is traditionally viewed as preferable to renting. Malaysia is commonly characterised as a homeownership-oriented nation, with a national homeownership rate of 76.5% (DOSM, 2023). However, recent trends indicate a decline in urban homeownership. According to DOSM (2023), the urban homeownership rate decreased from 74.5% in 2019 to 73.3% in 2022, underscoring the need to examine the factors shaping homeownership decisions among Malaysians. Although existing studies have explored determinants of homeownership in Malaysia (Aziz et al., 2022; Mohd Thas Thaker & Chandra Sakaran, 2016; Mang et al., 2020; Zulkifli & Ismail, 2023; Ali & Chua, 2023; Ahmad Fadzil Sumbandy et al., 2021), systematic synthesis remains limited. Specifically, there is a lack of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) based reviews addressing this topic. To address this gap, this study conducts a systematic literature review to identify the factors influencing homeownership decisions in Malaysia.

Understanding the factors that drive individuals to become homeowners is crucial for governments seeking to promote homeownership and to design targeted policies that support citizens in purchasing housing and increasing homeownership rates. Such understanding is also important for developers as it provides insights for developing marketing strategies that align with consumer demand, enhance marketability, and strengthen competitiveness.

The remainder of this paper is structured as follows. The second section presents an overview of homeownership in the housing market. The third section outlines the review methodology, followed by the fourth section, which discusses the review findings. The fifth section concludes the study.

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LITERATURE REVIEW

Overview of Homeownership in the Housing Market

Homeownership represents a significant life milestone for individuals worldwide, as it reflects social status (McCabe, 2018) and psychological stability (Saunders, 1989; Bryx et al., 2021). In addition, homeownership enhances life satisfaction (Seiler Zimmermann and Wanzenried, 2019), happiness (Hu & Ye, 2020), and perceived security (Bryx et al., 2021). Many individuals also regard homeownership as a more advantageous investment than other assets (Tan, 2008; Tan, 2009), and evidence suggests that it may increase marriage rates by enhancing attractiveness in the marriage market (Hu & Wang, 2020). Consequently, homeownership is widely preferred in both developed and developing countries.

Homeownership Trend in the Malaysian Housing Market

Homeownership is widely regarded as a significant life achievement among most Malaysians and has traditionally been viewed as preferable to renting due to its associated benefits (Tan, 2009). To promote homeownership, the Malaysian government has introduced numerous housing policies. According to the National Housing Department (2018), housing policy in Malaysia has evolved through six phases since independence: Early Post-Independence Phase (1957-1970), Housing for Poverty Eradication (1970-1985), Market Driven Housing (1986-1997), Housing for Zero Squatters (1998-2011), Affordable Housing (2012-2017) and National Housing Policy (2018-2025). Similar to other Asian countries, Malaysia's housing system prioritises homeownership (Yaacob et al., 2022). In the early post-independence period, housing policy primarily focused on public housing for public servants. (Samad et al., 2017). Subsequently, homeownership became a national priority encompassing broader population segments and supporting long-term economic development (Samad et al., 2017).

Despite these efforts, rising house prices and relatively low household incomes have made homeownership increasingly difficult for many Malaysians (Yap & Ng, 2018). Faraziera et al. (2019) report that young professionals in major cities have increasingly adopted renting in response to escalating housing costs. Consequently, the demand for rental housing has increased since 2020 (PropertyGuru, 2023). Evidence from Kajang indicates that 72.5% of low- and middle-income tenants cited financial constraints, including unaffordable house prices and insufficient income, as reasons for renting rather than owning (Kun Hing & Singaravelloo, 2018). Nevertheless, homeownership remains the preferred tenure among Malaysian youth, even though affordability challenges persist (Hamzah and Zyed, 2021). To address these challenges, the government has introduced various initiatives aimed at improving national homeownership rates (National Housing Department, 2018; Yaacob et al., 2022), including

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Depositku, MyHome, PR1MA rent-to-own, the Housing Loan Scheme (SPP), and the My First Home Scheme (National Housing Department, 2019).

Homeownership Trend in the Global Housing Market

Housing tenure preferences are shaped by cultural norms, economic conditions, policy frameworks, and demographic dynamics (Dano, 2024). Several European countries, including Greece, the United Kingdom, and the United States, record relatively high homeownership rates, reflecting cultural values that favour owner occupation (Dano, 2024). For example, Greece's homeownership rate of 71.5% has been attributed to strong cultural norms and mortgage availability, which encourage households to prioritise homeownership as a marker of stability and financial security (Dano, 2024). However, homeownership rates declined following the 2008 Global Financial Crisis in several Northern European countries, including Denmark, Sweden, and Finland, particularly among young individuals aged 18–34 (Lennart et al., 2016). In parallel, a shift towards renting has been observed in countries such as Canada (Zhu et al., 2024) and Australia (Baker et al., 2024), largely driven by rising house prices (Baker et al., 2024). Nevertheless, homeownership remains a preferred tenure among young people in some European countries (Bryx et al., 2021; Napiórkowska-Baryła et al., 2024). By contrast, several Western countries exhibit comparatively low homeownership rates, notably Germany and Switzerland (Dano, 2024). Germany's home ownership rate of 40.74% reflects a strong cultural orientation towards renting, reinforced by government policies that safeguard tenants' rights and regulate rental costs across much of the housing market (Dano, 2024; Easthope, 2014). Similarly, Switzerland's homeownership rate of 37.54% suggests that cultural preferences favour the flexibility and mobility associated with rental housing (Dano, 2024).

The trend of homeownership in many Asian countries remains strong compared with several European countries. Homeownership rates in China exceed those in countries traditionally classified as "ownership societies," including Australia, Canada, the United States, and the European Union (Clark et al., 2021). Similarly, homeownership rates in East Asia are higher than in some Western countries, reflecting strong societal aspirations towards a homeownership-oriented society (Yaacob et al., 2022). Evidence from China further highlights the social significance of homeownership by Fong et al. (2021), comparing major social groups including local urban residents, rural migrants, and urban migrants, find that although homeownership may impose financial burdens, it is associated with greater happiness among local urban residents and rural migrants. In addition, Hu and Wang (2020) report a significant relationship between homeownership and marriage in China, demonstrating that homeowners are more likely to marry than renters. These findings reinforce the strong aspiration for homeownership across many Asian societies. Although

homeownership trends remain robust in Asia relative to certain European countries, housing affordability challenges have increasingly constrained this pattern. In response, several Asian governments, including those in China (Shi et al., 2016; Zhang et al., 2020) and Singapore (Zhang et al., 2020), have promoted alternative policy approaches to support citizens in achieving homeownership. In summary, housing tenure preferences vary across countries due to differences in societal values and government policy frameworks.

RESEARCH METHODOLOGY

Scopus and Web of Science were used as the primary databases for this systematic literature review. In accordance with PRISMA checklist, review process comprises four stages: identification, screening, eligibility, and inclusion. This section outlines each stage in detail, while the selection process is summarised in the flow diagram presented in Figure 1.

The first stage is identification. Data collection commenced in March 2024. The keywords "homeownership", "owning", "purchase", "purchasing", "housing", "housing tenure", "Malaysia", "factor", "impact", and "influence" were used to search both Scopus and Web of Science. In Scopus, articles containing these keywords in the title, "abstract", or keywords were considered for preliminary screening, whereas in Web of Science, keyword presence across the full article was accepted. This initial search yielded 206 records, comprising 53 articles from Scopus and 153 from Web of Science. Duplicate records were subsequently removed through manual screening, during which articles were arranged alphabetically by title. As a result, 19 duplicate articles were excluded, leaving 187 articles for abstract screening.

The second stage is screening. At this stage, predefined inclusion criteria were applied to identify relevant studies. First, only articles published between 2008 and 2024 were included to ensure coverage of recent empirical evidence. Second, eligible document types were limited to journal articles and conference papers. Third, only studies published in English or Bahasa Malaysia were considered, while articles in other languages were excluded. Following application of these criteria, 178 articles were retained, and nine records were excluded for failing to meet the inclusion requirements.

The third stage is eligibility. Following title and abstract screening, studies that were not directly related to the research topic were excluded, even if relevant keywords appeared in the text. At this stage, 147 articles were excluded, and 31 articles progressed to full-text eligibility assessment.

The final stage is inclusion, during which full-text articles were assessed in depth. Twelve articles were excluded because they did not meet the objectives of the present study. Consequently, 19 studies, comprising 14 journal articles and five conference papers, were retained for analysis. Owing to the limited number of relevant studies identified through Scopus and Web of Science,

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Google Scholar was used as a supplementary database. The keywords "homeownership", "owning", "purchase decision", "housing", "decision", "factor", and "Malaysia" were applied in the Google Scholar search. This process yielded 12 additional studies, including 10 journal articles and two conference papers. In total, 31 studies (24 journal articles and seven conference papers) were included for further investigation.

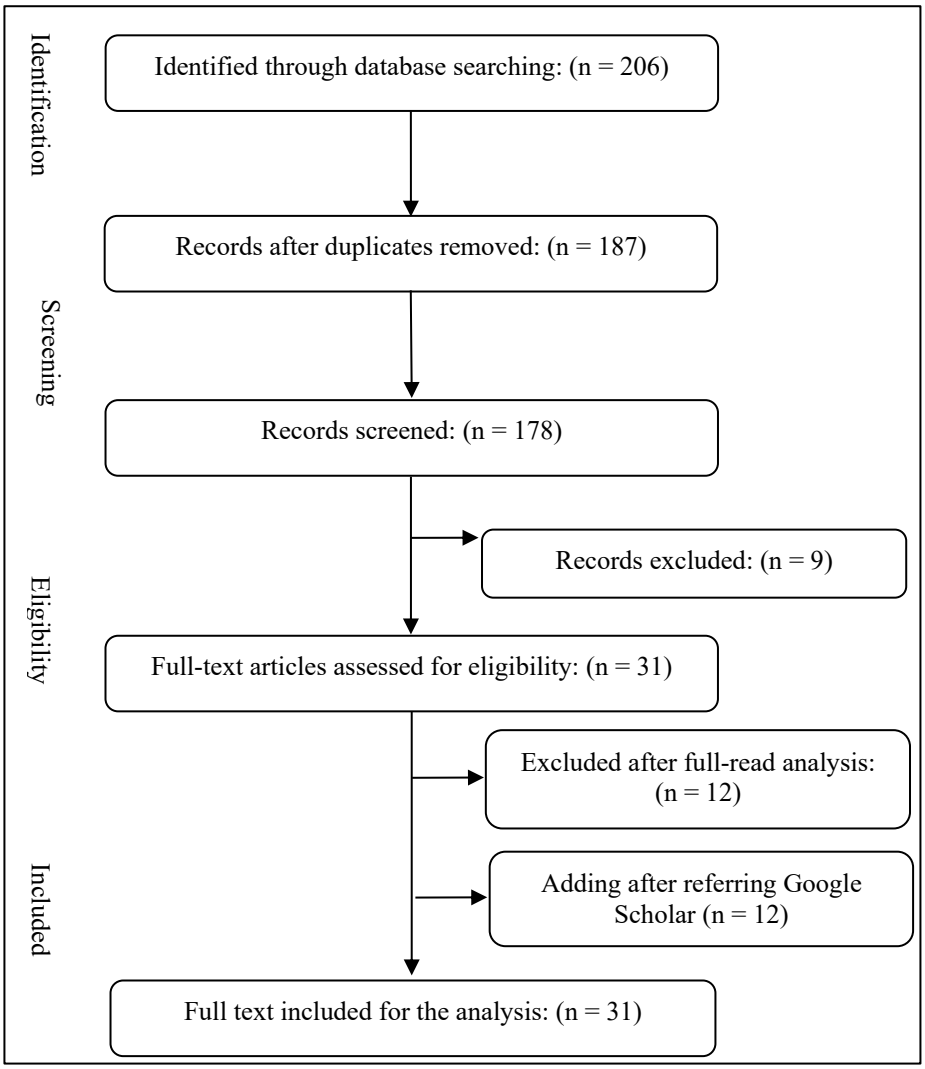


Figure 1: PRISMA Analysis Flow
Source: Author's Drawing (2024)

ANALYSIS AND DISCUSSION

The PRISMA framework was applied in this study, and all reviewed papers were published between 2008 and 2024. Following the PRISMA screening process, a total of 31 studies were retained, comprising 24 journal articles and seven conference papers. Most of the reviewed articles were published in Planning Malaysia and the International Journal of Housing Markets and Analysis. Of the selected studies, 19 were sourced from Scopus and Web of Science, while 12 were obtained from Google Scholar. Based on the synthesis of the 31 studies, eleven factors influencing homeownership decisions among Malaysians were identified. These factors include financial factors, location, building design and quality, neighbourhood attributes, demographic characteristics, developer's reputation, individual psychological factors, socio-cultural factors, government housing incentives, type of land ownership, and property investment value. Table 1 presents these factors and their relative frequencies across the reviewed studies. The reported percentages represent how often each factor was identified among the total number of studies (n = 31), indicating their relative prominence in the literature.

Table 1: Factors that influence homeownership decisions among Malaysians

Factor(s)		Percentage
1.	Financial	81%
2.	Location	77%
3.	Building Design and Quality	58%
4.	Neighbourhood	48%
5.	Demographic	42%
6.	Developer's Reputation	26%
7.	Individual Psychological	19%
8.	Socio-cultural	13%
9.	Government Housing Incentive	13%
10.	Type of Land Ownership	13%
11.	Property Investment Value	6%

Source: Author's Summary

The PRISMA analysis indicates that financial factors are the most frequently cited determinants of homeownership decisions among Malaysians, appearing in 81% of the reviewed studies. Within this category, housing prices are a major concern for individuals in the middle-income (M40) and higher-income (T20) groups (Mohamed et al., 2020; Zulkifli & Ismail, 2023). Reasonable housing prices have been shown to positively influence purchase intention in the housing market (Ali & Chua, 2023; Masukujjaman et al., 2023). Ismail et al. (2021) further demonstrate that purchase intention is significantly influenced by housing prices due to their implications for long-term financial

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commitments. In addition, individuals in urban areas tend to prefer lower down payments and monthly repayments when purchasing housing, largely reflecting savings constraints (Mang et al., 2020). Interest rates also play a critical role, as higher rates reduce the likelihood of loan approval and, consequently, homeownership attainment (Ahmad Fadzil Sumbandy et al., 2021). Location is identified as the second most influential factor affecting homeownership decisions among Malaysians, cited in 77% of the reviewed studies. Location-related considerations include proximity to facilities, housing views, and exposure to natural hazards, all of which shape individuals' housing preferences and tenure decisions. Malaysians tend to prefer purchasing housing located near workplaces, infrastructure, major highways, shops, schools, city centres, places of worship, parks, and medical facilities, as such proximity facilitates daily activities (Chong & Dastane, 2017; Aziz et al., 2022; Zulkifli & Ismail, 2023; Tan & Lee, 2018; Sarif et al., 2018). Evidence from a study focusing on youth in Petaling Jaya indicates that location significantly influences intention to own a house, with respondents showing a strong preference for housing close to their workplace (Ahmad Fadzil Sumbandy et al., 2021). Similarly, Salleh et al. (2019) report that proximity to the workplace ranked highest among location-related attributes, exceeding the importance of recreational parks and places of worship. In addition, Malaysians also prefer housing that is not exposed to natural hazards, such as floods and landslides, in order to minimise potential property damage and financial loss (Zulkifli & Ismail, 2023; Din & Tambi, 2022).

Furthermore, building design and quality, cited in 58% of the reviewed studies, represent the third most influential factor shaping homeownership decisions among Malaysians. This factor comprises two interrelated dimensions: housing design and construction quality. Housing design is considered important, with preferences for attractive layouts and contemporary concepts (Din & Tambi, 2022). Structural characteristics, including the number of bedrooms and bathrooms, parking provision, and overall dwelling size, are also key considerations, as these attributes accommodate household needs and enhance privacy (Chong & Dastane, 2017; Mohd Thas Thaker & Chandra Sakaran, 2016; Sarif et al., 2018; Din & Tambi, 2022; Ismail et al., 2021; Lamsali et al., 2020; Mohamed et al., 2020; Salleh et al., 2019). Building quality, particularly the materials used in construction, further influences homeownership decisions. Malaysians tend to favour housing with minimal defects, as construction quality is a tangible attribute that can be readily assessed during the purchase process (Zainon et al., 2017; Salleh et al., 2019; Chia et al., 2016; Ismail et al., 2021).

Moreover, neighbourhood characteristics, including safety, security, cleanliness, health conditions, and tranquillity, constitute an important determinant of homeownership decisions. Malaysians generally prefer to reside in neighbourhoods that are safe, peaceful, clean, and healthy. As neighbourhood safety is consistently identified as a primary concern when purchasing housing

(Salleh et al., 2019; Mang et al., 2020; Tan & Lee, 2018), many Malaysians are willing to pay a premium for high-quality neighbourhood environments to ensure comfort and personal security (Salleh et al., 2019). In addition, homeownership decisions among Malaysians are influenced by demographic factors. These include income, age, employment type, presence of children, education level, and living expenses. Existing studies consistently identify income as a key determinant shaping homeownership decision in Malaysia (Zulkifli & Ismail, 2023; Salleh et al., 2019; Olanrewaju & Woon, 2017; Mohamed et al., 2020). Evidence from Zulkifli & Ismail (2023) indicates that respondents across all income groups, lower-income (B40), middle-income (M40), and higher-income (T20), rank income as the most influential factor in housing purchase decisions, followed by employment status, life-cycle characteristics such as age, marital status, and the presence of children and level of education. Furthermore, relatively low minimum wages combined with rising living expenses have constrained housing affordability, reducing the ability of many Malaysians to attain homeownership (Ahmad Fadzil Sumbandy et al., 2021; Besar et al., 2020).

Additionally, developers' reputation significantly influences homeownership decisions among Malaysians. Developer reputation is carefully considered to reduce the risk of project failure and potential post-purchase issues (Chuweni et al., 2022). A reputable developer is associated with higher project completion rates and better housing quality, thereby increasing buyers' confidence in the purchase decision. Individual psychological factors also play an important role in shaping homeownership intention. These factors comprise attitude, subjective norms, and perceived behavioural control. More positive attitudes towards homeownership are associated with stronger intentions to purchase housing (Chanda et al., 2023; Masukujjaman et al., 2023). In addition, influence from reference groups under subjective norm, as well as individuals' perceived ability and confidence to purchase housing under perceived behavioural control, significantly affect housing purchase decisions among Malaysians (Yoke et al., 2018; Masukujjaman et al., 2023). Socio-cultural factors further act as key determinants of homeownership decisions. Among Malaysian Chinese households, cultural beliefs such as auspicious numbers and locational symbolism influence housing choices (Hassan et al., 2023; Chia et al., 2016; Sarif et al., 2018). For example, house numbers containing the number eight are preferred due to their association with prosperity in Mandarin, while locations characterised by favourable Feng Shui features, such as hills at the rear, open space at the front, and proximity to flowing water, are considered desirable (Hassan et al., 2023). Cultural considerations also influence housing orientation preferences. Muslim households tend to prefer housing aligned towards the Qibla for religious purposes, whereas Indian households often avoid houses with main entrances facing south-west due to beliefs associated with negative forces (Hassan et al., 2023). In contrast, Chinese households may prefer to avoid

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housing orientations that face sunrise or sunset to moderate indoor temperature (Hassan et al., 2023).

Furthermore, government housing incentives significantly influence homeownership decisions among Malaysians (Mohamed et al., 2020), as such measures enhance households' ability to access housing. This factor is particularly salient for lower-income (B40) households, who are more likely to qualify for low-cost and affordable housing schemes than other income groups (Zulkifli & Ismail, 2023). The type of land ownership also acts as an important determinant of homeownership decisions in Malaysia. Housing tenure is classified into freehold and leasehold arrangements. Freehold properties are generally preferred, as they provide long-term ownership security and clearer property rights compared with leasehold housing, which is subject to time-limited tenure (Salleh et al., 2019; Din & Tambi, 2022). Property investment value further shapes homeownership decisions. Prospective buyers often consider the future market value of housing when making purchase decisions (Zulkifli & Ismail, 2023), reflecting the role of homeownership as a long-term investment and a mechanism for household wealth accumulation.

In summary, homeownership intentions among Malaysians are shaped by eleven key factors: financial factors, location, building design and quality, neighbourhood attributes, demographic characteristics, developer's reputation, individual psychological factors, socio-cultural factors, government housing incentives, type of land ownership, and property investment value.

CONCLUSION

This systematic literature review identifies eleven factors influencing homeownership decisions in Malaysia, including financial factors, location, building design and quality, neighbourhood attributes, demographic characteristics, developer's reputation, individual psychological factors, socio-cultural factors, government housing incentives, type of land ownership, and property investment value. The findings offer policy-relevant insights for policymakers seeking to promote homeownership. Financial factors emerge as the most frequently cited determinants, with housing prices representing the primary concern among Malaysians. Accordingly, policymakers should strengthen housing incentives and financial support mechanisms, such as targeted subsidies and lower interest rates, to enhance households' ability to purchase housing and increase national homeownership rates. The findings also provide practical implications for developers in formulating effective housing marketing strategies. As location is a key consideration in homeownership decisions, developers should emphasise locational advantages, including accessibility to facilities and amenities, when promoting housing projects to improve marketability and competitiveness. This study focuses exclusively on factors influencing homeownership within the Malaysian housing market and relies on

evidence from prior Malaysian studies. As a result, the findings may not fully capture consumer perspectives in other regions with differing cultural, institutional, and market contexts. Future research should examine homeownership determinants across diverse geographical settings to provide a more comprehensive understanding of tenure decisions in global housing markets.

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DISCLOSURE STATEMENT

The authors declare no conflict of interest.

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CONTROLLING SHAREHOLDERS, POLICY ENVIRONMENT AND ANNOUNCEMENT EFFECT: EVIDENCE FROM PEPS IN CHINA LISTED PROPERTY COMPANIES

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Abstract

Over the past four decades, the Chinese real estate market has grown rapidly, accompanied by significant risk accumulation. Private equity placement (PEP), a major form of equity financing, has received limited scholarly attention with respect to its effectiveness, the role of controlling shareholders, and the influence of policy environments in the real estate industry. This study addresses this gap by analysing PEPs conducted by 109 listed property firms using an event-study method and regression analysis. The results show consistently positive cumulative abnormal returns (CARs) around PEP announcements, with placements involving controlling shareholders generating significantly higher CARs, indicating market recognition of their supportive role and certification effect. Although positive announcement effects persist across different policy environments, further analysis reveals that the announcement effect shows no statistically significant relationship with the policy environment variable within shorter event windows. This suggests that short-term announcement effects are primarily driven by market sentiment rather than by a rational reassessment of policy-induced fundamentals.

Keywords: Announcement Effect, Controlling Shareholders, Event Study, Private Equity Placement, Real Estate Firms, Regression Analysis

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INTRODUCTION

Over the past four decades, the Chinese real estate market has expanded rapidly. This expansion has been driven by China's unique land-finance hybrid development model (Xiong, 2025). While this model has increased leverage among households and real estate firms, it has also resulted in substantial risk accumulation (Fang et al., 2016). China's real estate industry relies heavily on traditional bank-based financing, but high leverage has made it increasingly difficult for firms to access low-cost capital (Hu & Meng, 2016). Although Real Estate Investment Trusts (REITs) have developed rapidly in other Asian markets, China's REITs market remains nascent (Victor & Razali, 2019; Wen et al., 2024). Consequently, the need for alternative, market-based financing channels has become increasingly urgent. Ning and Jalil (2023) argue that PEP, as a risk-mitigation strategy, may enable listed property companies to better manage risk and enhance firm value.

PEPs are a form of secondary equity offering (SEOs) in which companies issue additional securities to a small group of sophisticated investors (Wruck, 1989). Prior studies have documented positive market reactions to PEP announcements, yet the role of industry characteristics in shaping these outcomes remains underexplored. Debates persist over the influence of controlling shareholders, who may either support the firm or engage in tunnelling (Wang et al., 2020; Zhang et al., 2021). In China, the real estate sector is highly visible and heavily regulated, with frequent policy interventions such as land-supply controls, purchase restrictions, and financing measures (An & Wang, 2013). This environment provides a valuable setting to examine how firm-level and policy factors interact to influence PEP outcomes, addressing a key gap in understanding financing dynamics in China's property market.

The results indicate that PEPs generate significantly positive market reactions among Chinese listed property firms. Announcement effects are stronger when controlling shareholders participate, suggesting that the market interprets their involvement as a supportive signal that enhances confidence in firm value. Policy conditions are generally negatively associated with announcement effects, consistent with theoretical expectations, although this relationship is not statistically significant in shorter event windows. This pattern suggests that regulatory conditions shape investor behaviour over longer horizons, whereas short-term price movements are primarily driven by market sentiment and immediate reactions. Overall, the findings highlight the temporal variation in the effectiveness of policy influences on PEP announcement effects.

This study provides industry-specific evidence on private equity placements in China's real estate sector by jointly examining controlling shareholder participation and policy timing. By integrating governance signalling with regulatory conditions, it extends the certification hypothesis to a highly

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regulated property market and offers policy-relevant insights into market-based refinancing under regulatory tightening.

LITERATURE REVIEW

Private Equity Placements

Prior studies consistently document positive announcement effects for PEPs. Early studies attribute these effects to governance improvements arising from enhanced monitoring through changes in ownership concentration, whereas subsequent research emphasises signalling mechanisms that reduce information asymmetry (Hertzel & Smith, 1993; Wruck, 1989). Behavioural research suggests that investors may overreact to such signals, leading to temporary price increases followed by weaker long-term performance (Marciukaityte et al., 2005). Although similar positive effects have been found in China, existing work offers competing interpretations of the underlying mechanisms and largely overlooks industry-specific contexts (Zhang, 2008). This limits our understanding of how PEPs operate in sectors, such as real estate, where financing constraints, information asymmetry, and regulatory pressures interact.

Controlling Shareholders and Corporate Governance

Controlling shareholders in Chinese listed firms often hold substantial ownership and exert significant influence on corporate financing decisions (Chen & Wang, 2005). Existing research offers two competing perspectives. One view suggests that their involvement enhances monitoring and supports firm value through enhanced governance, particularly when external constraints are strong (Yang & Sun, 2017). The opposing view highlights risks of tunnelling under concentrated ownership structures (Zhang et al., 2021). These mixed findings indicate that the behaviour of controlling shareholders is context-dependent and shaped by institutional and regulatory conditions. Nevertheless, empirical evidence from the real estate sector, where leverage is high and policy oversight is intensive, remains scarce, leaving an important gap in the governance literature.

Policy Environment and the Real Estate Sector

Policy implementation plays a critical role in shaping market reactions to private equity placements. Marzukhi et al. (2022) note that bureaucratic complexity and uneven enforcement reduce institutional effectiveness. Similarly, frequent and unpredictable interventions in China's real estate sector affect investor expectations and placement pricing (Ge et al., 2023; Li et al., 2014). Policy inconsistency may increase placement discounts or trigger stock price overreactions by amplifying investor uncertainty. While prior studies show policy shifts shape macro and industry dynamics, firm-level effects on PEPs remain

underexplored, limiting understanding of how policy intensity interacts with market responses.

Conceptual Framework

This study conceptualises the announcement effect of PEPs as the central outcome influenced by internal governance signals and external policy conditions. As illustrated in Figure 1, two key factors are hypothesised to shape the price reaction around PEP announcements. First, the participation of controlling shareholders provides a governance-related signal that may mitigate information asymmetry and reduce concerns about tunnelling. Their involvement can therefore enhance investor confidence and strengthen the positive market response to PEPs. Second, shifts in the policy environment represent an important external force that affects firms' financing constraints and investors' expectations. Periods of regulatory tightening increase uncertainty and elevate discount rates, moderating or reversing the positive effects typically associated with PEP announcements, whereas more accommodative policy phases may reinforce favourable market reactions. Firm-level and market-level characteristics are included as control variables to address heterogeneity in financial conditions and industry dynamics. Together, the framework positions the announcement effect as the result of interactions between governance signals, regulatory conditions, and firm-specific controls.

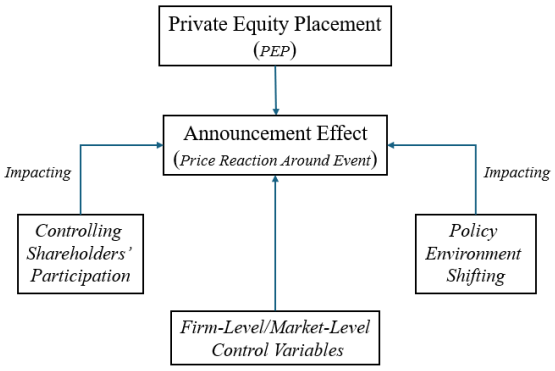


Figure 1: Conceptual Framework

Hypotheses Development

Prior studies consistently document positive stock price reactions to PEPs, largely due to signalling effects and reduced information asymmetry (Hertzel & Smith, 1993; Wruck, 1989). Given the valuation opacity and financing constraints prevalent in the real estate sector, PEPs are expected to convey credible

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information regarding project quality and firm prospects. Accordingly, we propose the following hypothesis:

H1: *PEP transactions in Chinese-listed real estate firms will lead to positive announcement effects.*

Controlling shareholders in China typically possess substantial influence over financing decisions. Their participation in PEPs provides an additional governance signal, suggesting confidence in future performance and mitigating concerns regarding tunnelling behaviour. Market reactions are therefore expected to be more favourable when controlling shareholders inject capital. Thus, we propose:

H2: *PEP transactions involving controlling shareholders in Chinese-listed real estate firms will lead to more positive announcement effects.*

The real estate sector is highly sensitive to policy interventions. Regulatory tightening increases refinancing costs, elevates uncertainty, and raises discount rates in expected cash flows, all of which weaken market responses to corporate financing events. During restrictive policy periods, the signalling effect of PEPs may be offset by adverse macro and policy conditions. Therefore, we propose:

H3: *During tightening regulatory periods, the announcement effect of PEP transactions by Chinese-listed real estate firms will be more negative.*

DATA AND METHODOLOGY

Data

The primary data source for this study is the China Stock Market and Accounting Research (CSMAR) database. We collected data on PEPs conducted by Chinese listed real estate companies from 2005 to 2023. The sample selection process excludes the following cases: non-A-share transactions; firms under special treatment (ST) or particular transfer (PT) status at the time of the transaction; firms engaged in other refinancing activities within one year before or after the PEP; transactions with missing data; suspended or incomplete placements; and cases in which multiple PEPs were conducted by the same firm on the same day, which are aggregated into a single observation. The final sample consists of 109 listed real estate firms that successfully implemented PEPs.

The reasons we exclude non-listed real estate firms and Chinese developers listed in Hong Kong from our sample are explained as follows. Non-listed or regional developers rely primarily on bank financing and lack access to market-based equity issuance, making them unsuitable for analysing PEP dynamics. In contrast, PEP transactions by Hong Kong-listed firms do not require regulatory approval, whereas all placements in mainland China must be reviewed and authorised by the China Securities Regulatory Commission (CSRC). This institutional difference materially shapes investor expectations. CSRC approval

functions as a form of quality assurance for the transaction. For these reasons, our analysis focuses solely on Chinese real estate firms listed on the A-share market.

Table 1 provides descriptive statistics of the sample data. Over the sample period (2005-2023), Chinese real estate firms raised an average of 21.43 CNY billion through PEPs, which accounted for about 25.42% of the total outstanding shares post-transaction. Consistent with previous studies, these companies issued new shares at an average discount of 8.89% in PEPs. The average market value of the sample firms is 23.22 CNY billion, with an average Tobin's q of 1.618, suggesting relatively strong growth prospects. The average leverage ratio is 67.25%, with a higher median of 70.51%, suggesting relatively high leverage among firms engaged in PEPs. The average ownership stake of the largest shareholder is 39.65%, suggesting limited concerns regarding dilution of control rights, highlighting their significant influence. Additionally, sample companies have an average Book-to-Market ratio of 0.7904 and an average return on equity (ROE) of 10.19%.

Table 1: Descriptive Statistics

Variable	N	Mean	Median	Std. Dev	Max	Min
Discount	109	0.0889	0.1168	0.4272	0.7631	-1.847
Placement Fraction	109	0.2542	0.2222	0.1619	0.9574	0.0155
Proceeds (CNY billions)	109	21.4254	21.3911	0.9063	24.8906	18.7012
Tobin's q	109	1.618	1.1874	2.0516	19.0936	0.7758
Leverage	109	0.6725	0.7051	0.1547	0.9136	0.0463
Largest Shareholder	109	39.6500	41.2500	17.0518	79.5700	6.5000
Market Value (CNY billions)	109	23.2237	23.0648	1.342	27.2529	20.49
Book to Market	109	0.7904	0.8422	0.2194	1.2889	0.0524
ROE	109	0.1019	0.0943	0.0909	0.4333	-0.2309

Source: Authors

Measurement of Announcement Effects and Regression Model

To measure announcement effects, we adopt the event-study approach proposed by De Jong et al. (1992) to calculate Cumulative Abnormal Returns (CARs).

$$R_{jt} = \alpha_j + \beta_j R_{mt} + \varepsilon_{jt} \quad \textbf{Eq.1}$$

$$AR_{jt} = R_{jt} - (\alpha_j + \beta_j R_{mt}) \quad \textbf{Eq.2}$$

$$CAR_j^T = \sum_{t=1}^{T} AR_{jt} \quad \textbf{Eq.3}$$

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Where R_{jt} is the return on company j on date t; R_{mt} is the daily return of the *Shanghai Real Estate Industry Index*; α_j is the intercept term estimated from the market model for firm j; β_j is the OLS estimate of the market model parameter for firm j; ε_{jt} is the error term of company j on the sample event day t; AR_{jt} is the abnormal return of company j at date t; CAR_j^T denotes the cumulative abnormal return of firm j over event window T; T is the event window.

To examine the effects of controlling shareholder participation and policy timing on PEP announcement effects, we estimate the following regression model:

$$CAR_j^T = \alpha_0 + \beta_1 Controller + \beta_2 Policy + \gamma_i \sum Control_i + \varepsilon \qquad \textbf{Eq.4}$$

WhereCAR_j^T represents the cumulative abnormal return during the announcement period T of the PEP transaction j. $Controller$ is a dummy variable indicating whether the controlling shareholder participates in the PEP transaction. It takes a value of 1 when the controlling shareholder participates in the transaction; otherwise, 0.$Policy$ is another dummy variable indicating whether the PEP transaction occurs during a tightening period of real estate regulatory policies. $Control_i$ represents the control variables involved in the model. ε represents the error term. The classification, definitions, and data sources of all variables used in the model are presented in Table 2.

Table 2: Definitions of Variables Used in the Empirical Analysis

Category	Proxy	Definition	Source
Dependent	*CAR*	The cumulative abnormal return around the event.	Wruck (1989); Hertzel and Smith (1993)
Key Explanatory Variables	*Controller*	Dummy variable equal to 1 if the controlling shareholder or its related parties participate in the transaction, and 0 otherwise.	Sun (2015)
	Policy	Dummy variable equal to 1 during periods of real estate policy tightening, and 0 otherwise.	Author
Control Variables	*Discount*	One minus the ratio of the placement price to the closing price ten trading days after the announcement.	Wruck and Wu (2009)
	Proceed	Natural logarithm of the money raised from the transaction.	Hertzel and Smith (1993); Barclay et al. (2007)

Category	Proxy	Definition	Source
	Fraction	The percentage of the number of shares issued to the total number of shares issued after the deal.	Hertzel and Smith (1993); Hertzel et al. (2002)
	MV	Natural logarithm of the market value of the Firm (CNY billions) in the previous accounting period (year [-1][2]).	Hertzel and Smith (1993); Wruck (1989)
	Leverage	Debt ratio in the previous accounting period (year [-1]), calculated as Total Debt (year [-1]) /Total Assets (year [-1]).	Yu et al. (2016); Zhang (2007)
	ROE	Return On Equity in the previous accounting period (Year [-1]).	Tao et al. (2018)
	Tobin_q	Tobin's q in the previous accounting period (year [-1]), equal to Market Value / (Total Assets - Net Intangible Assets - Net Goodwill).	Zhang (2007)
	BM	Book to Market Ratio in the previous accounting period (year [-1]), equal to Book Value/Market Value.	Hertzel and Smith (1993)
	Top1	The shareholding ratio of the first controlling shareholder in the previous accounting period (year [-1]).	Zhang et al. (2021)
	Bull	Dummy variable equal to 1 if the stock market is in a bullish phase, and 0 otherwise.	Sun (2015)

Notes: When data for 2023 are unavailable, values from 2022 are used as a substitute. Year [−i] denotes the i-th year before the event, year [0] refers to the event year, and year [+i] indicates the i-th year after the event.

This model is built upon several standard assumptions and is subject to certain limitations. It assumes that markets are efficient within short-term event windows. It also assumes that abnormal returns capture the information content of PEP announcements. The model presumes a linear and additive relationship between explanatory variables and CAR. Additionally, the error terms are assumed to satisfy exogeneity and other basic statistical conditions. However, the model cannot fully rule out the influence of unobserved factors. These may include concurrent disclosures, insider expectations, or shifts in market sentiment. Such factors could affect price reactions. For instance, the policy cycle dummy variable is included to capture regulatory cycles, but this approach may not reflect variations in policy intensity. Similarly, controlling shareholder participation is coded as a binary variable. It does not distinguish differences in motivations or degrees of involvement. Event study results may be sensitive to the choice of event window and benchmark model. This sensitivity could affect the robustness of estimated announcement effects.

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RESULTS

Announcement Effect

Consistent with previous literature and hypothesis H1, Chinese listed real estate companies exhibit statistically significant positive CARs during private placement transactions. Table 3 presents the values of CARs during different event windows. In the [-1,1] event window, the average CAR reaches 6.5%, which is significant at the 1% level. Similarly, CARs are also significantly positive during the [-3, 3] and [-10, 10] event windows. These results indicate that the market responds positively to private placement transactions in real estate companies.

Table 3: Announcement Effect in Various Event Windows

Variable	N	Mean	Median	Std. Dev	Max	Min
[-1,1]	109	0.0650***	0.0443	0.1070	0.3090	-0.1957
[-3,3]	109	0.0800***	0.0444	0.1717	0.5687	-0.3104
[-10,10]	109	0.1335***	0.0701	0.2776	1.1135	-0.3789

*Notes: *** $p < 0.01$. CARs are calculated using the market model. Source: Author.*

Participation of Controlling Shareholders

Table 4 compares announcement effects between PEPs with and without controlling shareholder participation. Panel A reports mean CARs for both groups, which are significantly positive. In the [-1,1] event window, the average CAR for transactions with controlling shareholder participation is 8.74%, compared with 4.28% for those without such participation. Panel B presents the differences in CARs between the two groups. The variable DIF denotes the mean CAR for transactions with controlling shareholder participation minus that for transactions without such participation. The estimated differences are negative across all event windows, with statistical significance based on t-tests. Although the *Wilcoxon* test does not show statistical significance, the positive CAR differences are consistent with the t-test results. The lack of significance may reflect the moderate sample size and variability in the differences, which reduces the test's power.

Table 4: CAR Comparison with Controlling Shareholder Participation

Panel A: CAR for Window [-1,1]					
Controller Shareholder			**Non-Controller**		
N	Mean	T	N	Mean	T
63	0.0874***	6.1233	46	0.0428***	2.8669

Panel B: CAR Difference					
		T-Test		**Wilcoxon Test**	
Windows	**DIF**	**T**	**p-value**	**Z**	**p-value**
[-1,1]	0.0446**	2.1215	0.0181	1.841	0.0657
[-3,3]	0.0508**	1.9788	0.0252	1.614	0.1066
[-10,10]	0.1069**	2.0429	0.0218	1.589	0.1130

*Notes: ** p < 0.05, *** p < 0.01, significance is based on t-test; DIF is equal to the mean of CAR with controlling shareholder participation minus the mean of CAR without controlling shareholder participation.*
Source: Author

Figure 2 compares the CARs during the announcement period for PEPs with and without controlling shareholder participation. The figure shows that transactions involving controlling shareholders exhibit significantly higher CARs over the event window than both the full sample and the non-participation group. This visual evidence further corroborates the results reported in Table 4. The stronger market response can be attributed to the positive signal conveyed by controlling shareholder participation. The results in Table 4 and Figure 2 suggest that the market responds positively to the participation of controlling shareholders in transactions of real estate companies.

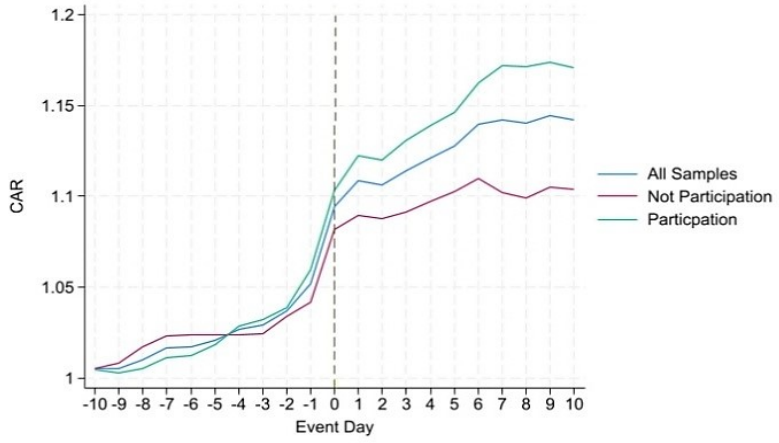


Figure 2: Comparison of CAR by Controlling Shareholder Participation

Real Estate Policy Effects

Table 5 compares the impact of private placement announcements during different real estate policy periods. Panel A shows that out of 109 private

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placement transactions, 71 took place during relaxed policy periods, while 38 occurred during tight policy periods. Despite differences in sample size, both groups show significantly positive average cumulative abnormal return rates. During relaxed periods, the CAR value is 7.64% (T: 5.6055), while during tight periods, it is 4.36% (T: 3.0555). Panel B compares CAR values between the groups, where DIF represents the difference. Except for the [-1,1] interval, where the difference is not significant, in other intervals, the difference is both positive and significant at the 1% level. This suggests that in Chinese listed real estate firms, private placement announcements are associated with larger CARs during relaxed policy periods compared to tight ones. These results suggest that PEP announcements generate positive market reactions across policy environments, with stronger effects observed during more accommodative policy periods.

Table 5: CAR Comparison in Different Policy Periods

Panel A: CAR for Window [-1,1]

Policy Relaxation			Policy Tightening		
N	**Mean**	**T**	**N**	**Mean**	**T**
71	0.0764***	5.6055	38	0.0436***	3.0555

Panel B: CAR Difference

		T-Test		Wilcoxon Test	
Windows	**DIF**	**T**	**p-value**	**Z**	**p-value**
[-1,1]	0.0328	1.5334	0.1281	1.571	0.1163
[-3,3]	0.0988***	2.9639	0.0037	2.245	0.0248
[-10,10]	0.2176***	4.1876	0.0001	4.101	0.0000

*Notes: *** $p < 0.01$, significance is based on t-test; DIF is equal to the difference of the mean of CARs in the policy relaxation minus the mean of CARs in the policy tightening period. Source: Author*

Regression Results

To further validate hypotheses H2 and H3, area fixed-effects regressions were conducted using Eq.4. Variance inflation factor (VIF) tests were conducted, and no serious multicollinearity was detected. We further assess the robustness of our results by re-estimating the regressions using alternative event windows. Specifically, CARs calculated over the [-3,3] and [-10,10] windows are employed as dependent variables.

Table 6: Announcement Effect Regression Analysis presents the results for these three regression equations. The variable *Controller*, representing major shareholder participation, is significantly positive in all tests, aligning with Table 4 findings and Figure 2. This evidence supports H2 and is consistent with a supportive role of controlling shareholders (Wruck & Wu, 2009). Furthermore, controlling shareholders' participation provides the market with a credible signal. Given their informational advantages, such participation is interpreted by investors as signalling either firm undervaluation or favourable long-term

outcomes from the PEP. This evidence also supports the certification hypothesis proposed by Hertzel and Smith (1993).

Table 6: Announcement Effect Regression Analysis

Dependent Variables：CARs	**[-1,1]**	**[-3,3]**	**[-10,10]**
Constant	-0.265	-0.230	-0.415
	(-0.753)	(-0.389)	(-0.436)
Controller	0.076***	0.081**	0.101*
	(3.279)	(2.217)	(1.969)
Policy	-0.003	-0.047	-0.177***
	(-0.116)	(-1.223)	(-3.189)
Other Control Variables	Not Significant	Not Significant	Not Significant
ROE	-0.384***	-0.328	-0.646*
	(-2.822)	(-1.530)	(-1.956)
Discount	0.079***	0.137***	0.257***
	(2.861)	(2.815)	(3.445)
Area-Fixed	Yes	Yes	Yes
N	104	104	104
R^2	0.434	0.361	0.450
Adj R^2	0.243	0.146	0.265
F	5.193	3.183	3.602

*Notes: * p < 0.1, ** p < 0.05, *** p < 0.01; Robust t-statistics in parentheses. Some control variables were included but not reported for brevity. Source: Author*

The variable *Policy*, indicating real estate regulation tightening, is negatively related to the dependent variable across all groups but is only significant in the [-10,10] interval. The regression and robustness test results provide limited support for Hypothesis H3. This suggests that the industry policy environment does not exert a consistently significant influence on the announcement effect of PEPs. These findings contrast with the univariate evidence in Table. One possible explanation is that, over shorter event windows, investor reactions are more influenced by investor sentiment. In longer windows, such as [-10,10], investors have greater time to process information and assess the implications of policy changes for PEPs more rationally. In contrast, the market's interpretation of controlling shareholder participation is relatively immediate and more easily interpretable, requiring little time for assessment. However, as time passes, investors may reassess whether the initial reaction to this signal was overly optimistic. As a result, although the estimated coefficients remain in the predicted direction across specifications, their statistical significance differs across event windows.

We also find a significantly negative relationship between ROE and announcement effects, which is consistent with market expectations of performance reversal. As ROE is measured before the transaction, lower profitability signals greater potential for improvement following a PEP. A similar interpretation applies to placement discounts. Larger discounts are typically

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associated with weaker firm quality and thus greater scope for post-transaction performance gains, leading to stronger market reactions. These results suggest that investors view PEPs as mechanisms for earnings recovery. Consistent with Wruck's monitoring hypothesis, discounts may also compensate investors for enhanced oversight, although performance reversal appears to play a more prominent role (Wruck, 1989).

This study employs an event study and cross-sectional regression to identify the statistical relationships between market reactions and key variables. However, potential endogeneity issues should be noted. The involvement of controlling shareholders in decision-making may not be random. Their motivation could stem from recognising growth opportunities or the firm's intrinsic value, which may introduce omitted variable bias. In addition, the use of dummy variables to measure policy simplifies complex regulatory changes and may not capture the full intensity of industry policy shifts. Furthermore, the insignificance of policy variables in shorter event windows suggests that market sentiment may play an important role. These endogeneity concerns imply that the findings should be interpreted as robust evidence of correlation rather than strict causal inference. Future research could employ instrumental variables or quasi-experimental designs to further validate the results.

CONCLUSIONS

This study examines the announcement effects of private equity placements by Chinese listed real estate firms. Consistent with prior research, we document significantly positive market reactions to PEP announcements, with an average CAR of 6.50% over the [-1,1] event window. Positive announcement effects are observed both with and without controlling shareholder participation, but are significantly stronger when controlling shareholders are involved, indicating that the market interprets such participation as a credible and supportive signal. In contrast, regulatory tightening is associated with weaker announcement effects over longer event windows, suggesting that short-term price reactions are largely driven by market sentiment rather than rapid reassessment of policy-induced fundamentals.

This study contributes to the literature by examining how governance signals and policy conditions jointly shape market responses to equity refinancing in a highly regulated and leveraged sector. The findings support the certification hypothesis and suggest that PEP announcement effects also reflect expectations of performance reversal under financing constraints. From a policy perspective, the results highlight that regulatory uncertainty weakens investor confidence. Greater policy consistency and transparency may therefore help stabilise market expectations while preserving firms' access to market-based financing. From a

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managerial perspective, controlling shareholder participation emerges as an effective signalling mechanism during refinancing.

Several limitations should be acknowledged. The analysis focuses on short-term announcement effects and does not examine long-term performance. In addition, controlling shareholders' participation and policy conditions are measured using simplified proxies. Future research could explore discount-setting behaviour, long-term outcomes, and more granular policy indicators to further understand equity financing dynamics in China's real estate sector.

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EXPLORING THE CHALLENGE OF DEVELOPING SUSTAINABLE AFFORDABLE HOUSING

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Abstract

The growing urgency of climate change and persistent housing inequality have intensified the need for sustainable affordable housing (SAH). This study aims to examine research trends linking housing and sustainability, identify key barriers to SAH development, and propose effective strategies to address these challenges. Using bibliometric analysis and a systematic literature review (SLR), studies were retrieved through an advanced search of the Scopus and Mendeley databases, yielding 14 articles for detailed analysis. The findings indicate that construction innovation inefficiencies, ineffective policies, and financial constraints remain major impediments to SAH implementation. By synthesising existing evidence, this study provides strategic insights to support policymakers, practitioners, and researchers in advancing sustainable, affordable, and inclusive housing development.

Keywords: Sustainable Affordable Housing, Affordable Housing, Bibliometric, Systematic Literature Review, Sustainability

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INTRODUCTION

SAH refers to housing that is financially accessible to low- and middle-income households while simultaneously promoting environmental sustainability, social inclusion, and long-term community resilience (Sohaimi et al., 2023, 2025). The concept has gained increasing attention amid rapid urbanisation, climate change pressures, and persistent housing affordability challenges worldwide. Despite this growing interest, cities continue to face escalating housing costs, environmental degradation, and social inequality (Sohaimi, 2022), underscoring the complexity of delivering housing that is both affordable and sustainable. Existing research on housing affordability, sustainability, and policy has evolved in parallel rather than as an integrated body of knowledge. Prior studies tend to focus on isolated dimensions, such as technical performance, financial mechanisms, construction materials, or governance frameworks, resulting in a fragmented evidence base (Narayani & Nagalakshmi, 2023). Reviews of affordable housing in developing and emerging economies similarly highlight that the literature often concentrates on specific materials, technologies, or national case studies, limiting cross-contextual learning and holistic understanding of SAH systems (Chan & Wong, 2022).

While numerous studies have identified challenges to SAH implementation, including misaligned incentives, land-market constraints, weak regulatory frameworks, and institutional capacity gaps, these are frequently examined in isolation (Adabre & Chan, 2021; Arham et al., 2025). This fragmented approach provides limited strategic guidance for policymakers and practitioners seeking scalable and integrated solutions that simultaneously address affordability, environmental sustainability, and social equity. Consequently, the interplay between housing affordability, public health, environmental performance, and governance remains insufficiently synthesised in the existing literature (Sharpe et al., 2025). Synthesising evidence on key barriers and effective strategies will provide an evidence-based overview to inform policy, practice, and future research, supporting the development of inclusive, resilient, and sustainable housing across diverse urban contexts.

RESEARCH METHODOLOGY

Material and methods

Three study objectives, each requiring a distinct approach, are summarised in Table 1.

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Table 1: Summary of Research Objectives and Methodologies

Research Objectives	Research Method/	Type of analysis
1. To explore the existing housing and sustainability research trend	Quantitative	Bibliometric
2. To identify key obstacles to SAH development	Quantitative	SLR
3. To propose effective strategies for addressing SAH	Quantitative	Thematic

This study employed a combined bibliometric analysis and SLR to ensure a comprehensive and rigorous examination of SAH research. Bibliometric analysis was used to map publication trends, influential sources, keyword networks, and thematic evolution, providing an objective overview of the field's intellectual structure. Complementarily, the SLR systematically synthesises selected high-quality studies to examine key challenges, policy gaps, and strategic responses that cannot be fully captured through quantitative mapping alone. Integrating both approaches enables the study to visualise research patterns while offering a focused qualitative interpretation of critical themes, thereby enhancing analytical depth and the reliability of the findings.

The review follows PRISMA guidelines to ensure transparency and replicability, with the PRISMA flow diagram documenting the search strategy, screening process, inclusion and exclusion criteria, and final study selection. Scopus served as the primary database due to its extensive coverage of peer-reviewed literature in housing, urban studies, and sustainability. Mendeley was used as a complementary screening tool to support duplicate removal, reference organisation, and cross-verification of relevant studies. This integrated approach enhances methodological robustness by combining quantitative trend analysis with qualitative thematic synthesis. This section also outlines the four key subsections, identification, screening, eligibility, and data abstraction.

Identification

The first stage was to identify keywords and search for associated related terms using a thesaurus, dictionary entries, encyclopedias, and previous research. After selecting the required terms, the search phrases for both the Scopus and Mendeley databases were established (see Table 2). During the initial step of the SLR technique, the current study successfully obtained 457 papers from both databases.

Table 2: The search strings.

Database	Search strings
Scopus	(challenge* OR issue* OR problem*) AND ("Sustainable Affordable Home*" OR "Sustainable Affordable House*" OR "Sustainable Affordable Home" OR "Sustainable Affordable Housing") AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (OA , "all"))
Mendeley	Challenges OR Issues AND Sustainable Affordable House*

Screening

The screening process entails reviewing a collection of potentially relevant research materials for content related to the selected research questions. One example of a content-related criterion used during the screening process is the decision to choose a group of subject matter items based on the issue or challenges of SAH. By this point, any duplicate papers would have been deleted from the original list of documents to be searched. Following the rejection of 332 articles, 125 articles were assessed in the study's second round of screening using a variety of inclusion and exclusion criteria (see Figure 1). The first criterion used was the literature (research articles), which was the primary source of helpful information. Reviews, meta-synthesis, meta-analyses, books, book chapters, and conference papers that were not covered in the most recent studies were also included. Furthermore, the review only covered papers in English.

Eligibility

The eligibility level, also known as the third level, produced 125 articles. Accordingly, all article titles and essential content were thoroughly reviewed to verify that they fulfilled the inclusion criteria and the current study's aims. Consequently, 111 papers were removed because they were unrelated to the study's topic, their names, study areas, and abstracts were mismatched, and they prohibited full-text access based on empirical evidence. As of the publishing of this article, 14 articles were available for evaluation.

Data Abstraction and Analysis

i. Bibliometric data abstraction

From 2010 until 2024, the Scopus database provided the information for this bibliometric analysis. Data analysis was conducted using the mapping and clustering approaches with VOSviewer software version 1.6.19. The Multidimensional Scaling (MDS) method proposed by (Van Eck et al., 2010) is an alternative to this software. A comparison of these two methods' shared objective is to precisely represent relatedness and similarity by placing the objects in a low-dimensional space, as measured by separation distance (Appio et al.,

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2014). To normalise co-occurrence frequencies and enhance the accuracy of the representation of relationships between items, it computes the association strength (ASij), as shown below.

$$AS_{ij} = \frac{C_{ij}}{\omega_i \omega_j}$$

By comparing observed and expected co-occurrences and assuming statistical independence between items i and j, Van Eck and Waltman (2010) established the association strength metric, which quantified the degree of relationship between items i and j. Using a weighted sum of squared distance reduction, the VOSviewer arranges items on a map. In compliance with the guidelines provided by Appio et al. (2014), the LinLog/modularity normalisation technique was also used. By applying the VOSviewer's visualisation tools to the dataset, patterns resulting from mathematical relationships were shown. VOSviewer arranges the components to create a map by first lowering the weighted total of the squared distances between each pair of objects. LinLog/modularity normalisation was recommended by Appio et al. (2014). Keyword co-occurrence analysis is useful for identifying subjects that are frequently addressed across several disciplines and can be used to monitor the development of a study area over time (Li et al., 2016). Consequently, by lowering the weighted total of the squared distances between each pair of objects, the VOSviewer uses this index to arrange the objects into a map. Appio et al. (2014) promoted the use of LinLog/modularity normalisation.

In addition, mathematical relationship patterns and VOSviewer's visualisation features were used to perform analyses on the dataset, including co-citation, co-occurrence, and keyword co-occurrence analyses. According to Li et al. (2016), keyword co-occurrence analysis is useful for identifying themes that are frequently discussed in various academic fields and for examining the evolution of a research subject over time. This makes it possible for researchers to evaluate the historical significance of the main field of study within a discipline. Correspondingly, important research topics, patterns, and techniques can be found with the use of citation analysis, which makes it simpler to determine the most important research questions, approaches, and techniques as well as to assess the historical significance of a discipline's central field of study.

ii. SLR data abstraction

Meanwhile, one of the evaluation processes employed in the SLR was an integrative analysis, which examined and synthesised several research methodologies (quantitative, qualitative, and mixed). The expert evaluation aimed to identify relevant concerns and subtopics. The data collection technique provided the foundation for the theme's development. The authors carefully

examined a collection of 14 articles, as shown in Figure 1, looking for remarks or material related to the current study's topics. After identifying and constructing key groupings in the second stage, the authors investigated the concerns and obstacles preventing the implementation of SAH. The result of the investigation yielded three key topics: Construction Innovation Inefficiencies, Ineffective Policies, and Financial Constraints.

From this point on, the authors continued with themes, concepts, or ideas for each established subject. As part of this research, the author collaborated with other co-authors to establish evidence-informed themes. Throughout the data analysis, a log was kept for capturing analyses, opinions, puzzles, or extrapolations that were relevant to the data interpretation. The authors examined the findings to determine any variations in the theme development process. It is critical to note that the authors discussed possible conceptual differences that may exist. After some time, the created designs were modified to maintain uniformity. Experts in housing and sustainability conducted a study to determine the validity of the difficulties. The expert analysis process guarantees that each sub-theme is clear, important, and appropriate by demonstrating domain validity.

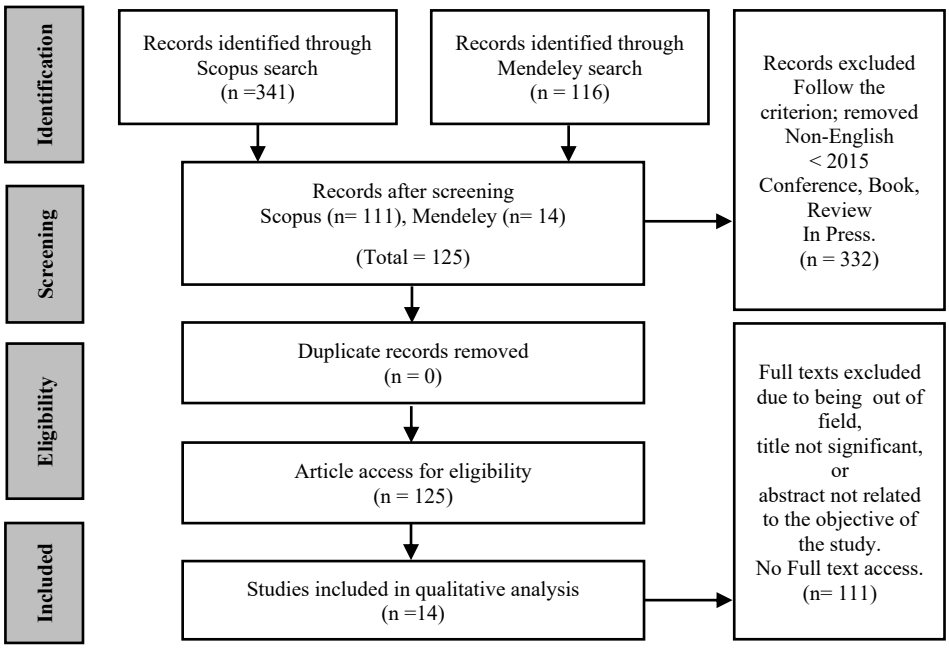


Figure 1: Flow diagram of the proposed search study for systematic literature review.
Source: Moher et. al., (2009)

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ANALYSIS AND DISCUSSION

Exploring the existing housing and sustainability research trends

The diagram in Figure 2 illustrates the co-occurrence of keywords in a body of literature that is related to sustainable housing. Figure 2 shows multiple phrase clusters that regularly appear together. For example, there is a cluster that includes terms such as "sustainable housing", "developing countries", "energy efficiency", "building", and "construction industry". This cluster suggests a body of research that focuses on how to construct sustainable housing. Another cluster includes terms such as "housing affordability", "stakeholder", "decision making", and "barriers". This cluster likely refers to research on the challenges of making SAH for low-income households in developing countries. Research on cutting-edge building materials, eco-friendly building techniques, and the incorporation of renewable energy sources to improve the sustainability of housing in both developed and developing nations may fall under this cluster. Researchers in this field probably observed how the building sector contributes to sustainable development and strives to solve issues that are unique to developing countries, such as scarce resources and infrastructural limitations. Researchers may also have examined frameworks and strategies for making decisions that are intended to overcome these obstacles and support the fair distribution of SAH options.

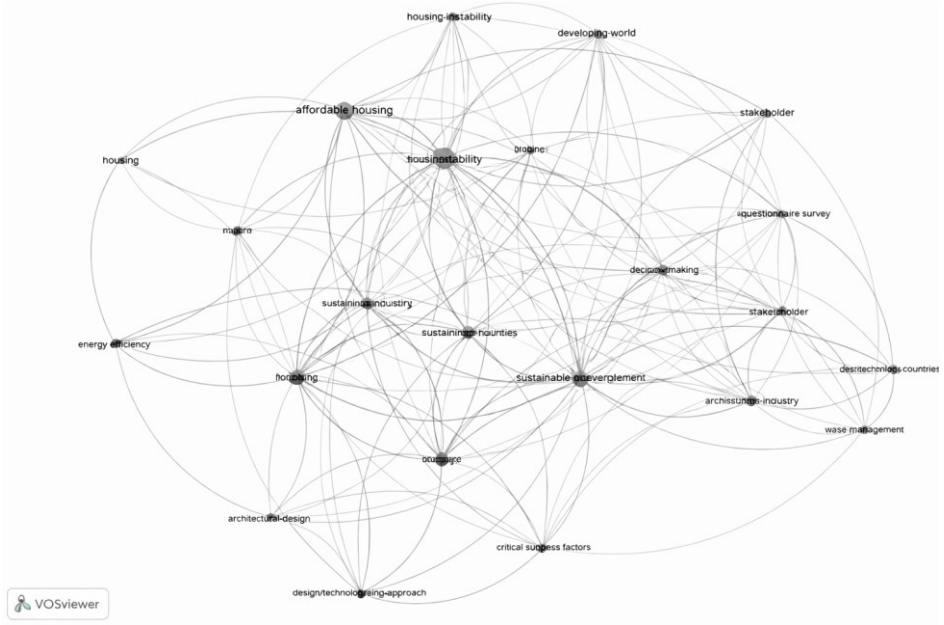


Figure 2: Visualisation of co-occurrence of keywords.

Figure 3 presents a three-field plot illustrating the relationships among author keywords, countries, and authors in housing sustainability studies. The plot depicts ten key author keywords, countries, and authors. Among the keywords, "sustainability", "sustainable housing", and "affordable housing" emerge as the most dominant themes, reflecting a strong scholarly focus on integrating sustainability principles with housing accessibility and affordability. In terms of geographic contribution, Hong Kong, Nigeria, and Malaysia appear as the most prominent countries, indicating significant global engagement in addressing sustainable housing challenges. Sustainability related studies are particularly influential in these countries, while research on affordable housing is especially prominent in Hong Kong and Malaysia. Sustainable housing also represents a major research focus in Hong Kong, followed by the United Kingdom and Nigeria, highlighting the global relevance and wide geographic distribution of research efforts in this field. The consistent contributions from Nigeria, Malaysia, and Hong Kong demonstrate a shared commitment to addressing housing-related challenges through sustainable approaches. Additionally, authors such as Oyetunji and Chan emerge as key contributors, reflecting their substantial influence on advancing knowledge in housing and sustainability research.

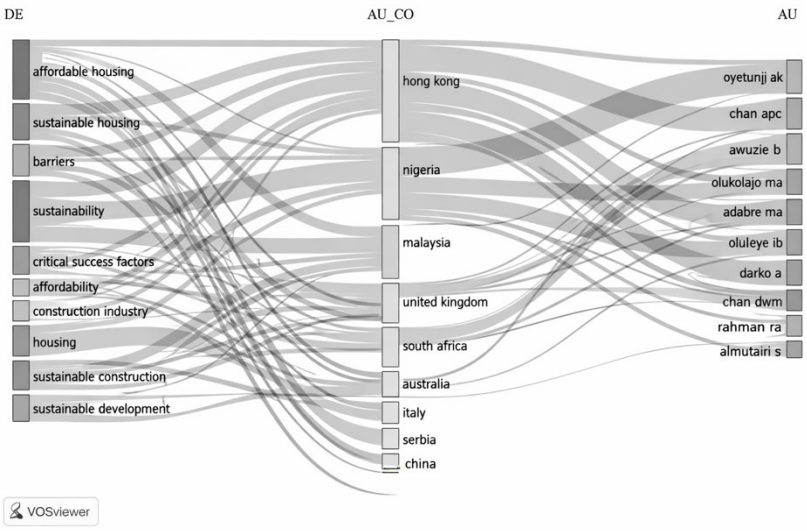


Figure 3: Visualisation of bibliographic coupling by authors.

The key obstacles to SAH development

In this study, the identification of key obstacles to SAH development was conducted solely through a SLR. Relevant articles were selected from the Scopus database based on predefined inclusion criteria to ensure the quality, relevance, and academic rigor of the sources. Each selected paper was then read and

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critically reviewed to extract and synthesise evidence related to barriers and challenges affecting SAH development. The SLR process involved a careful examination of empirical and conceptual studies to identify recurring patterns and dominant issues reported across the literature. This approach ensures that the findings are grounded entirely in a comprehensive and transparent review of existing scholarly evidence, thereby enhancing the credibility, reliability, and replicability of the study's results. Through this qualitative synthesis, three major obstacle categories were identified as follows:

a. Construction Innovation Inefficiencies

Inefficiencies in construction innovation pose significant challenges to the development of SAH. According to Reid (2023), innovative measures are crucial for addressing these inefficiencies, highlighting the need for sustainable and inclusive building practices, user involvement, eco-friendly homes, and improved training. Atta et al. (2021) emphasise the importance of developing decision support tools that are tailored for contexts with limited information, which can help decision-makers identify appropriate technological solutions. Without these tools, decision-making can be hindered, leading to delays and increased costs. Moghayedi et al. (2022) point out that the adoption of sustainability-oriented innovations is influenced by various factors. Inefficiencies in managing these factors can slow down the adoption of innovative construction technologies, thereby impeding the development of SAH.

Table 3: Summary of the Construction Innovation Inefficiencies Challenge

Authors	Methods	Result/Advantages
Reid (2023).	Exploratory data mining analysis	Innovative measures are desperately needed to solve the inefficiencies. Fixing affordable housing needs sustainable and inclusive building, user involvement, eco-friendly homes, and better training.
Atta et al. (2021).	Literature review	Suggesting the development of a decision support tool tailored for situations where information is limited. This tool would assist decision-makers in identifying appropriate technological solutions.
Moghayedi et al. (2022).	Structural equation modeling (PLS-SEM)	The need to prioritise and address external barriers to maximise the benefits of adopting sustainable innovations in construction.

b. Ineffective Policies

Ineffective policies pose significant challenges to developing SAH by contributing to several key issues identified in the referenced studies (see Table 4). These policies can lead to poor allocation of resources and corruption, as highlighted in the structural equation modelling approach by Adabre and Chan, (2021), which shows that political and procurement risks significantly impact the achievement of Sustainable Development Goals (SDGs) and influence all other

risk categories, namely, design and construction risks. Inefficiencies in policy implementation can result in regulatory barriers and delays, as noted by Adewunmi et al. (2023), who emphasise the importance of community visioning and public service improvement. Furthermore, Adabre et al. (2023) identify that potentially ineffective and counterproductive policies can hinder the success of sustainable housing projects. Additionally, Lea et al. (2021) stress the need for policies to account for climate change in Indigenous housing, suggesting that failure to integrate such considerations can lead to suboptimal housing solutions. Overall, ineffective policies can undermine efforts to create SAH by fostering an environment of mismanagement, inconsistency, and a lack of comprehensive planning.

Table 4: Summary of Ineffective Policies

Authors	Methods	Result/Advantages
Adewunmi et al. (2023)	Structural equation modeling (PLS-SEM)	A policy that requires community vision with an emphasis on public service improvement.
Adabre et al. (2023)	Qualitative & Quantitative	The success characteristics of mixed-use developments also have a big influence on sustainable housing. The results alert decision-makers to potential ineffective and counterproductive policies.
Lea et al. (2021)	Policy review & Interview	It is imperative that housing and health policies for Indigenous people take climate change into account.
Adabre et al. (2021)	Literature review Structural equation modeling (PLS-SEM)	Political and procurement risks significantly impact the achievement of Sustainable Development Goals (SDGs). This risk category significantly influences all other risk categories, with the greatest impact on design and construction risks.

c. Financial constraints

Financial constraints represent a critical obstacle to the development of SAH, as consistently reported in the literature (see Table 5). High construction and material costs directly increase housing prices, thereby reducing affordability for low- and middle-income households. (Oluleye et al., 2021) identify technology and cost-related barriers as major constraints, highlighting that financial limitations are closely linked to technological challenges and other structural factors. Similarly, Okoro et al., 2024) emphasise on the role of market dynamics, land supply and acquisition restrictions, and rising construction material costs as key financial pressures that undermine the provision of affordable housing.

Limited access to financing and credit further restricts developers' capacity to invest in sustainable design features, energy-efficient technologies, and durable materials, which often require higher upfront capital despite offering long-term cost savings. Spaan and Abraham, (2023) note that the lack of funding, compounded by complex regulatory and administrative procedures, significantly impedes affordable housing development. Moreover, weak financial incentives

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and subsidy mechanisms discourage private sector participation, prompting developers to prioritise conventional, cost-minimising construction approaches over environmentally sustainable alternatives.

Financial constraints also limit the retrofitting of existing housing stock, thereby constraining improvements in energy efficiency and environmental performance. Adabre et al. (2021) demonstrate that retrofit-related challenges are strongly influenced by incentive-related barriers that are, in turn, shaped by cost considerations, indicating a direct relationship between financial capacity and the implementation of sustainable housing solutions. Wang et al. (2020) identify government credit risks, legal and regulatory imperfections, and insufficient market income as significant financial risks in infrastructure and housing-related public–private partnership projects, which can delay or hinder sustainable housing development. These findings show that financial constraints undermine housing affordability by increasing development and purchase costs while simultaneously weakening sustainability outcomes by limiting the adoption of green technologies, retrofitting initiatives, and long-term resilience measures. Addressing these challenges therefore requires innovative financing mechanisms, targeted incentives, and supportive policy frameworks to facilitate the effective delivery of SAH.

Table 5: Summary of the Financial Constraints Challenge

Authors	Methods	Result/Advantages
Oluleye et al. (2021)	• Literature review • Factor analysis • Ranking and normalisation analysis	The 18 barriers to developing sustainable affordable housing can be simplified into six categories: **technology and costs**, knowledge and awareness, policy implementation, client/human factors, economic barriers, and environmental barriers.
Spaan & Abraham (2023)	• Semi-structured interviews	Recognised challenges, including a lack of funds, complicated regulations, and administrative obstacles.
Okoro et al. (2021)	• Systematic literature review • International expert Interview	The region's ability to provide affordable housing is at risk due to a number of reasons, including market dynamics, land supply and acquisition restrictions, construction material costs, unsupportive legislation, and technical and financial issues.
Adabre et al. (2021)	• Structural equation modeling (PLS-SEM)	Retrofit-related hurdles are significantly influenced by incentive-related barriers. Barriers connected to incentives were significantly impacted by barriers related to costs.
Wang et al. (2020)	• Literature review and in-depth case studies • Structured interviews	Government credit, legal and regulatory system imperfections, market income insufficiency, government approval delays, and fee changes are important risk considerations.

CONCLUSION

The findings highlight the need for governments to accelerate sustainable construction through policies that incentivise modern building methods and strengthen capacity-building initiatives. Supportive frameworks that encourage

collaboration between industry, academia, and public agencies are essential to promote the adoption of digital construction tools, such as Building Information Modeling (BIM), modular construction, and other resource-efficient technologies. Streamlining approval processes and supporting pilot or demonstration projects can further illustrate that environmentally sustainable construction practices can be implemented without compromising housing affordability.

The results also emphasise the importance of coherent and integrated governance structures in housing policy. Reducing regulatory fragmentation and improving inter-agency coordination are critical to ensuring that affordability and sustainability objectives reinforce one another rather than operate in isolation. Aligning national housing strategies with global development agendas, particularly the Sustainable Development Goals (notably SDG 11), provides clear policy direction, accountability, and consistency across scales. In addition, robust housing data systems and cross-sectoral planning linking housing with transport, environmental management, and social infrastructure can enhance the effectiveness and equity of urban development policies.

Furthermore, addressing financial constraints requires the mobilisation of innovative and inclusive financing mechanisms. Governments and local authorities can play a catalytic role by expanding public private partnerships, introducing targeted subsidies, and utilising tax-based incentives to reduce upfront costs and financial risks for developers. Integrated financial policies that incorporate risk-sharing arrangements and long-term incentives can attract private sector investment into sustainable housing initiatives. Innovative instruments such as green bonds, revolving funds, and concessional financing schemes offer further opportunities to simultaneously improve housing affordability, environmental performance, and long-term resilience.

Despite the growing body of literature on SAH, several critical research gaps remain, necessitating further investigation to advance empirical understanding, policy effectiveness, and practical implementation. Future research should further investigate the role of emerging technologies in enhancing the affordability and sustainability of housing, as existing studies remain largely conceptual or limited to small-scale applications. Digital construction methods such as BIM, three-dimensional printing, and prefabrication have demonstrated potential to improve efficiency, reduce material waste, and lower construction costs. However, empirical evidence on their long-term cost-effectiveness and scalability in affordable housing contexts remains limited (Ouda & Haggag, 2025). Similarly, the integration of renewable energy systems and smart-home technologies has shown promising results in improving energy efficiency and reducing carbon emissions, yet most findings are based on simulations or pilot-scale studies rather than real-world implementation (Bagdadee et al., 2025). Future research should therefore prioritise empirical

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investigations, including cost–benefit analyses of demonstration projects and living laboratories, to generate robust evidence on the economic viability and sustainability performance of these technologies in diverse housing contexts.

Longitudinal and comparative research is needed to address the limited understanding of how housing policies, financial models, and delivery mechanisms evolve over time and across regions, particularly in developing and emerging economies. Much of the existing literature relies on cross-sectional or single-country analyses, limiting insights into policy durability, institutional learning, and long-term outcomes (Muhammed et al., 2025). The use of long-term datasets, policy-tracking approaches, and cross-country comparisons would help identify the conditions under which SAH initiatives can be successfully scaled and adapted across different socio-economic and governance contexts.

This study underscores that advancing SAH requires an integrated approach that simultaneously addresses construction innovation, governance effectiveness, and financial constraints. The findings highlight the critical role of policy frameworks in accelerating the adoption of modern, resource-efficient construction methods, strengthening institutional coordination, and aligning national housing strategies with global sustainability agendas such as SDG 11. Equally important is the mobilisation of innovative and inclusive financing mechanisms, including public–private partnerships and risk-sharing instruments, to enhance affordability while supporting long-term environmental resilience. Despite growing scholarly attention, significant research gaps remain, particularly in the empirical evaluation of emerging technologies, the long-term performance of housing policies, and the scalability of sustainable housing models across diverse contexts. Addressing these gaps through robust empirical, longitudinal, and comparative research will be essential to inform evidence-based policymaking and support the effective delivery of affordable, inclusive, and sustainable housing globally.

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DIGITAL TECHNOLOGY ADOPTION FOR BUSINESS CONTINUITY IN REAL ESTATE AGENCIES DURING COVID-19

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Abstract

The COVID-19 pandemic disrupted real estate agency operations by restricting physical interaction, halting property viewings and forcing estate agents to work remotely. In response, many agencies adopted digital technologies to sustain operations, yet existing research offers fragmented insights into which technologies were adopted and how adoption supported business continuity at the agency level. This study addresses this gap through a qualitative systematic literature review guided by PRISMA, synthesising peer-reviewed studies published between 2020 and 2025. Content analysis was used to identify patterns of digital technology adoption and reported continuity outcomes in real estate agencies during the pandemic. The findings show that agencies primarily adopted operational and interaction-focused technologies, including virtual property tours, cloud-based communication systems, digital documentation and online transaction tools. These technologies supported business continuity by enabling transaction processing, remote coordination and sustained client engagement under movement restrictions. Advanced technologies such as blockchain and integrated PropTech platforms had a limited short-term impact due to cost, regulatory and organisational constraints. Overall, the study demonstrates that business continuity during a crisis depends more on functional fit and ease of integration than on technological sophistication. The findings contribute to planning and real estate literature by clarifying how digital technology adoption supported agency-level continuity during COVID-19 and by providing evidence-based insights relevant to policy, planning practice and real estate agency management in Malaysia.

Keywords: igital Technology, Real Estate Agencies, COVID-19, Business Continuity

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INTRODUCTION

The COVID-19 pandemic disrupted real estate agency operations by limiting physical interaction, suspending site visits and requiring agents to work remotely, particularly in Malaysia, where practice relies on face-to-face coordination (Lehan et al., 2020; Marona & Tomal, 2020). Existing studies report rapid adoption of tools such as virtual viewings, online platforms, cloud systems and digital marketing, but largely frame adoption around efficiency and customer experience rather than continuity of agency operations (Abu Bakar & Yaacob, 2020; Moro et al., 2022). Research rarely isolates real estate agencies or explains how specific technologies supported transaction continuity, remote coordination and operational survival during crisis, leaving fragmented guidance for planning and practice (Kosieradzka & Smagowicz, 2023; Al-Haimi et al., 2025). This study addresses this gap through a systematic literature review to identify the digital technologies adopted by real estate agencies during COVID-19 and to examine their reported impacts on business continuity at the agency level (Putritamara et al., 2023; Vigren & Tagliaro, 2025). This study is guided by the Technology Acceptance Model (TAM), which provides the analytical lens for interpreting digital technology adoption and its implications for business continuity in real estate agencies (Venkatesh & Davis, 2000).

Problem Statement

During the COVID-19 pandemic, real estate agencies in Malaysia faced operational strain from movement restrictions and remote work. Estate agents struggled to manage transactions, coordinate teams and maintain client relationships without physical interaction, thereby exposing weaknesses in informal coordination and manual processes (Lehan et al., 2020; Musa & Yusoff, 2022). Although digital use increased rapidly, existing studies focus on industry-level trends or isolated tools such as websites and virtual tours, with limited attention to how specific technologies supported agency operations under disruption (Moro et al., 2022; Al-Haimi et al., 2025). Evidence on how digital adoption influenced workflow stability, productivity, and business continuity at the agency level remains fragmented and unclear (Abu Bakar & Yaacob, 2020; Kosieradzka & Smagowicz, 2023). This gap impedes informed decision-making for practice and policy, underscoring the need for a focused synthesis of how digital technologies supported business continuity in real estate agencies during the pandemic (Putritamara et al., 2023; Vigren & Tagliaro, 2025).

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Objective

1. To explore the types of digital technologies adopted by real estate agencies during the COVID-19 pandemic.
2. To identify the reported impacts of digital technology adoption on business continuity in real estate agencies during the COVID-19 pandemic.

LITERATURE REVIEW

Pandemic Disruption and Real Estate Agency Operations

The COVID-19 pandemic disrupted real estate agency operations through movement restrictions, reduced market demand and constraints on physical interaction. Estate agents faced challenges maintaining transactions, coordinating work and engaging clients under lockdown conditions, exposing weaknesses in manual, face-to-face-dependent workflows (Nah and Siau, 2020). In response, agencies adopted digital technologies to support remote work, virtual interaction, and contactless transactions. However, existing studies broadly describe accelerated digital adoption without critically examining how adoption supports business continuity at the agency level, underscoring the need for focused analysis of technology adoption outcomes during crisis periods.

Digital Technology Adoption in Real Estate

According to Tihinen et al. (2016), digitalisation is widely recognised as a transformative force that is reshaping both society and business, with significant implications in the short, medium, and long term. Nawaz et al. (2024) explored how e-services are used in business marketing and how they improve the e-quality of goods and services. Here are some forms of technology that were especially valuable for real estate businesses during the pandemic disruption:

Artificial Intelligence (AI)

From a Technology Acceptance Model (TAM) perspective, the adoption of artificial intelligence in real estate agencies depends on perceived usefulness and perceived ease of use. Recent studies report high perceived usefulness, as AI supports automated valuation, market forecasting, customer segmentation, and targeted digital marketing, helping agents process information faster and reduce manual decision-making effort. AI-enabled chatbots and virtual assistants also enhanced perceived usefulness by sustaining client communication and personalised recommendations during periods of restricted physical interaction (Song, 2025).

However, perceived ease of use varies widely across agencies. Skill gaps, high implementation costs, data quality issues and limited organisational readiness reduce confidence in deploying AI tools into daily agency workflows (Kassa & Worku, 2025; White & Liptak, 2025). Where agents perceive AI

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systems as complex or difficult to integrate, behavioural intention to adopt weakens and actual usage remains limited. This gap between perceived usefulness and perceived ease of use explains why AI adoption supports business continuity only in agencies where systems align with existing practices and staff capabilities, reinforcing the relevance of TAM in understanding uneven continuity outcomes.

Virtual Reality and Augmented Reality

Virtual Reality and Augmented Reality emerged as practical tools for real estate agencies during periods of restricted physical interaction. Empirical studies show that VR-based virtual tours and 360-degree visualisation reduced dependence on site visits and supported continued property marketing during movement restrictions, particularly in Malaysia and comparable markets (Sahray et al., 2023; Yan et al., 2025). AR applications further enhanced client engagement by overlaying property information and spatial modifications onto real environments, thereby improving decision clarity and shortening transaction cycles (Sekar et al., 2024; Fan et al., 2025).

From a TAM perspective, adoption of VR and AR was primarily driven by perceived usefulness in maintaining client interaction and perceived ease of use through platform-based deployment that required minimal technical skills. Studies report higher acceptance when these technologies align with existing marketing routines and agent workflows, while adoption remained limited among smaller agencies facing cost, skill and integration constraints (Azmi & Ibrahim, 2022; Prema et al., 2024). These findings indicate that VR and AR supported business continuity primarily as accessible, task-oriented tools rather than as fully integrated operational systems, reinforcing the role of perceived usefulness and ease of use in shaping technology adoption under crisis conditions.

Blockchain

From a TAM perspective, blockchain adoption in real estate agencies depends on perceived usefulness and perceived ease of use. Existing studies report high perceived usefulness, as blockchain provides secure, tamper-resistant records, reduces fraud, and automates execution through smart contracts, especially for property registration and ownership transfer processes (Spiga et al., 2024). Evidence from Malaysian Industry 4.0 studies further shows that these benefits align with sector needs for traceability, transparency, and process reliability, particularly during operational disruptions (Azmi et al., 2025).

However, perceived ease of use remains low at the agency level. Research highlights regulatory uncertainty, lack of shared standards, weak integration with paper-based and legacy systems, and limited digital skills as significant barriers to routine use. Malaysian estate-related studies also note that

fragmented digital infrastructure and uneven organisational readiness reduce confidence in adopting advanced Industry 4.0 technologies within daily workflows. As a result, behavioural intention to adopt blockchain remains weak, and actual use among real estate agencies stays limited (Jasimin & Nordin, 2022; Yeoh et al., 2024). This imbalance between high perceived usefulness and low perceived ease of use explains why blockchain adoption has not translated into consistent support for routine agency operations or short-term business continuity during crisis periods, despite its strong theoretical potential.

Big Data

Big data adoption in real estate agencies is commonly explained through the TAM, where perceived usefulness plays a central role. Empirical studies show that analytics derived from online listings, transaction records and customer interactions improved market analysis, client targeting and pricing decisions, thereby strengthening agents' perception that big data enhanced job performance during disruption (Barbosa, 2021). During the COVID-19 pandemic, these perceived performance gains increased agents' intention to rely on data-driven tools when physical market signals weakened, and remote work became dominant (Almeida, 2025). However, perceived ease of use remained uneven across agencies, as fragmented data systems, limited integration, and low analytical capability reduced practical usage despite recognised benefits (Jiang, 2025). These findings indicate that big data adoption at the agency level depends not only on its strategic value, but also on usability and organisational readiness, consistent with TAM assumptions.

Internet of Things (IoT)

Internet of Things (IoT) adoption in real estate agencies has increased due to its perceived usefulness for remote property monitoring, digital property management, and service continuity during disruptions. Smart sensors, connected security systems, and automated maintenance tools allow agencies to monitor properties, manage utilities, and coordinate services without physical presence, which became critical during movement restrictions (Saari et al., 2022; Sing and Zhang, 2025).

From a TAM perspective, perceived usefulness drives IoT adoption where agencies recognise clear operational benefits, such as reduced maintenance delays, improved service responsiveness, and enhanced client confidence in managed properties (Fel et al., 2025; Kassa & Worku, 2025). However, perceived ease of use remains a barrier, particularly for small agencies lacking technical expertise or integration capability. Studies report uneven adoption due to system complexity, data interoperability issues, and cost concerns, which weaken behavioural intention despite recognised benefits (Xu, 2025; Yeoh et al., 2024).

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Overall, IoT adoption in real estate agencies aligns with TAM's core mechanism: adoption occurs only when operational value outweighs perceived complexity. This explains why IoT adoption supports continuity in property management functions but remains limited in transaction-focused agency workflows during crisis periods (Saari et al., 2022; Sing and Zhang, 2025).

Business Continuity and Digitalisation

Business continuity in digitally enabled organisations depends on the effective integration of digital technologies with organisational processes and capabilities. Recent studies show that digitalisation supports continuity by enabling remote operations, ensuring data availability and enabling rapid recovery during disruptions, particularly under volatile and uncertain conditions such as the COVID-19 pandemic (Rădoiu et al., 2024; Jaggernath-Furlonge & Pun, 2025). Digital tools such as cloud systems, data analytics and secure platforms strengthen operational resilience only when supported by precise continuity planning, cybersecurity readiness and leadership commitment (Lusiah & Parulian, 2025). Without these supporting structures, digital adoption increases exposure to risk rather than improving stability. The literature, therefore, positions digitalisation not as a standalone solution but as a continuity-enabling capability that requires alignment among technology, organisational readiness, and continuity governance to sustain performance during disruption.

Limitations of Existing Studies and Research Gap

Existing studies on digitalisation in real estate broadly describe the use of technology for efficiency, marketing or innovation, with limited focus on business continuity during crisis conditions. Most research examines digital tools in isolation, adopts broad industry-level perspectives, or concentrates on user perceptions, while rarely analysing real estate agencies as organisational units with distinct operational constraints. Evidence on how specific digital technologies supported transaction continuity, remote coordination, and agency survival during COVID-19 remains fragmented and uneven across contexts. Moreover, few studies apply a clear theoretical lens to explain why some technologies were adopted, and others were not, or how adoption translated into continuity outcomes. This gap highlights the need for a focused synthesis that identifies the types of digital technologies adopted by real estate agencies during the pandemic and critically examines their impacts on business continuity through an adoption-oriented perspective.

RESEARCH METHODOLOGY

This study employs a qualitative research design grounded in a systematic literature review (SLR). The method supports a structured and transparent

synthesis of academic evidence on digital technology adoption and business continuity in real estate agencies during the COVID-19 pandemic. A systematic approach strengthens rigour, transparency and replicability, which are required in planning and built environment research (Page et al., 2021). This study used a four-step mapping process, as depicted in Figure 1, to present a comprehensive methodology that, along with the previous work by Abdullah et al. (2023), offers further insights.

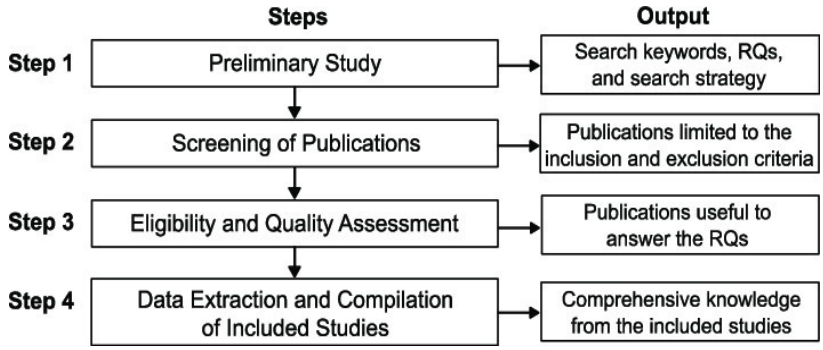


Figure 1: The Literature Study Mapping Process

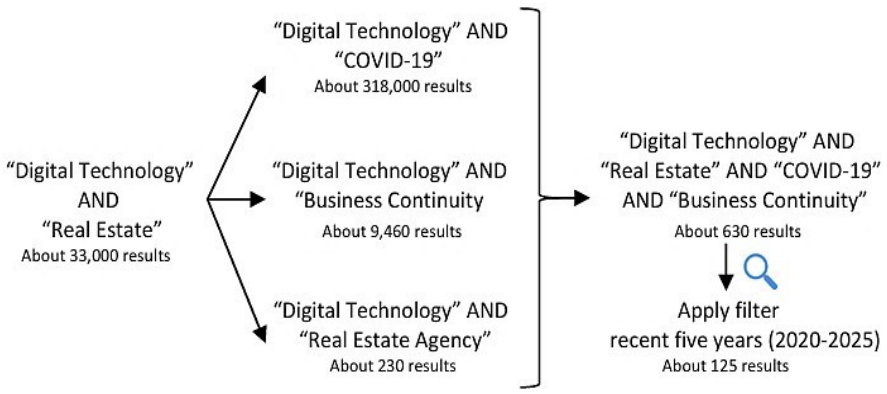


Figure 2: A Summary of Google Scholar's Keywords

Relevant literature was identified using established academic databases, including Emerald Insight, IEEE Explore, ScienceDirect, Scopus, SpringerLink, and Google Scholar. The search focused on peer-reviewed journal articles published between 2020 and 2025 to capture research conducted during and immediately after the pandemic period. Key search terms included "digital technology", "real estate agencies", "COVID-19" and "business continuity".

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Reference lists of selected articles were also reviewed to identify additional relevant studies.

Article selection followed the PRISMA 2020 guidelines to ensure transparency and systematic screening. Inclusion criteria comprised studies that examined digital technology adoption, digital transformation or digital practices in real estate agencies or closely related property sectors, with an explicit discussion of operational continuity, resilience or crisis response. Conceptual papers, empirical studies and systematic reviews were included. Studies focusing on unrelated industries, non-agency property actors or purely technical system design without organisational relevance were excluded. Figure 3 presents the PRISMA flow diagram outlining the identification, screening, eligibility and inclusion of studies reviewed in this research.

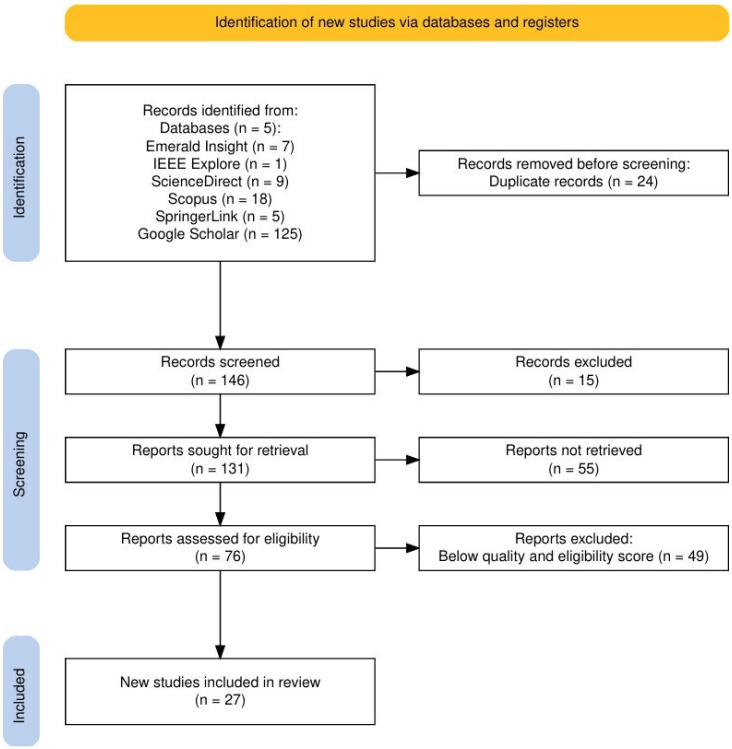


Figure 3: PRISMA Flowchart of the Systematic Literature Process

As illustrated in Figure 3, the initial database search yielded a broad set of records. Following duplicate removal and screening, only studies that explicitly examined digital technology adoption within real estate or closely related agency-based contexts during periods of disruption were retained. Full-

text assessment was conducted to ensure alignment with the research questions. The final set of selected studies served as the basis for qualitative synthesis and content analysis, enabling a structured examination of the adopted technologies and their reported impacts on business continuity at the agency level.

After screening and eligibility assessment, the final set of articles was analysed using qualitative content analysis. This involved coding and categorising data based on two analytical dimensions aligned with the research questions. First, the types of digital technologies adopted by real estate agencies during the COVID-19 pandemic. Second, the reported impacts of these technologies on business continuity, including transaction continuity, agent coordination, service delivery and operational stability. Themes and patterns were identified across studies through iterative comparison and synthesis. Figure 4 presents a flowchart of content analysis:

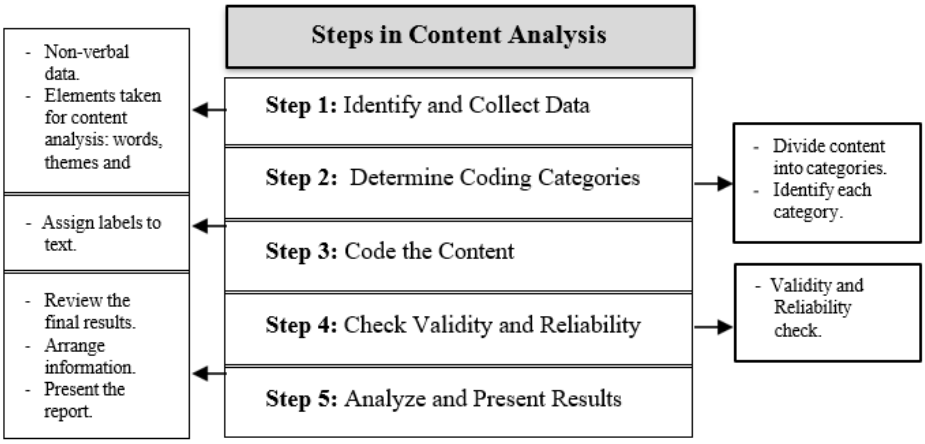


Figure 4: Content Analysis Flowchart

As illustrated in Figure 4, this study applied content analysis to systematically and transparently synthesise findings from the selected literature. The analysis focused on secondary sources, including peer-reviewed journal articles and academic publications related to digital technology adoption in real estate agencies during the COVID-19 pandemic. Relevant texts were examined using keywords related to digital technology, real estate agencies, business continuity, and pandemic disruption to ensure alignment with the research objectives.

To manage variation across studies, the reviewed content was organised into predefined analytical categories. These categories reflected the major types of digital technologies discussed in the literature, including artificial intelligence (AI), virtual and augmented reality (VR/AR), blockchain technology, big data

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applications and Internet of Things (IoT) solutions. This categorisation supported consistent comparison across studies and reduced interpretive bias.

Coding focused on identifying references to technology adoption and reported operational outcomes at the agency level. Text segments were coded based on the type of technology discussed and the nature of its reported impact on agency operations and business continuity. Frequency of occurrence and contextual interpretation were used to identify dominant adoption patterns and continuity-related outcomes.

Reliability and validity were addressed through consistent application of coding rules across all selected studies. Coding decisions were aligned directly with the research questions, ensuring stability and coherence throughout the analysis. Cross-checking themes across sources strengthened analytical credibility and supported internal consistency.

The synthesised findings were then organised and interpreted to highlight relationships between digital technology adoption and business continuity outcomes in real estate agencies. This approach enabled the study to move beyond descriptive reporting and develop an integrated understanding of how digital technologies supported agency operations during pandemic disruption. The results of this analysis are presented in the following section.

FINDINGS

The findings of this study are derived from a systematic synthesis of the final set of selected articles identified through the PRISMA-guided review process. The analysis focuses on two key dimensions. First, it identifies the types of digital technologies adopted by real estate agencies during the COVID-19 pandemic. Second, it examines the reported impacts of these technologies on agency-level business continuity. After that, the findings are organised with two analytical themes aligned with the research objectives. Theme 1 presents the types of digital technologies adopted by real estate agencies during the COVID-19 pandemic. Theme 2 reports the impacts of these technologies on business continuity at the agency level. The themes emerged from systematic coding and synthesis of the selected studies.

The following section identifies the types of digital technologies adopted by real estate (RO1).

Theme 1: Type of Digital Technology Adopted (RO1)

Table 1: Types of Digital Technologies Adoption

a) Core Operational Technologies		
Sub-Theme	**Description**	**Coding Indicators**
Digital documentation and e-contract Online transaction systems Cloud-based agency management systems Remote workflow and approval tool	To ensure the continuity of internal operations, transaction processing, and administrative activities when physical offices and face-to-face work were disrupted during COVID-19.	"digital documentation", "online transaction processing", "cloud-based system", "remote access to records", "electronic approval", "digital workflow continuity"
b) Digital Marketing and Online Platform		
Property portals and agency websites Social media platforms Digital advertising and SEO tools	To maintain market presence, generate leads, and engage clients when physical marketing channels and property visits were restricted	"online listings", "property portals", "social media marketing", "digital promotion", "online enquiries", "website-based marketing"
c) Virtual Interaction Technologies		
Virtual property tours (360°, 3D) Video walkthroughs Video conferencing tools Online client consultation platforms	To substitute physical interaction, enabling remote property viewing, client consultation, and negotiation during mobility restrictions.	"virtual property viewing", "3D/360-degree tour", "video walkthrough", "online consultation", "remote negotiation"
d) Data-Driven, Automation and Intelligent Technologies		
Data analytics and big-data tools Artificial intelligence (AI) applications Automated reporting and productivity systems	To include technologies that support data analysis, automation, productivity improvement and decision-making, enhancing efficiency and adaptive capacity during crisis conditions.	"data-driven decision-making", "analytics tools", "AI-based systems", "process automation", "digital productivity improvement"

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e) Emerging, Advanced and Strategic Digital Technologies		
- Blockchain and smart contracts - Internet of Things (IoT) - Smart Real Estate platforms - Integrated PropTech ecosystems	To capture advanced or experimental technologies with long-term strategic potential but limited short-term adoption during the pandemic due to cost, complexity and organisational readiness constraints.	"blockchain-based transactions", "smart contracts", "IoT enabled monitoring", "smart real estate system", "integration challenges", "high implementation cost"

The content analysis identified five dominant categories of digital technologies adopted by real estate agencies during the COVID-19 pandemic to sustain operational activities. These technologies were adopted to maintain operations amid movement restrictions, remote work and reduced physical interaction.

Artificial intelligence emerged as a key technology supporting agency operations. Studies report the use of AI-driven chatbots, automated customer response systems and data-assisted decision tools to maintain client engagement and support agent productivity during lockdown periods (Moro et al., 2022; Odebode et al., 2025). AI applications helped agencies manage enquiries, screen clients and support marketing decisions when face-to-face interaction was restricted.

Virtual reality and augmented reality were widely adopted to replace physical property viewings. Virtual tours, video walkthroughs and remote viewing tools enabled agencies to continue property marketing and client decision-making during mobility restrictions (Moro et al., 2022; Yan et al., 2025). These technologies supported transaction continuity by allowing buyers and tenants to evaluate properties without site visits.

Big data analytics supported market analysis and strategic decision-making during periods of uncertainty. Prior studies report the use of data-driven tools to analyse demand trends, pricing signals and client behaviour during the pandemic (Grybauskas et al., 2021; Tan & Miller, 2023). These tools helped agencies adjust marketing strategies and manage risk in volatile market conditions.

Smart home technologies and Internet of Things applications contributed indirectly to agency continuity. Studies highlight increased client interest in smart-enabled properties during the pandemic, which influenced marketing narratives and property valuation strategies (Ayimaa et al., 2025; Zhuang, 2025). Agencies leveraged these features to align listings with changing client preferences.

Blockchain technology appeared less frequently and showed mixed outcomes. While some studies report potential benefits for transaction

transparency and contract processing, adoption remained limited due to regulatory uncertainty and operational complexity (Jasimin & Nordin, 2022; Spiga et al., 2024). As a result, blockchain adoption did not consistently support short-term business continuity during the pandemic.

The following section reports findings related to the impacts of digital technology adoption on business continuity (RO2).

Theme 2: Impacts of Digital Technology Adoption on Business Continuity (RO2)

Table 2: The Impacts of Digital Technology Adoption

a) Operational Continuity		
Observed Impacts	**Description**	**Coding Indicators**
Continuation of daily agency operations Remote work enablement Reduced operational disruption	To capture the extent to which digital technology adoption enabled real estate agencies to maintain internal operations, workflows, and administrative functions during COVID- 19 disruptions.	"continuity of operations" "remote working arrangements" "uninterrupted workflows" "operational stability" "digital operations during lockdown"
b) Service Continuity		
Ongoing client engagement Continuity of property marketing and advisory services Maintenance of service quality	To reflect the role of digital technologies in enabling agencies to continue delivering services to clients, particularly when face-to-face interactions, property inspections and in-person consultations were restricted.	"continued service delivery" "virtual client engagement" "online consultation" "remote property viewing" "service continuity"
c) Revenue and Market Continuity		
Sustained lead generation Continued deal closure Reduced revenue decline	To capture how digital technology adoption supported income generation, lead flow and transaction completion, thereby reducing revenue loss during pandemic-related disruptions.	"sustained revenue" "online lead generation" "digital transactions" "continued sales activity" "market access during lockdown"
d) Adaptive and Strategic Continuity		

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Faster organisational response to disruption Process reconfiguration	The contribution of digital technologies to organisational adaptability allows agencies to reconfigure processes,	"adaptive response" "process reconfiguration" "strategic adjustment" "digital adaptation" "organisational flexibility"
• Strategic adjustment under uncertainty	adjust strategies and respond flexibly to rapidly changing conditions.	
e) Organisational Resilience and Long-Term Continuity		
Improved crisis preparedness Enhanced long-term resilience Strengthened business survival prospects	To capture the longer-term impact of digital technology adoption on organisational resilience, preparedness and the ability to withstand future disruptions beyond the immediate COVID-19 crisis.	"business resilience" "organisational survival" "crisis preparedness" "long-term continuity" "post-pandemic sustainability"

Digital technology adoption supported business continuity in real estate agencies through operational, service, and revenue-related mechanisms. Digital tools enabled agencies to sustain workflows under remote work, maintain client engagement without physical interaction, and continue transaction processing during movement restrictions (Lehan et al., 2020; Abu Bakar & Yaacob, 2020; Moro et al., 2022). Some studies also report adaptive effects, in which agencies reconfigured processes in response to prolonged disruption, although outcomes varied depending on organisational readiness and staff capability (Kosieradzka & Smagowicz, 2023; Bäcklund et al., 2024; Caon et al., 2025).

Overall, continuity outcomes differed by technology type. Operational and interaction-focused tools, including virtual tours, cloud systems, and digital documentation, showed the most consistent short-term benefits (Lehan et al., 2020; Moro et al., 2022; Langleron, 2023). Advanced technologies such as blockchain and integrated PropTech platforms delivered limited immediate value due to high costs, regulatory uncertainty, and low integration capacity (Jasimin & Nordin, 2022; Al-Haimi et al., 2025; Tan & Miller, 2023). These findings indicate that crisis continuity depends on functional fit and ease of integration rather than technological complexity alone (Putritamara et al., 2023; Vigren & Tagliaro, 2025).

The following discussion interprets the findings in relation to existing literature, technology adoption theory, and implications for planning practice and real estate agency management in Malaysia.

DISCUSSION

This study shows that digital technology adoption played a practical role in supporting business continuity in real estate agencies during the COVID-19 pandemic, particularly in Malaysia. Agencies prioritised technologies that replaced physical interaction and supported remote work, including virtual property tours, cloud-based communication systems and digital documentation tools. These technologies helped agencies maintain transaction workflows, sustain client engagement and reduce operational disruption under movement restrictions. The findings also indicate that continuity outcomes depended less on advanced or sophisticated technologies and more on functional fit, ease of integration and staff readiness. Technologies such as blockchain and integrated PropTech platforms delivered limited short-term value due to cost, regulatory uncertainty and low organisational preparedness. Overall, the discussion reinforces existing literature on crisis-driven digital adoption while extending it by highlighting real estate agencies as distinct organisational units. For planning, practice and agency management, the results emphasise the need to align digital adoption with operational processes and continuity planning rather than focusing solely on innovation or long-term competitiveness.

CONCLUSION

This study synthesised existing literature to examine how digital technology adoption supported business continuity in real estate agencies during the COVID-19 pandemics. The findings show that agencies relied mainly on practical, operation-focused technologies, such as virtual property viewings, cloud-based communication systems and digital documentation, to sustain transactions, coordinate remote work and maintain client engagement during movement restrictions. These technologies delivered the most immediate continuity benefits because they aligned closely with core agency workflows and required minimal structural change. In contrast, advanced technologies such as blockchain and fully integrated PropTech platforms offered limited short-term value due to high implementation costs, regulatory uncertainty and low organisational readiness. Overall, the study demonstrates that business continuity during a crisis depends less on technological sophistication and more on functional fit, ease of integration and organisational capability. The findings contribute to planning and real estate literature by clarifying which digital technologies supported agency-level continuity during disruption and by offering evidence-based insights relevant to policy formulation, professional practice and future crisis preparedness in the Malaysian real estate sector.

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ASSESSING GREEN ROOF IMPACT ON MENTAL HEALTH IN MALAYSIA VIA QUESTIONNAIRE BASED FREQUENCY ANALYSIS

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Abstract

Green roof implementation around the residence and workplace is beneficial in terms of improving mental health by enhancing mood, productivity and decreasing stress, depression, and anxiety. Various studies have shown the benefits of green roof in improving mental health but there are limited studies that shows the quantitative value of green roof and its attributes efficiency in improving mental health in Malaysia. Thus, the objective of this paper is to identify attributes of green roof that affects mental health and to assess the percentage of efficiency of green roof and its attributes in enhancing mental health among community. Quantitative approach was used via questionnaire survey within green roof residents and visitors to assess green roof capabilities in improving mental health. A total of 385 respondents participated in this survey which resulted in Cronbach's alpha value of 0.985. Then, the results are tabulated, and frequency and descriptive analysis is done to analyse the data. Questionnaire frequency analysis shows that green roof is 67% efficient towards improving mental health, and maintenance attribute recorded the highest percentage of efficiency towards the green roof effectiveness which is 11% followed by accessibility, distance, and size at 10%, and exposure, tree canopy, and facilities at 9%. This paper provides quantitative information and proof that green roof implementation does influence the mental health of the community and the productivity of green roof to provide such social benefits could be enhanced by focusing on the efficiency of the attributes as well.

Keywords: Green Roof, Greenery Exposure, Mental Health, Green Infrastructure.

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INTRODUCTION

Urbanization is increasing throughout the world, and people are moving to urban areas for a better standard of living. In relation to that, people in urban areas tend to face various types of environmental, economic, and social problems, which contribute to mental health issues such as stress, depression, anxiety (Trivedi et al., 2008). In relation with the rising mental health issues, many past researchers have emphasized the advantages of green space which leads to decreased anxiety, depression, and stress feelings (Macintyre et al., 2017). Greenspace is defined as a place that is covered with green plants, trees, and water on an open metropolitan space plant (Taylor and Hochuli, 2012). Green spaces provide numerous environmental, economic, and social benefits (Ab. Azis et al., 2019; Misni & Kamaruddin, 2015)

The introduction of green space in the form of green infrastructure in urban settings is one of the solutions for the mental health issues (Bajirao, 2015). Green infrastructure is a manmade infrastructure that has whole and partial natural structures such as vegetation, plants, and trees which includes green roofs, public parks, green walls, urban tree canopies, community gardens, and urban wetlands. However, looking into the characteristics of urban setting, which is filled with dense building infrastructure and a low supply of land area, the availability of greenery areas is limited. In Malaysia, Kuala Lumpur city is known to be a famous destination for urbanisation which also has high number of mental health issues according to recent surveys (Department of Statistics, 2023; Zaliha Mustafa, 2023). Therefore, introducing green roof as an innovative green infrastructure in urban settings is vital as an appropriate solution to reintroduce greenery areas in urban settings. The green roof implementation for the purpose of recreational and social activities has proven effective in conveying positive mental health for the visitors (Rezaei et al., 2021). However, none of these studies have quantified the quantitative value of green roof efficiency in Malaysia in terms of mental health improvement to the visitors and the attributes of green roof that plays a role in the successful implementation of green roofs.

Hence, this study aims to identify the green roof and its attributes efficiency in improving the mental health of the citizens in Malaysia from the perspectives of green roof residents and green roof visitors in Malaysia. A total of two objectives is derived in this paper to fulfil the aim of the study. The first objective is to identify the green roof attributes that affect the efficiency of green roofs. The second objective is to quantify the green roof and its attributes efficiency in improving mental health of the visitors. This study is designed to understand the hypothesis that green roofs can improve the community's mental health. This study contributes to the body of knowledge regarding the association between green roofs and mental health, which can serve as a reference and guide to the policymakers and developers in Kuala Lumpur, Malaysia. Lastly, this study

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also provides information and consciousness to the citizens regarding the benefits of green roof and its attributes in terms of mental health.

LITERATURE REVIEW

Mental Health

According to Galderisi (2015), mental health is a form of human health that is the state of a person's equilibrium emotion that allows them to live daily life with the people around them. According to the World Health Organization (WHO) common mental health symptoms include depression, anxiety, stress, schizophrenia, and bipolar disorder. Most of the person who is undergoing mental health issues tend to isolate themselves from society too, which makes them unable to communicate with anyone, and they would keep procrastinating about it every day, and this leads to the symptoms getting worst by day and in the long run it would affect their physical health too. These mental health issues should be addressed and improved to sustain a healthy community. From the perspective of this research, there should be an effective solution that needs to be implemented to reduce the probability of citizens being affected by these mental health symptoms.

Green Roof

The green roof is a roof fitted in a building that is covered with green vegetations. Green roof is an implementation of a green space wholly or partly on a surface of a building or a property. Green roof systems are fitted to the buildings for their aesthetical values by the developers, but they provide many other benefits in terms of environmental, economic, and social as well (Berndtsson, 2010). Furthermore, there are two types of green roof commonly known as extensive green roof and intensive green roof. The extensive green roof is generally placed on top of the building, which cannot be accessed, and the intensive green roof is placed either in the buildings or on an accessible rooftop. The intensive green roof generally has a higher depth of soil, higher cost of implementation, higher tree heights and eight as well as higher maintenance costs weight when compared to the extensive green roofs (Dunnett and Kingsbury, 2004). In terms of its mental health benefit for the citizens, intensive green roof could perform better due to its accessibility, which allows visitors to get greenery exposure, social interaction and indirectly promotes physical and mental well-being in a dense urban area that has limited green space (Jim, 2011).

Green Roof Benefits on Mental Health

The green roof provides various types of social benefits to the people and ecological benefits to natural habitats such as flora and fauna. There is a growing body of evidence which reports the positive association of green roof with the

physiological stability in humans such as better stress management, improved mood, and better attention to things due to its greenery view, and its appealing aesthetic view (Razaei, 2021). Meanwhile, several theories have emphasised the non-material benefits that could be gained by the citizens in the interaction and exposure to greenery environments such as the Attention Restoration Theory (ART) (Kaplan, 1995) and Stress Reduction Theory (SRT) (Ulrich, 1986). ART explains that citizens whom are in contact with the natural environment tend to have feelings that the environment is very fascination, it is extensive enough for them to feel like they are being very far from their daily stresses and compatible. Meanwhile, SRT explains that stresses in the daily life of citizens can be reduced by exposing and interaction themselves with the natural environment as it has the capability to improves a person's cognitive function which also leads to better clarity and improved mental health. The conceptual framework of this study is shown in Figure 1 below.



Figure 1: Conceptual Framework

RESEARCH METHODOLOGY

The objective of this study is achieved by using quantitative method approach. The first process is to identify the attributes that affect the green roof in improving mental health through the literature review process. As for the green roof and its attribute efficiency, a questionnaire survey is conducted on the green roof residents and visitors using the list of attributes collected from the literature review. The questionnaire survey is collected and analysed using descriptive analysis, which is the frequency analysis.

Study Area

The green roof residents and visitors in Kuala Lumpur are chosen as the they have the idea regarding the green roof, and they have experienced the environment of green roof so they would have a better understanding regarding the researched attributes. This research is conducted in Kuala Lumpur, which is the capital city of Malaysia and has the highest frequency of mental health issues in community which is 43% (Institute for Public Health, 2015). The selected green roof buildings that this research will focus on are The Saffron Sentul, Lot 10, Menara Binjai, One Utama Secret Garden, and Riana Green East Kuala Lumpur and The Maple Sentul which can has variation of green roofs and can be accessed for data collection. For the sample size, the number of people in the population is unknown as there is no readily available data regarding the number of population

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and number of visitors to the selected study area. Thus, the formula from Cochran (1977) is used to calculate the sample size that is required when the population in the selected study area is unknown or infinite. By determining p value of 0.5 with confidence level of 95%, the required sample size was calculated to be at 385.

Questionnaire Survey

The questionnaire survey aims to identify the percentages (%) of green roof and its attribute efficiency in improving mental health. The scale that is used in the questionnaire survey is the continuous rating scale which ranges from 0-100.0 being least efficient (%) and 100 being very efficient (%) The continuous rating scale, or in the online survey terms it is called as Visual Analogue Scale (VAS) is a method that is used to measure the changes in psychological terms in the body such as mood changes, stress, productivity, and feelings of a person daily and generally continuous rating scale is used on health-related studies. In the context of this questionnaire survey, the influence of the green roof attributes from the improvement and changes in the mental health of a person through green roof visiting is measured so the continuous rating scale which has higher choice of answer 1-100 is a better scale to be used for the respondents to rate the influence of the green and its attributes (Bradlow,2001). The questionnaire survey was conducted in respect with adherence to research ethics without harming any citizens, by obtaining consents, informing their rights and with integrity and confidentiality (Shamoo & Resnik, 2009).

Data Analysis

In the data analysis phase, a total of two procedures is undergone. The first phase is to test the validity and reliability of the questionnaire survey. Then, frequency analysis will be done to identify the information regarding the demographic profile of the respondents, the percentage of efficiency of green roofs and its attributes. The construct validity is determined by carrying out Exploratory Factor Analysis (EFA) and the reliability test is performed using Cronbach's alpha (Sekaran, 2009). The Statistical Package for Social Science IBM (SPSS) was used as a tool to carry out the analysis. Apart from that, the correlation between the attributes and the green roof benefits were also analysed to understand their relationships.

Every attribute has its percentage of efficiency, which contributes to this study's the overall green roof efficiency. Thus, it is essential to calculate the percentage of efficiency of each attribute that contributes to the overall green roof efficiency that will be analysed. To evaluate that, every attribute's average percentage of efficiency that will be analysed will calculated using the formula shown below which was adapted from the traditional percentage calculation formula but instead of multiplying the calculating component by 100%, the

percentage of green roof efficiency is used. This step of the calculation is carried out to ensure that all the analysed attributes efficiency is based on the overall green roof efficiency that is derived from the community and not assuming the green roof to be 100% effective in terms improving the mental health of the green roof residents and visitors.

$$\frac{EEa}{SaE} \times GrS$$

Where, EEa = Efficiency of Each Attribute (%); Sae = Sum of Attributes Efficiency (%); Grs = Green Roof Satisfaction (%)

RESULTS

As there is a lack of information regarding green roof attributes, the green space attributes are reviewed and used as an indicator for green roof attributes as well. This is because green roofs are a type of green space like parks, forests and gardens which share the same characteristics. A total of seven attributes were found from the literature that influence the level of efficiency of the green space's exposure, accessibility, distance, tree canopy, size, facilities, and maintenance. The exposure attribute explains the degree of exposure to the green space a person receives in a particular period. If green roofs exist in their residence, workplace and visited shopping malls, there be close to no benefits received from it if the community does not actually get the exposure of it (Feda et al., 2015; Lee and Lee, 2019). The second attribute is the accessibility to green space. Accessibility to green space defines the tendency to easily access or enter a green space environment without any restrictions for public use. Researchers concluded that less accessibility to the green areas tends to result in a higher tendency to experience mental health problems (Guite et al.,2006; Lo, 2003).

Moving on to the third attribute, which is the tree canopy that is defined as the measure of density of greenness on a particular place, whereby when a place has a higher tree canopy, it means that the place has a higher number of vegetation plants and trees. Recent studies portray that when the tree canopy in a particular area is higher in terms of trees, shrubs, grass, and flowers, it leads to the lesser impact on the mental health and could promote a harmony living of people (Astell-Burt & Feng, 2019; Feng, 2022). Furthermore, the size attribute also plays a key role in determining the efficiency of green spaces. Green spaces with larger sizes have greater impacts and influence on the betterment of mental health (Wood et al.,2017). Williams et al. (2019) explained that the benefits in terms of mental health conveyed by green spaces, such as green roof, is very critically affected by the size of the green roof. There are also the facilities attributes, which includes the availability of recreational facilities such as jogging

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tracks and places to sit and relax, which encourage social communication between citizens while enhancing their mental health as well (Wood et al.,2017). Citizens who perform their sports activities in an area that is covered with green are reported to have decreased stress, anxiety, and depression when compared to performing sports in a non-green environment (Pope et al., 2018).

Another attribute is the distance attribute, which is the distance of a person from the greenery area. When a person is closer to the green environment, their overall mental health condition seems to improve due to the higher tendency of exposure (James, 2016). Lastly, the maintenance attribute which compromises the security, maintenance, and cleanliness of the green space. The maintenance works that should be done to the green roofs include a good water supply for vegetation and plants in the green roof to ensure the process of evapotranspiration, which promotes and enhances the green roof function in providing ecosystem service benefits, fertilization to promote the growth and ensure the healthiness of the plant and to clean and trim unwanted vegetation and plant leaves and branches (Ismail et al., 2018; Lehmann, 2014). Overall, these are the attributes that has been identified that affects the level of efficiency of green spaces in the urban areas. As this research is focusing on green roof as a green infrastructure which has the same properties to provide green space for the citizens, these attributes are implicated in the context of green roof. There are seven attributes involved in enhancing the efficiency of green space providing green infrastructure such as green roof.

The process of determining the validity of items in the questionnaire is undergone, where a total of five panel experts are chosen to validate the items. The Scale-Content Validity Index Average (S-CVI Ave) value was 0.9, which means that the items met the validity criteria. Table 1 below shows the finalised green roof and its attributes, descriptions, and items that are used in the questionnaire in continuation from the content validation from the panel experts to quantify the percentage of efficiency of green roof and its attributes towards mental health.

Table 1: Green Roof and its Attributes Items

Green Roof	**Items**	**Reference**
Mental Health	Item 1: Stress Level Item 2: Anxiety Feeling Item 3: Depression Item 4: Well-Being	Grahn and Stigsdotter (2003); Dannenberg (2003); Macintyre (2017)
Green Roof Attributes	**Items**	**Reference**
Exposure	Item 1: Degree of Exposure	Feda et al. (2015); Lee and Lee (2019); Van Dillen et al. (2012)
Accessibility	Item 1: Easy Access Item 2: Free Access	Guite et al. (2006); Lo (2003) ; Feda et al. (2015); Lee and Lee (2019)

Distance	Item 1: Close to Residential Item 2: Close to Work Area	Roe (2013); James (2016); Wood et al. (2017)
Tree Canopy	Item 1: Large Woody Tree Item 2: Shrubs Item 3: Green Grass Item 4: Flowering Plants Item 5: Herbs	Astell-Burt and Feng (2019); Feng (2022); Weeland (2019)
Size	Item 1: Bigger Size	Wood et al. (2017); Williams et al. (2019)
Facilities	Item 1: Playground Item 2: Exercise Equipment Item 3: Jogging Track Item 4: Seat (Bench) Item 5: Roofed Hut Item 6: Swimming Pool Item 7: BBQ Area Item 8: Space for Event Item 9: Small Café Item 10: Vending Machine	Wood et al. (2017); Pope et al. (2018)
Maintenance	Item 1: Secured Item 2: Well-Maintained Item 3: Clean Environment	Ismail et al. (2018); Lehmann (2014)

As for the Exploratory Factor Analysis (EFA), Kaiser-Meyer-Olkin Measure of Sampling Adequacy value was 0.950 which validates that the sample size is enough to conduct EFA which is above the threshold of 0.5. The results were significant where $p < 0.05$. The analysis fruited one component which explained 74.72% of the total variation. As for the reliability test, the Cronbach alpha value for the exposure attribute was 1, accessibility was 0.846, distance was 0.813, tree canopy was 0.980, size was 1 as it has only one item, facilities were 0.964, security was 1 as well and maintenance was at 0.812.

Respondents Characteristics

A total of 385 responses was achieved after cleaning the data where missing data and incomplete responses were eliminated. The data consists of 154 (40%) female and 231 (60%) male respondents. Most of the respondents are green roof visitors in Lot 10 Kuala Lumpur with 92 (24%) respondents, followed by One Utama Secret Garden 85 (22%), Menara Binjai Ampang with 62 (16%) respondents, Riana Green East with 54 (14%) of them and The Maple Sentul and The Saffron Sentul has a frequency of 46 (12%) respondents each. The most common purpose of visit to the green roof is for the aesthetic and greenery environment, where 290 (70%) of the respondents enjoy the green roof for this purpose. Another purpose that gained a high percentage of frequency is recreational activity where 243 (63%) of the respondents visited the green roof for the purpose of carrying out the recreational activity.

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Green Roof and Mental Health

The green roof efficiency towards the mental health of green roof residents and visitors is measured from various perspectives such as its efficiency towards stress, anxiety, depression, and well-being. Table 2 below shows the results of the descriptive analysis of the green roof efficiency towards the mental health of the respondents. Every aspect of mental health, which is stress, anxiety, depression, and overall wellbeing was improved where stress level is believed to be reduced by 72% in the presence and visit to the green roof, followed by a reduction in anxiety feelings as much as 67%, not forgetting 61% reduction in depressive feelings and lastly 66% promotion in well-being.

From the results, it can be concluded that green roofs have 67% efficiency in improving the mental health of the community. This explains that in relation to visiting the green roof, the community has 67% of betterment in terms of their mental health in overall. However, the green roof efficiency varies according to its attribute's efficiency as well, and these should also be taken into consideration when evaluating the overall green roof effectiveness in improving the community's mental health.

Table 2: Descriptive Statistics of Green Roof and Mental Health

Green Roof Efficiency	Min (%)	Max (%)	Average (%)	Standard Error Mean (SEM)	Standard Deviation (SD)
Stress	22	100	72	1.029	20.19
Anxiety	21	100	67	1.056	20.72
Depression	25	100	61	1.181	23.17
Well-Being	33	100	66	1.086	21.31
Overall Green Roof Efficiency in Improving Mental Health	67 %				

Green Roof Attributes and Mental Health

A total seven green roof attributes were analysed in this stage according to their items. Table 3 below shows the results of the descriptive analysis of the green roof attributes efficiency. The exposure attribute recorded a 65% efficiency in enhancing the green roof efficiency in improving mental health. Apart from that, accessibility attribute contributes to the enhancement at an average of 68% efficiency. For the distance attribute an average of 69% efficiency is discovered. Moving on to the tree canopy, the items contribute to an average 65% towards the enhancement of mental health by the green roof.

Apart from that, the size of the green roof also mattered to the visitor's in influencing the mental health benefits that are portrayed by the green roof, where bigger size of the green roof contributes to 68% efficiency. Furthermore, the facilities that are available in the green roof area are analysed to understand the importance of these facilities in enhancing the green roof's environment for

the purpose of enhancing mental health. The ten facilities that are listed have efficiency and contribution towards the green roof at an overall average efficiency of 63%.Lastly, the highest contributing attributes is the maintenance attribute with an average percentage of efficiency of 72%.The respondents indicated that these attributes should be considered and should be given priority to ensure a successful green roof implementation for mental health improvement where there are three items listed which is secured (70%), Maintained (83%) and Clean (76%).These findings shows the green roof attributes plays a vital role in enhancing the green roof benefit in proving mental health improvement.

The results from the person's correlation analysis are shown in Table 4 below. Generally, all the attributes have positive correlation on providing mental health benefits but varies in terms of its strength of correlation and all of them are statistically significant too.

Table 3: Descriptive Statistics of Green Roof Attributes and Mental Health

Attributes	Items	Average Items Efficiency (%)	Standard Error Mean (SEM)	Standard Deviation (SD)	Average (%)
Exposure	1: Degree of Exposure	65	1.21	23.81	65
Accessibility	1: Easy Access	68	1.12	21.98	68
	2: Free Access	67	1.31	25.74	
Distance	1: Close to Residential	72	1.02	20.07	69
	2: Close to Work Area	66	1.25	24.44	
Tree Canopy	1: Large Woody Tree	65	1.22	24.00	65
	2: Shrubs	63	1.25	24.49	
	3: Green Grass	67	1.25	24.45	
	4: Flowering Plants	66	1.23	24.17	
	5: Herbs	63	1.29	25.40	
Size	1: Bigger Size	68	1.20	23.44	68
Facilities	1: Children Playground	62	1.23	24.22	63
	2: Exercise Equipment	63	1.27	24.93	
	3: Jogging Track	68	1.29	25.39	
	4: Seat (Bench)	68	1.38	26.98	
	5: Roofed Hut	63	1.06	20.71	
	6:Swimming Pool	53	0.76	14.85	
	7: BBQ Area	64	1.33	26.13	
	8: Space for Event	63	1.43	27.98	
	9: Small Café	67	1.37	26.97	
	10:Vending Machine	60	1.37	26.80	
Maintenance	1: Secured	70	1.26	24.74	75
	2:Maintained	83	0.78	15.23	
	3: Clean	76	1.16	22.76	

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Table 4: Correlation Between Green Roof Benefits and Green Roof Attributes

Variable	Pearson Correlation	Sig. (2-tailed)	N
Green Roof Benefits	1.000	—	385
Exposure	.820	.000	385
Accessibility	.825	.000	385
Distance	.854	.000	385
Tree Canopy	.901	.000	385
Size	.768	.000	385
Facility	.817	.000	385
Security	.651	.000	385
Maintenance	.774	.000	385

Green Roof and its Attributes Efficiency

Based on Table 5, every attribute has its percentage of efficiency, which contributes to the overall green roof efficiency, as shown in Table 2.To evaluate that, every attribute average percentage of efficiency is analysed and calculated using the formula shown in sub-section 3.4. Table 4 below shows the average percentage of efficiency of green roof attributes and overall green roof. The validated percentage of efficiency of the attributes is portrayed where the exposure, tree canopy and facilities attribute have a 9% effect on the green roof efficiency towards improving mental health followed by accessibility, distance and size attribute which has a 10% effect on green roof efficiency levels. The maintenance attribute recorded the highest percentage of efficiency towards the green roof effectiveness, which is 11%. Contrary to the conceptual framework of the study, the results shows that green roof together with the availability of all the listed attributes could provide mental health improvement benefits to the citizens.

Table 5: Average Percentage of Green Roof and its Attributes Efficiency

Attribute	Percentage of Efficiency (%)	Average Percentage of Efficiency (%)
Exposure	65	9
Accessibility	68	10
Distance	69	10
Tree Canopy	65	9
Size	68	10
Facilities	63	9
Maintenance	75	11
Overall Green Roof	**473**	**67**

DISCUSSION

The findings on the green roof and its attributes efficiency proves that there is a positive association between green roof and mental health improvement. Apart from that, it also aligns with the ART and SRT theory that proves that exposure

to green natural environment has impact on overall mental health and stress levels reduction. These findings also support the previous finding, which shows that the green roof attributes have an impact on the green roof benefits in improving the mental health of a person (James, 2016). Apart from that, the most common purpose of visits to the green roof is for its aesthetic greenery environment and for carrying recreational activities. This shows that green roofs provide great aesthetics to the environment and carrying out recreational activities in the green roof and green spaces is preferred compared to normal environments. These findings also are like previous studies which suggest that green roof also could be a platform for the public to carry out recreational activities in a modern way with supported benefits as the exposure to greenery which can concurrently reduce mental health issues (Rezaei et al., 2021).The overall green roof has been shown to have positive effects on the betterment of mental health symptoms such as stress, anxiety, depression, and overall well-being as well.

As for the green roof attributes, the results shows that every attribute, which has its own characteristics and functions, has an independent role in enhancing the overall green roof effectiveness in improving mental health in the community. Maintenance is reported to be the highest impacting attribute compared to others. This is because, a green roof that is filled with all the necessary attributes and facilities would not perform in its peak productivity if it is not cleaned or maintained after implementation. Poor maintenance also demotivates citizens to visit the green roof and it will subsequently lose its implementation objective. Thus, the results suggest that maintenance should be considered as a priority for the green roof to be at its highest and best use capacity and to achieve the aim of implementation (Ismail et al., 2018). The findings on the green roof and its attributes effectiveness can be a guide and referral for planners, developers and policymakers in promoting and implementing green roof in urban areas concurrently increasing the availability of green spaces.

There are some limitations that is present in this study. Firstly, there is a sampling bias where the study respondents in this study are from the general community that are living in properties with green roof and the green roof visitors, where not all of them were facing mental health issues at the time of the survey or prior to the time of the survey. Secondly, there is a location restriction limitation existed where this study only focused on visitors and residents in six places in Kuala Lumpur due to the unavailability of access to the respondents in other properties that have green roofs. Despite these limitations, this paper provides substantial information that green roof has the ability and performance to the improve mental health condition of the community in Malaysia. There is also a need to research the association of these listed attributes to the already existing green roofs in Malaysia for enhancing its benefits and to understand better the green roof benefits in the mental health improvement aspects and to

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understand the latest state of mental health conditions of people living in the urban areas such as Kuala Lumpur.

CONCLUSION

In conclusion, this paper quantified the percentage of efficiency of green roofs together with their attributes efficiency in improving mental health. Generally, green roof is 67% efficient in improving mental health of the citizens. The most notable reduction in mental health symptoms was stress levels, according to the visitors. As for the green roof attributes efficiency, the most important green roof attribute is the maintenance of the green roof and there are also accessibility, distance and size that should be focused in the green roof implementations. This study contributes to the body of green infrastructure knowledge in which it provides a quantitative value of green roof's social benefit in improving mental health. The federal, state government and non-profit making organization bodies such as the Ministry of Finance Malaysia (MOF), Ministry of Economy Malaysia (MOE) and Malaysia Green Building Council (MGBC) can use the information gathered and analysed in this study as a guidance to encourage the implementation of green roof in Malaysia especially in the urban cities which has benefits in improving the mental health of the citizens. Apart from that, the green building policy creation and amendment also could be done by using this study results as the baseline and guidance.

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PLANNING AND MANAGEMENT BARRIERS IN MARINE PARK ISLAND GOVERNANCE: INSIGHTS FROM EAST COAST PENINSULAR MALAYSIA

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Abstract

Local authorities in many countries serve local communities by facilitating and maintaining public amenities. Apart from that, local authorities also manage the planning and development of local tourism. A tremendous number of responsibilities and work are burdening local authorities to manage the planning and development of tourism islands. This research aim is to identify management barriers faced by local authorities managing the Peninsular Malaysia Marine Park Islands. The results were obtained from in-depth interviews with the four local authority officers and document analysis. The local authorities are Majlis Bandaraya Kuala Terengganu (MBKT) for Redang Island, Majlis Daerah Marang (MDM) for Kapas Island, Majlis Daerah Besut (MDB) for Perhentian Island and Tioman Development Authority (TDA) for Tioman Island. Two officers from each local authority were interviewed. The officers are from the Department of Town Planning and the Department of Municipal Services and Licensing. Altogether, nine officers were interviewed. Several barriers have emerged from the analysis. The results indicated that six barriers are common, and three barriers are specific to the departments. The common barriers are a lack of funding, a lack of staff, time constraints, substantial distance from the mainland and a lack of commitment from top management and a lack of intergovernmental coordination/collaboration. This research can be extended to marine parks located in Sabah and Sarawak, and a comparative study can be accomplished for further improvements in the planning and management of the MPIs.

Keywords: Management Barriers, Marine Park Islands, Town and Country Planning, Municipal Services and licensing

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INTRODUCTION

Malaysia is a rich country with marine biodiversity assets such as colourful coral reefs and marine fish. In Peninsular Malaysia, 42 Marine Park Islands (MPIs) are gazetted and managed by the Marine Park Department under the Ministry of Natural Resources and Environment. East Coast Peninsular Malaysia's MPIs are managed in a three-tiered system. Top management is the Federal Government, followed by the State Government and then the Local Government. The Federal Government's task is to formulate policies related to Marine Parks. Two relevant Acts are the Environmental Quality Act 1974 and the Fisheries Act 1985.

The second government level is the State Government. The State Government has the authority to make decisions for the development, planning and promotion of the MPIs. State Governments formulate Structure Plans as a reference for local authorities to formulate District Local Plans. State Structure Plans lay strategies and programs for the development of MPIs for each state. State Governments prepare regional and structure plans in accordance with the National Physical Plan (2005) under the Town and Country Planning Act (1976). The third level of government is the local authority. The Ministry of Housing and Local Government is a federal agency that plays a major role in coordinating and managing funds of local authorities across Peninsular Malaysia. The secondary purpose of local authorities is to look after the planning and management of MPIs.

In conclusion, Federal, State and Local authorities are responsible for developing, managing and promoting MPIs in Peninsular Malaysia. The Federal Government is in charge of MPI's marine affairs. The State Government is in charge of MPI's land affairs. Meanwhile, local authorities are in charge of MPIs' land development, management and maintenance of the public amenities. Among the three government levels, local authorities play significant roles in the success of the tourism industry at the MPIs (Abdul Khalid et al., 2013).

A tremendous amount of responsibilities and work burden local authorities to manage the planning and development of tourism islands (Safuan et al., 2022). Several studies have discussed the barriers local authorities face in many countries. However, studies regarding barriers faced by Peninsular Malaysia's local authorities in managing East Coast Peninsular Malaysia MPIs are limited.

The objective of this paper is to identify barriers faced by local authorities in managing East Coast Peninsular Malaysia MPIs. The outcomes of this paper will help local authorities manage the MPIs properly.

LITERATURE REVIEW

Local authorities in many countries serve local communities by facilitating and maintaining public amenities. Apart from that, local authorities also manage the planning and development of local tourism. Several studies have discussed the

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barriers local authorities face in many countries (Table 1). However, studies regarding barriers faced by local authorities in managing East Coast Peninsular Malaysia MPIs are not available.

Table 11: Studies on the Barriers Faced by Local Authorities in Managing Marine Tourism Areas

Authors	**Country involved**	**Barriers faced by local authorities in managing marine tourism areas**
Connor, et al (2010)	Ireland	• Negative political Influences-Lack of commitment of top officials. • Insufficient technical expertise –Frequent personnel transfer. • Limited financial resources.
Dredge, et al (2011)	Australia	• Too many local government bodies. • Lack of financial resources. • Frequent movement of staffs among departments. • Tourism industry not priority for local government. • Lack of experts' staffs.
Liu, et al (2011)	Taiwan	• Management authority- Existing laws not sufficient and consistent. • Management capacity and resources- Lack of resources (financial, facilities, manpower). • Officials' commitments - Lack of political commitment. • Lack of intergovernmental coordination and collaboration.
Yates, et al (2013)	Northern Ireland	• Too many policies, legislation, best practices, and guidelines from all levels of governments. • Lack of staff. • Lack of financial capacity. • Lack of communication and cooperation between departments.
Brokaj (2014)	Albania, Vlora	• Limited enforcement. • Weak capacity • Lack of resources • Lack of coordination between departments. • Overlapping of functions and duties between departments. • Lack of reliable information about the tourism industry.
Saad, et al (2014)	Malaysia Perak	• Shortage of skilled workers. • Overlaps in jurisdiction between local government. • Lack of development funds.
Siti Nabiha, et al (2015)	Malaysia	• Lack of stakeholder involvement.

Authors	**Country involved**	**Barriers faced by local authorities in managing marine tourism areas**
	Penang Island	• Unclear roles and functions of the LA in tourism planning. • Different points of view between various agencies. • Weak communication between agencies.
Ramirez (2016)	Colombia	• Lack of harmonisation between policies. • Lack of consensus and coordination among organisations. • Lack of financial, technical, control and surveillance capacity • Lack of participatory mechanisms between community and government.
Brooks, et al (2016)	Australia	• Lack of coordinated planning and action of local authorities. • Lack of financial resources. • Lack of political motivation.
Botero, et al (2020)	Colombia	• Lack of knowledge and skills on managing tourism islands • Lack of fund from main government • Negligence from local authorities • Frequent changes of political powers
Safuan, et al (2022)	Malaysia, Terengganu Islands	• Too many laws and overlapped jurisdiction between federal and state government on the marine islands

One of the main obstacles identified is the lack of resources such as funds, expertise and time. The majority of the studies agreed that lack of resources is a common barrier (Abdul Khalid et al., 2013; Brokaj, 2014; Liu et al., 2011; Ramirez, 2016; Yates et al., 2013). Regarding the lack of funds, local authorities receive funds from the State and Federal Governments. The majority of the funds are allocated for core activities rather than tourism activities. For example, local authorities in Peninsular Malaysia are under the purview of the Ministry of Housing and Local Government. The majority of the funds are allocated for the development and maintenance of public facilities located on the mainland.

Local authorities in many countries are facing a lack of administrative staff and expertise (Abdul Khalid et al., 2013; Dredge et al., 2011; Yates et al., 2013). Local authorities usually lack expertise in the area of tourism planning and management. The numbers of staff hired are usually limited due to budget constraints. Moreover, the frequent movement of officers among departments further reduces the expertise (Abdul Khalid et al., 2013; Dredge et al., 2011).

Time constraint is another common barrier faced by many local authorities (Khalid et al., 2013; Borja, 2010). Local authorities have various tasks

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to fulfil. Huge amounts of work with few staff can cause time constraints for officers to perform enforcement and monitoring of remote areas, such as islands.

The next barriers are overlapping jurisdiction and lack of collaboration between government agencies in managing and promoting marine tourism (Liu et al., 2011; Safuan et al, 2022). Three-tiered government structures with various tourism units are leading towards overlapping efforts and ineffective use of resources (Brokaj, 2014). Sometimes, the overlapping of roles results in ignorance of problems, where agencies start to point fingers at each other as being responsible.

The lack of collaboration between local authorities is well known. Most local authorities are adopting '*go-it-alone'* policies (Dredge et al., 2011). Sharing of knowledge, information and resources between adjacent local authorities and stakeholders can help to manage tourism areas in more efficient ways and solve problems more systematically. Insufficient consultations between local authorities and stakeholders resulted in a lack of collaboration.

Other barriers identified are inappropriate, outdated, and inconsistent legislation of the marine tourism industry (Liu et al., 2011; Ramirez, 2016). The federal government is responsible for formulating tourism policies to be implemented by local authorities. Usually, tourism policies are formed without the integration of local communities and stakeholders' opinions and interests. In many countries, policies are created to benefit the government, not stakeholders.

In some countries, such as Australia, the UK, Malaysia, and the Philippines, some marine tourism policies and bylaws were formulated in the 1970s and 1980s. Since then, the Laws and Acts have not been updated. Outdated marine laws are not suitable for solving new emerging issues for the marine tourism industry.

The last barrier identified is the lack of commitment from top management because tourism and sustainable tourism are not a core business of most countries' local authorities. In Malaysia, sustainable tourism development and planning are still not considered the main agenda among the local authorities. Therefore, there is a lack of enforcement and monitoring at the marine tourism islands.

In conclusion, the discussions above indicate that local authorities of various countries face many barriers in managing marine tourism areas. Therefore, to fulfil the literature gap, this study's fourth objective is to determine the management barriers faced by Peninsular Malaysia's local authorities in managing the four MPIs.

RESEARCH METHODOLOGY

This study was conducted in Peninsular Malaysia and focuses on the East Coast Peninsular Malaysia's MPIs. Four MPIs were chosen for investigation. The

islands are Kapas Island (Terengganu Marine Park), Perhentian Kecil and Besar Island (Terengganu Marine Park), Redang Island (Terengganu Marine Park) and Tioman Island (Pahang Marine Park). These four MPIs are the most populated and developed with tourism accommodation facilities. This study conducts qualitative research. This study employs semi-structured interviews because it lies between structured and unstructured interviews which is considered the most appropriate technique (Sarantakos, 2005). According to Robson (2002), semi-structured interview questions are usually pre-determined, but the order and wording can be omitted or added during the interview session, depending on the situation. All the interviews were conducted by taking notes and with the aid of a tape recorder. All the interviews were conducted in Bahasa Malaysia due to the official language. The interviews were recorded verbatim and analysed using ATLAS.ti. The interview was conducted to identify management barriers faced by the local authorities in managing the MPIs. MPIs in Peninsular Malaysia are managed by the local authority in terms of solid waste management and planning matters. The departments involved are the Department of Municipal and Health Services and the Planning Department. Officers from the related local authorities were interviewed. The lists of the officers interviewed are shown in Table 2.

Table 2: Details of the Local Authorities Officers Interviewed

MPIs	**Department**	**Interviewees**	**Position**
Kapas Island Majlis Daerah Marang (MDM)	Town Planning Division	Respondent 1	Asst. Town Planner
	Urban services and Licensing Division	Respondent 2	Asst. Environmental Health Officer
Perhentian Island (Kecil and Besar Island) Majlis Daerah Besut (MDB)	Building Control	Respondent 1	Asst. Engineer
	Department of Licensing-SWM	Respondent 2	Asst. Environmental Health Officer
Redang Island Majlis Bandaraya Kuala Terengganu (MBKT)	Town Planning Division	Respondent 1	Town Planner
	Department of Licensing- SWM	Respondent 2	Asst. Environmental Health Officer
Tioman Island Lembaga Pembangunan Tioman (LPT)	Department of Planning and Development	Respondent 1	Manager of Planning and Development Division
	Department of Municipality and local government	Respondent 2	Asst. Manager

The study was answered by analysing the interview transcripts using ATLAS. ti coding. Figure 1 indicates step-by-step procedures adopted to answer the study question. The barriers faced by the related local authorities are identified using priori and emergent coding. Priori coding is the code that has been predetermined from the literature (Talib, 2013). The six priori codes

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identified from the above literature were lack of resources, overlapping of jurisdiction, lack of collaboration, outdated legislation, lack of commitment from top management and lack of enforcement. Meanwhile, emergent coding is the code that emerged after analysing the transcripts (Talib, 2013). The emergent codes are known as specific barriers, whereas Priori codes are identified as common barriers. These codes will be discussed in the analysis section.

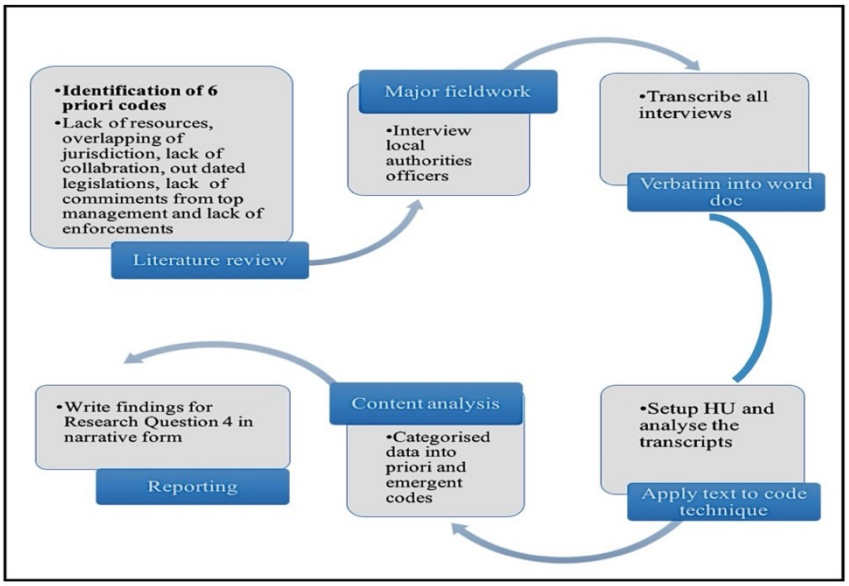


Figure 12: Procedures for data analysis using ATLAS.ti

ANALYSIS AND DISCUSSION

The study findings were obtained from in-depth interviews with the four local authority officers and document analysis. Altogether, nine officers were interviewed. Several barriers have emerged from the analysis. The results indicated that six barriers are common, and three barriers are specific to the departments. Table 3 indicates the common and specific barriers.

Table 3: Summaries of The Management Barriers Faced by the Local Authorities in Managing the Four Islands

No	Departments	Common Barriers	Specific Barriers
1.	**Town Planning**	1. Lack of funding 2. Lack of staff 3. Time constraint 4. Substantial distance from the mainland 5. Lack of commitments from top management	1. Illegal construction and extension 2. Lack of development plans and programs for islands 3. Lack of involvement and communication with chalets operators
2	**Municipal Services and Licensing**	6. Lack of intergovernmental coordination/collaboration	1. Careless attitudes of waste contractors 2. Lack of support from operators in reducing waste on the islands 3. Small and unsuitable waste boats

Common Barriers

Both departments of the local authorities are facing several common barriers in managing the four MPIs. The barriers are a lack of funding, a lack of staff, time constraints, substantial distance from the mainland, a lack of commitment from top management, and a lack of intergovernmental coordination and collaboration.

1) Lack of Funding

Lack of funding is the most common barrier identified throughout the literature (Abdul Khalid et al., 2013; Brokaj, 2014; Liu et al., 2011; Ramirez, 2016; Yates et al., 2013). Analysis of the interviews indicates that local authorities have limited funds. Funds are available for local authorities to carry out their core responsibilities. For example, the MDB planning officer said: "The *Council always have a limited budget"*. While the MBKT Licensing officer put it: "*We have a budget, but always limited*". Moreover, the LPT planning officer informed: "*We do not have enough capital to maintain public amenities on the island".* All the officers reported that local authorities do not have sufficient funds to develop and maintain public amenities on the islands. The reason is that local authorities receive funds from the State Government. Most funds provided by the State government are for core activities on the mainland, such as the development and maintenance of roads, transportation facilities, drainage systems, recreational areas, and garbage disposal. This was supported by the MBKT officer. According to him, *"We have to give priority to the maintenance of the public facilities on the mainland compared with the island because the mainland is our primary responsibility".* Only extra capitals are utilised to

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maintain the public amenities on the islands. Observations on the islands also indicate that local authorities are putting less effort and funds into the development and maintenance of the public amenities on the islands. For example, existing public toilets are not maintained. Some beaches have no public toilets, waste bins, proper landscape areas, seating, or pedestrian walkways. Thus, it can be suggested that the State Government should allocate separate development and maintenance funds for local authorities to utilise for the development of the MPIs.

Another significant finding was that the Department of Marine Park Malaysia (DMPM) receives Marine Park entrance fees. Four local officers address their concerns regarding the entrance fees. According to them, local authorities should collect the marine park entrance fees because local governments oversee the development and maintenance of the amenities on the islands; meanwhile, DMPM's task is only to protect and conserve the marine biodiversity. Split jurisdiction between the local and the federal government in managing MPIs is creating many problems regarding management and fund distribution. Local authorities' officers suggested that local authorities should be entirely in charge of the MPIs' development, management, taxes and entrance fee collections. Consequently, this will ease local authorities in managing the islands properly.

2) Lack of Staff

Concerning the lack of staff, all the officers stated that this is the most significant barrier. According to Rahimi Abidin (2025), resource constraints such as a lack of manpower are one of the barriers on the Tioman island. Discussions with the officers indicated that only one officer from each department oversees the planning and solid waste management of the islands. Moreover, the same officer oversees managing mainland matters. The MBKT planning officer said, "*Currently, our department has a shortage of staff. I'm alone in charge of the planning matters for the mainland and Redang Island."* While the MDB planning officer informed, *"I'm alone in charge of the Perhentian Island and the Besut district".*

The Department of Municipal Services and Licensing are having a similar problem. As the MDB officer informed, *"I'm alone tasked to monitor the cleanliness of the Perhentian Kecil and Besar Island".* Meanwhile, the TDA officer stated: *"I need more staff to visit all the villages on Tioman Island to see whether the waste contractor is doing his job properly"*. These findings indicate that a lack of staff is making monitoring, inspection and enforcement difficult. Therefore, many issues arise on the MPIs, such as illegal extension and development, destruction of ecological assets, dredging, contamination of water bodies, excessive disposal of garbage in the sea and forest area, open burning,

land clearing and damage to public amenities. The finding agrees with the previous studies, which mentioned that a lack of staff is a significant barrier (Abdul Khalid et al., 2013; Marang, 2014; Yates et al., 2013). State governments are responsible for hiring staff for local authorities. Therefore, it is the state government's responsibility to appoint more staff for better management of the islands.

3) Time Constraint

In terms of time constraints, all the officers stated that they are very busy conducting regular inspections and monitoring the islands because their main tasks are to provide services to the public on the mainland. As the MBKT planning officer put it: *"Planning staff usually are very busy because they have to handle planning applications on the mainland"*. The MDM planning officer said: *"Site inspections are not conducted frequently on the island because our primary responsibilities are on the mainland. Moreover, we have a shortage of staff"*. Moreover, the TDA Licensing officer informed: *"We lack staff. Therefore, we do not have enough time to monitor all the areas on the island".* These findings indicate that the time constraint barrier is strongly related to the lack of staff barrier. The result is also consistent with the previous literature (Khalid et al., 2013; Brokaj, 2014). Local authorities need to have more staff, and staff need to be appointed specifically for the management of the MPIs to overcome the time constraint barrier.

4) Substantial Distance from the Mainland

Substantial distance from the mainland is also identified as the primary barrier for some local authorities. Substantial distance from the mainland hinders officers from doing frequent monitoring and enforcement. However, officers have no problem conducting frequent inspections of islands located near the mainland.
For example, MDM (Kapas Island) and TDA Branch (Tioman Island) officers have no difficulties conducting frequent monitoring compared to MBKT (Redang Island) and MDB (Perhentian Island) officers. Therefore, substantial distances from the mainland impede monitoring and enforcement. Consequently, to overcome this barrier, local authorities should hire officers to stay on the islands to do frequent monitoring.

5) Lack of Commitment from Top Management

Malaysia uses the Westminster system, where the head of State is a Minister appointed by the Sultan from the winning party. Different ministers have different mandates and directions. Some ministers might have a strong vision to develop a State as a tourism hub, while others may have the idea to develop a State as an industrial hub. A five-year period for ministers is a very short time to implement

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any ideas. Frequent changes of ministers, mandates and directions hinder the proper development and management of the islands. As one officer informed, they submitted several proposals to the State Government to improve utilities on the islands, such as to have incinerators and to have proper sewage treatment plants. However, the State Government did not approve the proposal. While another officer said, *"If the previous Chief Minister is still in charge, the incinerator project and the four generators installation on the island have been approved".*

Any development and management decision on the islands comes from senior officials. According to the officers, development proposal, inspection, maintenance and monitoring are only conducted when they receive direction from top management. As the MBKT planning officer stated, *"We cannot do anything. Our top management is responsible for making any decision for us".* While the MDB planning officer said, *"We take action after receiving instructions from our bosses".* Therefore, the federal government needs to educate, encourage or push top management staff at the state and local government level to be more proactive in developing and managing the islands sustainably.

6) Lack of Intergovernmental Coordination and Collaboration

The lack of collaboration between intergovernmental agencies is another barrier (Lim et al., 2024). As the TDA planning officer informed,*" We only have once in a while technical meeting with other local authorities and government agencies once in a while".* Moreover, the MBKT planning officer said, "*We have technical meetings at the State level once a year",* and the MDB officer also informed, *"We rarely have meetings with other local authorities regarding planning issues on the islands".* These findings indicate that meetings with other local authorities or agencies are not conducted regularly.

A similar issue also occurs in the Department of Municipal Services and Licensing. MDB Licensing officer informed, "*Department of Marine Park Malaysia has conducted a program due to the celebration of World Ocean Day at the Perhentian Island. They did not invite us to join the program. After the program, we must clean up all the garbage"*. Whereas, the TDA officer informed that villagers and operators at Tioman Island always burn their waste every day, which is causing air pollution. This issue was reported to the Department of Environment (DOE) (Terengganu) a few times. However, there was a late response from the department.

Lack of communication and collaboration between government agencies causes many environmental and development issues to remain unsolved on islands (Rahimi Abidin et al., 2025). Once-a-year meetings are considered insufficient for the proper management of the islands. Regular discussions between local authorities and other government agencies are required to solve

any issues with the MPIs. Moreover, coordination and collaboration should not end at the meetings but need to be continued up to monitoring, site inspection and enforcement levels. During an investigation, all related government agencies should visit the islands together. According to Zulkefli (2021), local authorities have a limited role in tourism development. Tourism is seen as the main responsibility of the state government, while the local authority only deals with operational matters, such as development, improvement of infrastructure and public facilities, which have been unsuccessful due to financial constraints allocated for tourism development at the federal level.

Specific Barriers Faced by the Town Planning Department

The Department of Town Planning of the islands is facing several barriers. The barriers are illegal construction and development of chalets, lack of development plans and programs, and lack of communication and collaboration from operators.

1) Illegal Construction and Extension of MSICs

One of the planning problems on the MPIs is the illegal construction and extension of tourism accommodations. As the MBKT planning officer said, "*The problem on the Redang Island is that chalet operators like to do an illegal extension of their resorts and chalets"*. Whereas, according to an MDM officer, *"Chalet's operators on the island are building their chalets illegally during monsoon seasons".* Most of the operators never apply for approval for development and extension. However, some operators do apply only after finishing the building. Interestingly, this study also found that recently built chalets are not following the planning and building guidelines. For example, the MBKT officer said, *"Many resort operators extend their resort and chalets without applying for approval from the local authority. It's hard for us to act against them because most of the operators are politicians or connected to some politician".*

Moreover, the MDM officer informed that some chalet operators submit fake plans for approval. During construction, they use a different plan. These findings revealed that illegal building and extension of chalets are due to the lack of inspection and enforcement on the islands. Local authorities are unable to do frequent inspections on the islands due to political interference, lack of staff, (lack of time and substantial distance from the mainland. All the barriers need to be addressed so that monitoring can be conducted frequently on the islands.

2) Lack of Development Plans and Programs for the MPIs

All the officers agreed that there are no tourism development plans and strategies available for MPIs. As the MDM officer said: *"We do not have short- or long-*

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term development plans for Kapas Island, but we are thinking of creating one". Other officers also give similar statements. The lack of development plans and strategies at the local level is hindering officers from managing the islands properly. Therefore, local authorities often overlook the management of the islands with the idea that islands are the responsibility of the operators and tourism agencies because they are the ones who receive direct tourism profits. This finding indicates that local authorities do not give thoughtful attention to tourism in the development of the islands. This finding is consistent with the finding above that local authorities rarely do monitoring and maintenance of infrastructures on the MPIs. Therefore, the suggestion is that local authorities need to formulate their short and long-term development plans for tourism islands based on the sustainable tourism development policy as specified by MOTAC under the National Ecotourism Plan.

3) Lack of Involvement and Communication with Chalet Operators

Lack of involvement and communication from the chalet operators is another barrier. According to the officers, there is a lack of communication from the operators. Operators rarely approach local authorities regarding planning matters. The TDA officer informed that 70% of the chalet developments on the islands are conducted without approval. Meanwhile, the MDB officer said, government officials are not welcome on the islands due to mistrust and misperceptions. According to him, *"Once before our staff visited the Island for inspection. Some operators came with machetes. Since then, our officers requested police and land officers to escort us during an inspection*".

Another finding is that operators on the islands do not support programs held by local authorities. All the officers were informed that only a few operators usually turn up for any programs. As the MDM officer said, "*We usually conduct meetings with the chalet operators at the Kapas Island. However, not many operators will turn up*". While the MDB officer informed, *"Every time we call operators for discussion, the majority of them do not come".* Hence, this finding indicates that chalet operators give less attention and cooperation to the programs conducted by local authorities. A possible explanation for the lack of involvement is a centralised government operating style where local communities and tourism stakeholders' opinions are not considered in making policies and strategies. Therefore, local authorities must involve chalet operators and stakeholders during meetings. Their views should be considered in formulating strategies and plans for the islands.

Specific Barriers Faced by Municipal Services and Licensing Department

Local authorities are facing several specific barriers in managing solid waste on the islands. Solid waste is one of the major issues on the MPIs. Improper

management of the solid waste on the islands causes adverse impacts on the marine ecological assets. The barriers are careless attitudes of waste contractors, a lack of support from chalet operators in reducing waste, and technical problems of waste boats.

1) Careless Attitude of Waste Contractors

Improper management of solid waste on the islands is strongly related to the careless attitude of the waste contractors. According to the MBKT officer, local authorities should hire waste contractors based on a yearly contract. However, due to the lack of waste contractors, local authorities usually prolong their contracts for up to five years. The long duration of the contract makes contractors careless in carrying out their duties. As the MBKT officer said, *"He is a little lazy because he has already worked for five years"*. The officers also informed that some of the waste contractors like to dump garbage in the sea and force chalet operators to pay additional charges.

The officers also informed that a lack of staff, time and a substantial distance from the mainland impede them from monitoring waste contractors frequently. Officers only act when chalet operators make complaints, which is not very frequent. The suggestion is that local authorities should hire one or two islanders to monitor waste contractors' operations. Waste contractors should be penalised for deception. Moreover, local authorities should renew waste contractor permits based on their performance.

2) Lack of Support from Chalet Operators in Reducing Waste on the Islands

Chalet operators on the islands produce an enormous amount of waste. All the officers stated that operators give less support and effort in reducing their waste. As the MDB officer said, *"Most of the operators are not conducting recycling"*. MDB officer informed that the Council had conducted several programs regarding waste management and recycling for the island operators, but the number of operators who participated was disappointing. The MDM officer also stated that most of the Kapas operators are not separating their waste. They mixed wet and dry waste, which became a problem at the mainland landfill. All the officers have similar comments on this matter.

3) Small and Unsuitable Waste Boats

Small and unsuitable waste boats are a barrier for the local authorities. According to MDB officers, it is difficult to find waste contractors and suitable waste boats. Fisherman boats are not designed to collect waste. Garbage bags and leachate water frequently fall into the sea from the boats. Small boats are unable to collect all garbage bags on the same day. Another problem is that waste boats are easily inoperable due to the substantial distance from the mainland. Inoperative boats

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cause waste to pile up on the islands for a few days. Consequently, local authorities should consider buying or hiring appropriate waste boats. Again, lack of funds is the main hindrance.

CONCLUSION

In conclusion, this study has identified several common and specific management barriers faced by the local authorities. The six common barriers are the lack of funding, the lack of staff, time constraints, the lack of commitment from top management, the lack of intergovernmental coordination/collaboration, and substantial distance from the mainland. These barriers are faced by most of the local authorities in the world, and Malaysia. The three specific barriers faced by the planning departments are illegal construction and extension of chalets, lack of development plans and programs for MPIs, and lack of involvement and communication with chalet operators. Three specific management barriers faced by the Municipal departments are careless attitudes of waste contractors, a lack of support from operators to reduce waste on the islands, and small and unsuitable waste boats. Consequently, the recommendations from this study can help local authorities formulate suitable plans and strategies to manage tourism development in the MPIs in a more sustainable manner.

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POST-OCCUPANCY EVALUATION OF COMMUNAL SPACES: USAGE PATTERNS AND RESIDENT SATISFACTION IN THREE LOW-COST FLATS

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Abstract

Low-cost flats in Malaysia provide only minimal communal facilities, with likely impacts daily life and satisfaction. Despite their importance to residents' social interaction and well-being, few studies assess how specific communal spaces of the low-cost flats are used and rated. This paper evaluates usage and residents' satisfaction across three low-cost flats. A mixed-method design was used. First, semi-structured interviews with the Joint Management Body (JMB) identified various communal spaces and their typical uses. Survey with residents then measured frequency of use and satisfaction of the communal spaces. Descriptive statistics and cross-comparisons classified spaces into high/low use and high/low satisfaction categories. Findings suggest that everyday community life is anchored in informal (emergent), unscheduled areas. Open yards, corridors, and parking are heavily used for casual play and socialising. Where provided, formal communal space (programmed) such as multipurpose hall and surau achieve the strongest combination of use and satisfaction. With flat without an indoor hall, the parking lot became the default gathering space resulting to high use but low satisfaction due to heat, limited seating, and safety concerns. High-use/low-satisfaction spaces emerged as priority future improvements. Low-cost, basic upgrades matter, ensure at least one dedicated indoor communal room and humanise informal outdoor areas with shade, seating, lighting, and maintenance. It implies that combining management insights with resident feedback offers a practical framework to target optimal improvements and guide more liveable, inclusive communal environments in low-cost housing.

Keywords: Communal space, Shared space, Resident satisfaction, Low-cost housing, Quality housing environment

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INTRODUCTION

Rapid urbanisation is reshaping Malaysian cities. In Fourth Industrial Revolution, Malaysia is one of the fastest in economic development, in line with the population increase especially in urban areas. Affordable and low-cost housings are in demand for lower income citizens. Low-cost housing is affordable housing for the section of society whose income is below the median household earning (Abdul Hadi, 2019: Liu & Ong, 2021). Malaysia's low-cost housing provision is anchored by the Program Perumahan Rakyat (PPR), launched under the First Malaysia Plan to resettle squatter communities and deliver affordable flats (Srirangam et al., 2022). These compact high-rises (typically ≤700 ft² per unit) follow minimal amenity standards—hall, *surau*, kindergarten, playground, parking, refuse house set by state guidelines (JPBD, 2016). For example, in Selangor, low-cost housing options include PR4 (Low/Medium/Medium Apartment Houses), PR5 (Selangorku), and PR6 (Independent Price) flats.

While meeting urgent housing needs of urban residents, limited outdoor spaces have sacrificed the communal quality of the housing areas, as tight budgets and limited land yield bare bones, overcrowded shared spaces (Kuok et al., 2025). Nonetheless, residents in low-cost housing most definitely require more spaces that can fulfil their individual, recreational, social and community needs, which they can call their own. Communal space is the lever to close this limited space gap. These semi-public in-between areas when accessible, comfortable, and well maintained, strengthen neighbourly ties, improve well-being, and lift the flat's visual character (Amirjani et al., 2025; Wu & Ge, 2020; Fu et al., 2015; Zhu, 2015). Research evidence shows various impacts to wellbeing due to limited outdoor spaces in residential housings. For example, children show more play activities in spaces that are visible from home and supervised. Routine failures such as poor maintenance, cluttered corridors, unsafe playgrounds, limited accessibility signal the need for substantial upgrades and tighter management (Srirangam et al., 2022). Inadequate outdoor facilities and overcrowding reduce children's play, lower physical activity, and decrease overall satisfaction (Hanapi & Ahmad, 2016; Karim, 2012). National health data from the National Health and Morbidity Survey (NMSH) reported high obesity and noncommunicable diseases (NCD) burdens, with 9.2% of B40 children in experiencing mental-health challenges (Ministry of Health, 2019; 2023). Weak communal settings also suppress neighbourly interaction. High-rise residents often do not recognise each other, which erode social trust and natural surveillance and undermining National Housing Policy goals (NHP, 2019).

The housing management authority and the residents' feedback are therefore essential. Malaysian studies directly linking communal space typologies and programming to resident-level satisfaction remain sparse. Recent work skews to overall satisfaction, design systems, or broad low-cost housing

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effects rather than shared-space use (e.g. studies by Alias et al., 2025; Kuok et al., 2025; Srirangam et al., 2022; Ishak et al., 2016). To narrow this gap, this research applied two objectives: 1) Quantify participation frequency and satisfaction of spaces defined by the Joint Management Body (JMB) in each flat, and 2) Prioritise actions by classifying spaces into high-use/high-satisfaction, high-use/low-satisfaction, low-use/high-satisfaction, and low-use/low-satisfaction groups, and recommend targeted, low-cost, code-compliant improvements for each flat. This is to evaluate the performance and satisfaction of communal spaces in three low-cost flats by integrating JMB's provision data with residents' usage and satisfaction and identify optimal spaces and low-cost modification.

LITERATURE REVIEW

Definition and Function of Communal Spaces in Low-Cost Housing

Basic outdoor facilities in low-cost housings as defined in planning guidelines/ standards are common structures including a community hall, *surau*, food stall, and kindergarten (JPBD, 2016). Formal open spaces are the playground, play courts and parking space. Others that are not stated are the informal spaces such as in between flats, entrances, lift lobby, and along walkways and corridors. The green areas are most often left-over spaces for buffer zones, and plantings parameters. Communal spaces in residential flats are most often both the formal and the informal spaces shared by the community. These include indoor lobbies, corridors, stairwells, lifts, parking and passages, plus outdoor/semi-outdoor courtyards, gardens, rooftops and ground-level interfaces (Wu & Ge, 2020). The communal spaces also include any commonly owned facility from a small sitting corner or playground to a multipurpose hall. These settings anchor daily life, hosting neighbourly encounters, children's play, family relaxation and community events, and accommodating shared amenities such as laundry rooms and *surau*. Overall, minimum provisions in Malaysia's PPR or low-cost housing schemes include open spaces, playgrounds, *surau*, food stalls, kindergartens and refuse facilities, underscoring their role in high-density liveability (Alias et al., 2025).

Communal spaces operate as third places, where routine encounters weave social ties beyond what formal governance can deliver. Observational studies in Australia and Vietnam find that residents who frequent landscaped courtyards or roof gardens report stronger neighbourhood attachment and lower loneliness, while non-users feel detached and unsafe (Kleeman et al., 2023: Nguyen et al., 2024). Malaysian evidence aligns with international studies: the absence of quality green commons in Program Perumahan Rakyat (PPR) flats is associated with weaker collective efficacy and higher perceived crime (Harun et al., 2023). Outdoor housing environment and landscaped spaces are therefore

pivotal. Flexible, green indoor–outdoor nodes encourage lingering, multigenerational play, and casual gatherings, strengthening social ties and natural surveillance (Nguyen et al., 2024; Omar, 2008).

Shade trees and seating nooks along footpaths encourage people to walk and use the stairs instead of relying on lifts or cars. Planted edges around sports courts reduce noise and heat, allowing the spaces to be used for longer hours. A study survey in Sarawak found that flats offering green courtyards and children's play lawns scored significantly higher on overall housing satisfaction even when the built units were identical, highlighting the multiplier effect of communal space on perceived quality of life (Kuok et al., 2025). When maintenance is neglected or access is poor, people stop using the space. Satisfaction drops even if open-space quotas are met. This shows that providing space alone is not enough without user-centred management.

Programmed and Emergent Activities in Communal Spaces

Planned communal activity hinges on facility provision and active management. Although low-cost housing standards list a multipurpose hall, playground, *surau* and open space as programmed spaces, these venues are often too small and too few, producing chronic overcrowding (Abdullah et al., 2025). Resident feedback shows broad dissatisfaction, signalling that on-paper provision rarely matches lived demand (Ismail et al., 2019). In some residential blocks, a nominal recreation area is effectively monopolised by adults, thus displacing children, where housing is equipped with only a single small hall or pocket playground (Abdullah et al., 2025). Spatial constraints limit what can be formally programmed. This restriction exists from the very beginning.

Despite the availability of decent facilities, the quality of housing management largely determines their overall impact. Where JMBs or local authorities keep spaces open, maintained and actively programmed, social networks and stewardship improve (Harun et al., 2024). While community gardens and *gotong-royong* promote collective use, many low-cost housing areas do not have enough resources. This highlights a gap between what policies promise and what happens in practice, as residents end up carrying the responsibility. Residents often self-organise and appropriate shared areas for daily needs. In Malaysian high-rises, spaces such as corridors, landings, lobbies, and courtyards become extensions of the home. A lack of amenities encourages residents to use informal and adaptable areas, which then evolve into emergent spaces. They include leftover areas such as hallways and stairwells, leading to more noise, blockage, and fire hazards, and less privacy (Nguyen et al., 2024). Where drying yards are inadequate, clotheslines and potted plants spill into corridors, creating maintenance conflicts in spaces not designed for such use (Goh & Ahmad, 2011). As such, emergent adaptations can enhance liveability

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when tolerated but can also pose issues to the community. For example, in Shah Alam low-cost flat, a resident-funded *wakaf* becomes a valued social node that enhanced liveability and community well-being (Karim, 2012). The implication is clear, that is resident-led micro-interventions can close outdoor design gaps, but it will remain fragile and with challenges without official support, accommodating layouts and management administration (Karim, 2012).

RESEARCH METHODOLOGY

Case Study Sites

The study sites are low-cost flats located in Selayang, Gombak, and Ulu Klang in Gombak district (Figure 1). The sites were selected based on information obtained from Majlis Perbandaran Selayang (MPS) and Majlis Perbandaran Ampang Jaya (MPAJ) on easy cooperation by the JMBs and the residents of each housing flat.

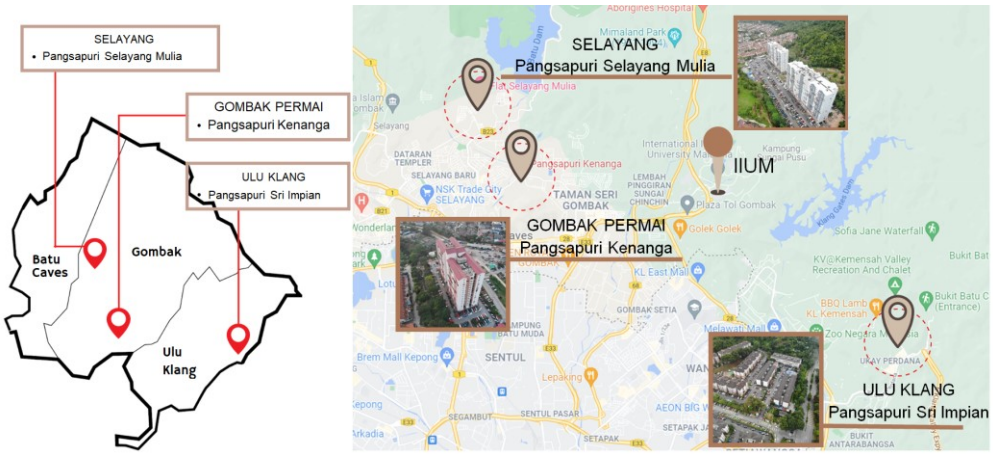


Figure 13: Case study sites in Gombak district
Source: Authors; Adapted from Google map

Pangsapuri Kenanga

Pangsapuri Kenanga is a leasehold low-cost flat in Batu Caves, Selangor, comprising of 297 compact three-bedroom units (~650–775 sq ft) on an 8,340.09 m² site surrounded by buildings (https://www.iproperty.com.my). The amenities are basic: a *surau*, open parking with some covered bays, and 24/7 security. Geared to B40 small families and first-time owners, the flats sit near schools and shops with strong connectivity to Kuala Lumpur (public transport, Duta-Ulu Kelang Expressway-DUKE, Middle Ring Road 2-MRR2). It occupies a transitional zone between Kuala Lumpur's metropolitan core and the suburban areas of Selangor. Communal life concentrates at the playground and ground-

level open spaces, which substitute for private yards. Figure 2 shows the site and its context.

Pangsapuri Sri Impian

Sri Impian is a low-cost, five-storey walk-up flat in Ukay Perdana, Ampang, with roughly 750 units. Typical units are about 650 sq ft (3 bedrooms, 1 bathroom). On its 18,457.57 m² site surrounded by buildings and an extensive green area, facilities include several small playgrounds/open areas, a *surau*, and common parking. There are an informal resting area and a badminton court, but underuse due to limited seating and shade. Located near a Giant supermarket, schools, and a local college, the flat typifies 1990s–2000s PPR stock—medium-rise, high-density (https://jmbmalaysia.org/) where targeted upgrades to courtyards and corridors could substantially improve daily experience. Figure 2 shows the site and its context.

Pangsapuri Selayang Mulia

It is also referred as PPR Selayang Mulia. This low-cost flat in Selayang comprises of two 17-storey blocks, Mawar and Teratai, with lift access, which is a notable upgrade over older walk-ups. House units are about 650 sq ft (3 bedrooms, 2 baths), set on a 33,414.16 m² site (https://jmbmalaysia.org/). On-site amenities are basic but essential such as open-air parking, a children's playground, a play court, small stalls, and the lifts. The site setting is urban, whereby it is close to shops, schools, and clinics. The site is surrounded by large undulating green area (Figure 2). As a newer high-rise form of public housing designed to optimise limited land, its communal spaces are essential to residents' daily liveability.



Figure 2: Drone aerial views of Kenanga (left), Sri Impian walk-up flat (middle) and Selayang Mulia (right)
Source: Authors

Data Collection

Post-occupancy evaluation (POE) was used to obtain data. POE is an evaluation that is commonly used in the built environment and architectural studies to

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provide user feedback. POE usually involves feedback from the occupants, through questionnaires, interviews, and workshops (Jiboye, 2012). It has been conducted in various types of research related to facilities including schools, universities, hospitals, landscape/civil works, learning environments and housing.

A preliminary site observation and drone images across all three flats produced a definitive spatial survey and inventory of their communal spaces. Systematic walk-throughs covered every block and ground-level exterior, recording type, location, and key attributes. Each feature was photographed, logged on a standard pro-forma and coded into a shared typology. Where floor plan of the flats existed, entries were cross-checked to prevent double counting and harmonise labels. This field inventory then anchored the JMB's interviews and filtered the residents' questionnaire.

Semi-structured interviews with one JMB representative per case study site captured management perspectives on provision and use. A flexible guide steered discussion toward space types and hosted activities. Interview sessions (30–60 minutes) were held on site, and included detailed note taking and, in some instances, audio recording with consent. The interviews included probing for concrete examples and recommendations, which produced a nuanced view of day-to-day communal-space operations.

The survey questionnaires to the residents yielded 401 valid responses: 150 from Selayang Mulia (37%), 139 from Kenanga (35%), and 112 from Sri Impian (28%). For a population of several thousand households, 400 cases typically deliver about ±5% margin of error at 95% confidence, and 300–400 respondents are generally adequate for reliable descriptive work (using Cochran's formula). The sample is therefore sufficient for generalisation and basic subgroup comparisons. Fieldwork proceeded smoothly with limited refusals. Non-contacts were replaced via random substitution per floor level. All questionnaires have undergone complete checks in the field, and again at data entry. Inconsistent records were removed or corrected, yielding the 401 cases analysed.

Data Analysis

Data were analysed descriptively for an exploratory, cross-comparison of the three case study sites. The analysis is recorded in three stages: Stage 1 consists of systematic site observations that produced a shared inventory of communal-space types, tagged with/without greenery. Stage 2 was semi-structured interviews with the JMB representatives, who confirmed space types and on-site activities, which harmonised labels across three housing flats. Stage 3 consists of resident questionnaires that limit to the JMB-confirmed inventory. They captured participation/frequency, activity uptake, and satisfaction. Limiting the survey to verified spaces ensured construct validity and contextual relevance, avoided

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responses about non-existent facilities, and enabled a direct, actionable comparison between resident use and satisfaction and the facilities provided by management. The outputs consisted of tables and figures highlighting well-performing matches, underutilised facilities, and resident-driven activity hotspots. Table 1 summarises scope and descriptions of the research methodology. Figure 3 shows the summary of data collection and analysis processes.

Table 1: Scope and descriptions

Scope	Description
Typology setup	From site observation, compile the master list of common communal-space types. Code each space as with greenery or without greenery.
JMB inventory	Transcribe JMB interviews per flat to establish: (i) spaces available/operable, (ii) activities organised or occurring.
QS filter to JMB list	Filter the resident questionnaire to only the JMB-identified spaces/activities. Exclude any QS items that are not in the JMB inventory to keep the analysis aligned with management-defined provision.
Satisfaction profiling	Compute satisfaction distributions for the same spaces/activities. Visualise with stacked bars for quick comparison.
Alignment test: JMB vs residents	Crosstab JMB provided/programmed vs resident used/satisfied to flag: Matches high-use, high-satisfaction, high-use, low-satisfaction, low-use, high-satisfaction, low-use, low-satisfaction
Best-fit identification	Using a simple rule, nominate the most suitable communal space per flat and overall.
Targeted modifications	For underperforming but important spaces, specify typical, low-cost upgrades linked to observed issues.

Source: Authors

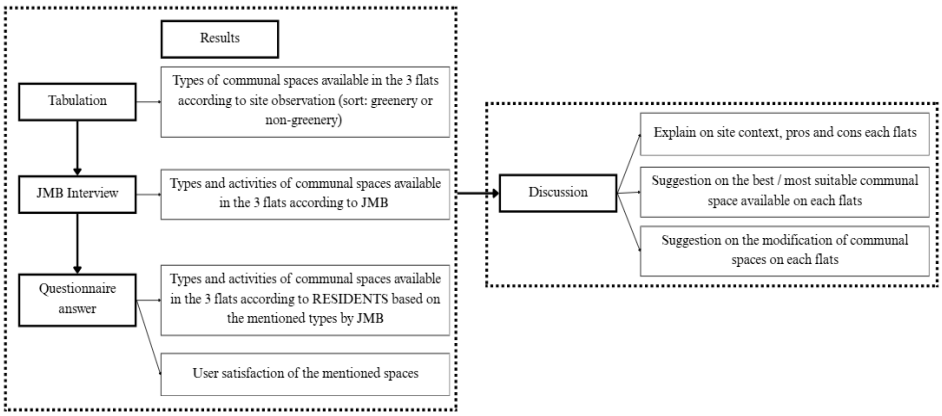


Figure 3: Data collection and analysis process
Source: Authors

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ANALYSIS AND DISCUSSION

Table 2 presents the three flats, Kenanga, Sri Impian, and Selayang Mulia by listing their common communal space locations and classifying each as with greenery or without greenery. All three flats share a basic green core, which is an open green space plus a community garden.

Table 12: Common communal spaces across the three flats

Kenanga		Sri Impian		Selayang Mulia	
Greenery	**Without Greenery**	**Greenery**	**Without Greenery**	**Greenery**	**Without Greenery**
Open green spaces	*Surau* area	Open green spaces	Playground	Open green spaces	Playground
Community garden	Community hall	Community garden	Play court	Community garden	Play court
	Parking area		Community hall		Community hall
	Shaded area (shelted by roof)		Open spaces		*Surau* area
	Seating area		Parking area		Open spaces
	Front yard and backyard of the flats		Shaded area		Parking area
	Playground		Seating area		Seating area
			Pedestrian walkways		Pedestrian walkways
					Front yard and backyard of the flats

Source: Authors



Figure 4: Community hall in Kenanga – (left), *wakaf rukun tetangga* in Sri Impian (middle) and Selayang Mulia (right)
Source: Authors

Green spaces are rare features across the three low-cost flats, highlighting a lack of provision for communal greenery. Each flat provides a

small lawn/field and a modest community garden, but scale and numbers are limited. Hardscaped provision dominates: *surau* or multipurpose rooms and a single court/playground are standard, matching Malaysia's bare minimum provision for low-cost housing development (5-10% for public facilities reserve and open space). Kenanga, Sri Impian, and Selayang Mulia all fit this template. One or two green amenities were identified amid extensive concrete infrastructure. Community gardens help, but land constraints push open space into residual corners. Unfortunately, greenery or nature plays a minor supporting role while daily life unfolds on hard surfaces.

Interview

The semi-structured interviews with JMB representatives identified various communal spaces in each flat and described their typical usage and users. Table 3 summarises the communal spaces, typical user groups, activities and the status of the spaces in Kenanga, Sri Impian, and Selayang Mulia, as reported by the JMB representatives.

Table 3: Communal spaces identified by JMB across three flats

Flats	Communal space	Typical users	Activities	Programmed or emergent
Kenanga	Front yard and backyard of the flats	Children	Playing (free play, running around)	Emergent
	Playground	Children	Play; adults supervise and chat informally	Programmed
	Open green spaces	Teenagers	Playing sports/games informally	Emergent
	Surau & community hall	All residents	Community activities and events	Programmed
Sri Impian	Playground	Children	Play; adults supervise and chat informally	Programmed
	Small court	Children and adults	Play space and badminton	Programmed
	Seating area & *wakaf*	All residents	Informal gathering and chatting	Emergent
	Parking area	All residents	Occasional community events	Programmed
Selayang Mulia	Community hall	All residents	Planned community functions	Programmed
	Wakaf rukun tetangga	All residents	Community functions; children's activities	Emergent
	Play court	Teenagers	Sports and games	Emergent

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Flats	Communal space	Typical users	Activities	Programmed or emergent
	Playground	Children	Play (children); adults accompany and socialize	Programmed

Source: Authors

Across all three flats, communal use is dominated by emergent spaces, and everyday activities are largely informal. Spontaneous play, teen hangouts, and adult chatting fill semi-public open spaces, patches of green, and corridors. Only one or two spots in each flat are set aside for scheduled or programmed events. Kenanga relies on its *surau* and hall, Sri Impian converts a parking lot, and Selayang Mulia uses a built community hall. Formal functions are infrequent and supported by a thin, multi-use infrastructure. Differences are clearest in youth sport. Selayang Mulia has a dedicated court that attracts teens, Kenanga does not have a play court but only a small space for playground, and youths have to improvise in open areas. Sri Impian offers only a small playground and court. Social patterns vary too. The front yard and backyard of Kenanga flats skews to children, while Sri Impian and Selayang Mulia's playgrounds and seating areas foster mixed, intergenerational use. Overall, all three flats depend on informal in-between spaces to meet day-to-day social and recreational needs.

The differences observed, for example on the presence of a formal sports court in Selayang Mulia versus its absence in Kenanga. It shows that available infrastructure can shape where certain activities concentrate. Yet, the underlying reliance on informal, ad-hoc spaces is a common denominator across these communities. Ultimately, these flats depend on a modest platform of formal facilities sustained by a much richer tapestry of informal communal spaces, together supporting the social and recreational needs of their low-income resident populations.

Questionnaire

Questionnaire survey captured residents' perspectives for each JMB-verified communal space/activity, the usage and how satisfied they are. Figure 5 and Figure 6 summarise the flat-level distributions of frequency and satisfaction for Kenanga, Sri Impian, and Selayang Mulia.

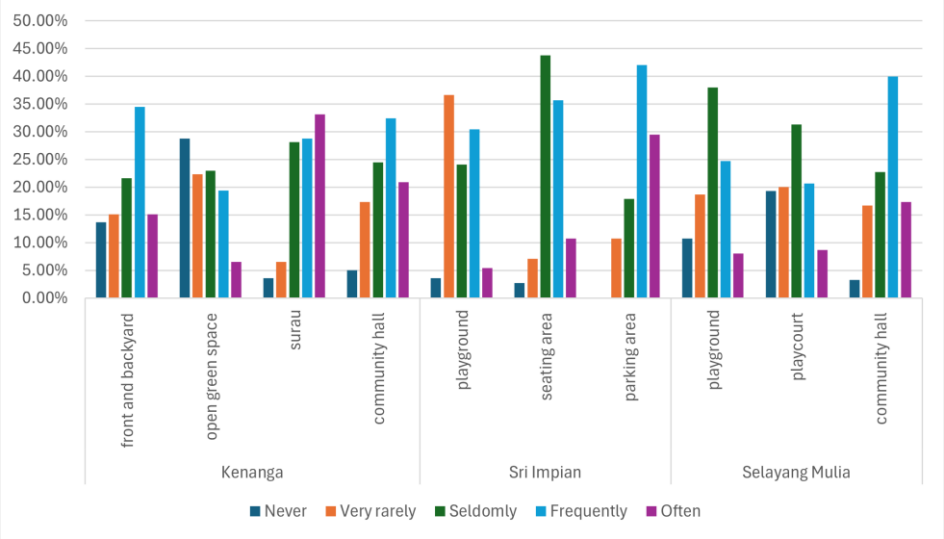


Figure 5: Frequency of communal space usage for each flat
Source: Authors

Kenanga's activity clusters in a few core spaces, reflecting its thin formal offer. *Surau* is the busiest (62% frequent/often), with the multipurpose hall close behind (53%). The open green is the idlest—it is very limited. Over half responded seldom or never use it (28.8% never; 22.3% rarely). Front/back yards see moderate–high use as play and casual socialising spill into these informal zones in the absence of courts or playgrounds.

At Sri Impian, a hardscaped area anchors daily voluntary activities. The open parking lot is the genuine social hub with nearly three-quarters responded frequent/often. The playground draws only about one-third on a frequent/often basis, while seating areas sit at the middle (46% regular users). In essence, the car park doubles as a versatile gathering space, the playground is moderately used, and seating serves a steady subset.

Selayang Mulia shows a split pattern, which are a highly active indoor hub and selective outdoor use. The hall dominates (57% frequent/often), anchoring meetings and events. Outdoor play caters to niches activities. About one-third respondents use the playground and a similar share the court, while 19% never use the court. Everyday activity is hall centred. However, the play spaces remain valuable but less broadly used.

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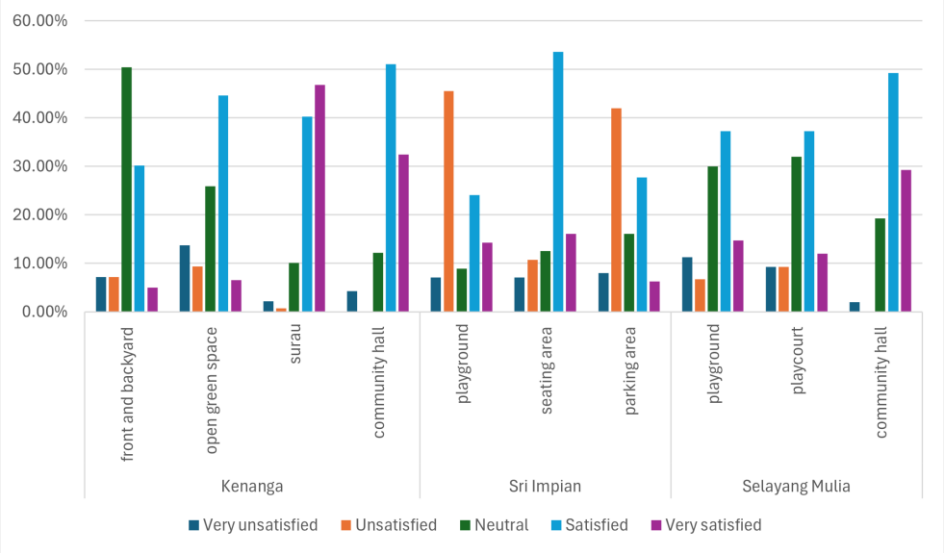


Figure 6: Satisfaction of communal space for each flat
Source: Authors

Kenanga's satisfaction mirrors its use patterns. Formal facilities perform best, the *surau* records 87% satisfied/very satisfied and the community hall 83%, reflecting strong fit for prayer, meetings, and events. However, informal outdoor communal areas lag. Only about one-third are satisfied with the front/back yard, while over half are neutral. Residents use it out of necessity, not comfort. The open green spaces, similarly, >23% dissatisfied and fewer than half are satisfied. As a result, a few well-loved formal venues, alongside heavily used but underwhelming improvised spaces give indication to upgrade outdoor yards and the green area. This is necessary if everyday satisfaction wanted to match usage.

Sri Impian's satisfaction profile is uneven. The simple seating areas perform best. About 70% of users are satisfied and very satisfied, showing that basic, comfortable places to sit meet usage expectation. At the opposite end, the playground scores worst, with over 52% dissatisfied, pointing to poor maintenance, inadequate equipment, or weak appeal to families. The parking area is the biggest mismatch. It sees heavy use but leaves roughly half of users unhappy, suggesting it functions as a social spillover space out of necessity rather than preference. It is deficits in shade, safety, and comfort. Ultimately, seating shows use and satisfaction alignment, while the playground and parking show divergence. Thus, priorities for future are clear, that is upgrading the playground and humanise the parking area, while preserving and modestly enhancing the already-valued seating provision.

Selayang Mulia shows strong use–satisfaction alignment. The multipurpose hall leads on both fronts, nearly four in five residents are satisfied and very satisfied, indicating a well-run, well-sized, and valuable communal hub. Outdoor facilities also rate solidly with their users, the playground draws mostly positive feedback (50%+ satisfied, 18% dissatisfied). The play court, while the lowest rated still posts about 49% satisfied versus 19% dissatisfied. No space exhibits a serious usage–satisfaction gap. The hall anchors everyday community life, and the playground and court adequately serve their target groups, pointing to communal infrastructure that is functioning as intended.

Across the three flats, formal indoor multi-purpose spaces, community halls and *surau* consistently lead on both use and residents' approval. Table 4 places both in the high-use/high-satisfaction quadrant, about 58% use the *surau* frequently with 73% satisfied, while the hall records 50% frequent use and 75% satisfaction. With a purpose-built for gatherings, these venues reliably anchor communal life of the residents. Hence, a flexible indoor room whether a hall or a well-equipped *surau* that doubles as a meeting space is the most broadly effective communal provision across the flats.

Table 4: Crosstab JMB provided communal space vs resident used/satisfied

Quadrant (Use x Satisfaction)	Communal space	Use (Freq+Often)	Satisfaction (Sat+Very sat)
High-Use, High-Satisfaction	*Surau*	58.1%	72.6%
	Community hall	49.6%	74.6%
High-Use, Low-Satisfaction	Parking area	64.1%	39.9%
Low-Use, High-Satisfaction	Open green space	31.9%	53.9%
	Seating area	35.9%	50.9%
Low-Use, Low-Satisfaction	Playground	31.7%	43.9%
	Play court	17.9%	43.4%
	Front & backyard	48.7%	45.7%

Source: Authors

Sri Impian's lack of an indoor hall is revealing. Hence, residents default to the parking lot for gatherings, but with far lower satisfaction. The result is clear that an indoor community room is a must have. Where it exists, it becomes the social anchor. A second reliable communal space generator is simple, that is shaded seating. Sri Impian shows that low-cost benches and resting corners can score high with residents when they provide basic comfort and a place to linger. Hence, a formal indoor hub plus informal, comfortable outdoor seating/pocket space delivers a balanced communal offer. By contrast, playgrounds and courts are valuable but niche, which is great for families with children or youth, but not universally used. If prioritisation is for all spectrum of users and social benefit, multipurpose halls and modest outdoor social spaces come first.

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The findings from the three low-cost flats are not meant to be compared due to different settings, but to indicate that outdoor facilities and open spaces are inadequate for residents' needs. Overall, the result shows the provision of communal space is about closing gaps with the basic facilities, and not at all about big spends. For examples, for high-use/low-satisfaction areas (parking, front/back yards), addition of shade, seating, lighting, and marked pedestrian/event zones are essential. For low use but important spaces (playgrounds, open greens), fixing maintenance issues is crucial. Then only one or two durable play pieces, perimeter benches, bins, and light activation (garden beds, a simple loop) can be added for comfort and social activities. Halls and *surau* should be well maintained and well scheduled. Replication of shaded seating near activity generators invites users. In addition, facilities should be standardized according to site-specific needs. For instance, for Kenanga (8,340.09 m², framed by buildings) use modular shade at parking edges, provide wall-mounted benches, lighting, painted lanes and planter micro-greens. For Sri Impian (18,457.57 m², buildings and sizeable green), provide shaded loop path, pocket seating under trees, minor play refresh, and formalised temporary parking-event barriers. For Selayang Mulia (33,414.16 m², surrounded by extensive green), offer shaded plaza spine linking hall to open space, canopy trees and seating at court/play edges, and safe lit routes to spread use. This blends an indoor hub plus comfortable outdoor micro-communal spaces, which delivers the broadest, most dependable satisfaction across the three flats.

CONCLUSION

This study combined JMB interviews with a resident survey to quantify use and satisfaction by communal space type in three low-cost flats. Findings show clear patterns. The informal in-between areas (such as yards, corridors, parking) carry daily social life, while formal facilities (such as community halls, *surau*) are high-use, high-satisfaction communal hubs. Where a hall is absent, emergent activities happen, where residents repurpose parking for gatherings. However, comfort level is sacrificed. Heavy use, low satisfaction due to heat, lack of seating, and safety issues are the primary concerns. The flat with a fuller set of amenities (hall, playground, court) shows the best use–satisfaction alignment, underscoring the value of dedicated communal infrastructure.

Thus, by pairing JMB interview insights with resident survey data, the study pinpoints which communal space types deliver broad benefit and which underperform. The findings from this research are not intended for comparison across the three flats, but rather to highlight that the provision of outdoor facilities and open spaces is insufficient to meet residents' needs. The findings underscore that the allocation of only 5–10% of low-cost flat developments for public facilities and open spaces remains inadequate in addressing residents' needs. A

more substantial provision of public amenities such as play areas, community centres, pedestrian walkways, and green belts is necessary to promote outdoor relaxation, recreational opportunities, social interaction, and overall community well-being.

The study has several limitations, including its focus on three low-cost flats within a single region and reliance on cross-sectional, self-reported data, which may overlook seasonal or behavioural variations. As such, future work should expand the site sample, add direct and longitudinal observation, and trial low-cost interventions (shade, seating, maintenance) to measure gains in satisfaction and social well-being of low-income group residents.

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ENHANCING SUSTAINABILITY THROUGH THE INTEGRATION OF RELATIONAL CONTRACTING ELEMENTS IN BIM CONTRACTUAL FRAMEWORK FOR THE MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract

Construction projects involve a myriad of parties with distinct roles that often result in fragmentation, coordination challenges and adversarial relationships. The emergence of Building Information Modelling (BIM) has been regarded as one of the driving forces for integration and collaboration among project stakeholders. Nevertheless, the additional contractual risks brought by BIM may undermine its benefits, as the failure to address these risks could potentially lead to more disputes. Given that construction projects fundamentally rely on contracts to govern stakeholders' relationships, the present study aims to promote social sustainability in BIM-based construction by incorporating relational contracting elements (RCE) into BIM Protocol context, which in this study refers to a supplementary contractual arrangement used to govern BIM-related roles, responsibilities and risk allocation. Using data gathered from a research survey conducted among industry players in Malaysia and analysed through factor analysis, the study identified sixteen (16) significant BIM contractual risks that need to be addressed, and twenty-five (25) factors grouped under three (3) relational contracting elements (RCEs) that should be considered in BIM-enabled contractual arrangements. The findings are expected to contribute towards embedding sustainability in BIM-based construction projects in Malaysia.

Keywords: Building Information Modelling (BIM), contractual risks, sustainability, construction contract, construction management

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INTRODUCTION

Building Information Modelling (BIM) is a collaborative process that provides an information-rich digital representation of the physical and functional characteristics of a construction project throughout its entire life cycle. Besides technical benefits such as visualisation, cost and time reduction, and early error detection, BIM also fosters an innovative and integrated working environment that can boost the social sustainability of the construction industry (Elimualim & Gilder, 2014). The adoption of BIM able to transform the traditionally fragmented approach in construction management towards a greater collaborative and coordinated environment among the project participants. In Malaysia, BIM has been promoted through various national policies and strategic initiatives such as the Construction Industry Transformation Programme (CITP) 2016-2020, the Twelfth Malaysia Plan 2021–2025 (12MP), the Public Works Department (JKR) Strategic Plan 2021–2025, and the National Construction Policy 2030 (NCP 2030), all of which emphasise digitalisation and technology integration in the construction sector. BIM implementation is expected to be further strengthened under the upcoming Thirteenth Malaysia Plan (13MP) as part of Malaysia's long-term digital transformation agenda for the construction industry.

Although BIM has the potential to improve social sustainability among the contractual parties, it also exposes the stakeholders to contractual and legal risks that may adversely impact business performance and working relationships. Various studies have examined BIM-related contractual risks (Winfield, 2015; Habib et al. 2020; Baharom et al., 2021) which emphasise the criticality for the risks to be addressed in order to attain the full potential of BIM implementation. These concerns are further reinforced by recent research, such as Mohammadi et al. (2024), who examines critical risks and mitigation strategies in BIM contract documentation; and Alotaibi et al. (2024) who analyses the regulatory and legal implications of BIM adoption within contractual frameworks.

In order to address the risks, some researchers recommend the adoption of collaborative procurement methods, such as alliance contracting and integrated project delivery (IPD), both of which embed relational contracting principles (Holzer, 2015; Abd Jamil & Fathi, 2019). However, many BIM-based construction projects still adopt conventional non-collaborative procurement approaches due to industry familiarity and risk aversion (Holzer, 2015; Baharom et al., 2021; Ndwandwe et al., 2024). Therefore, a more pragmatic alternative is required to integrate relational elements into the existing contractual arrangements without necessitating a complete transformation of procurement systems. Furthermore, while countries such as the United Kingdom and the United States utilise BIM Protocols as supplementary contractual documents to support BIM-enabled project delivery, the extent to which relational contracting elements are embedded within these BIM Protocols remains unclear.

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Relational contracting is a governance approach that emphasises the management of long-term working relationships rather than relying solely on rigid contractual provisions (Macneil, 1980; Nwajei, 2021). It promotes collaboration through behavioural principles such as trust, commitment, cooperation and shared problem-solving, which complement traditional contract mechanisms (Rahman & Kumaraswamy, 2008). In the context of construction projects, Relational contracting elements (RCEs) refer to measurable components that operationalise such principles within contractual practices, ensuring coordinated decision-making, mutual accountability and equitable risk allocation among project participants (Liu et al., 2022). These elements strengthen social interaction and reduce adversarial behaviour, making them particularly relevant in BIM-enabled projects where multi-party collaboration and interdependency are critical for project success. Incorporating RCEs into BIM-related contractual arrangements may therefore address behavioural and coordination issues that are not adequately governed by conventional contract clauses alone.

Therefore, this study was conducted using a quantitative questionnaire survey and aims to: (1) identify the critical BIM contractual risks that need to be addressed, and; (2) to determine the key relational contracting elements (RCEs) that support the integration of relational contracting factors (RCFs) into BIM-enabled contractual arrangements. The findings of this study are expected to provide insights for integrating relational principles into BIM-related contractual practices and enhancing social sustainability in BIM-based construction projects.

LITERATURE REVIEW

BIM and Relational Contracting

The execution of tasks in a BIM environment differs from conventional working process, as BIM requires a higher level of cooperation and collaboration among project stakeholders. A greater degree of information sharing among the stakeholders is necessary to ensure seamless integration of data through the use of cloud platforms and BIM models. However, as various proprietary data are continuously incorporated and exchanged during the development of BIM models, such practices may compromise the data security and reliability, intellectual property rights (IPR), liability in cases of damaged or corrupted data, and data infringement risks (Brelih & Klinc, 2025). Furthermore, the unclear additional roles and obligations of stakeholders in a BIM environment, such as the role of a BIM Information Manager, can lead to disputes if parties resist the perceived liabilities and risks associated with these added responsibilities, thereby leading to antagonistic behaviour (Alwash, et al., 2017). Although this phenomenon remains underexplored, unresolved contractual risks and ambiguities are widely recognised as factors that may trigger disputes in BIM-based projects (Dalir et al., 2025)

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Working with BIM also raises issues related to the doctrine of privity of contract, which stipulates that only parties who are legally bound by a contract can be granted rights or subjected to obligations (Ya'acob et al., 2018). In most construction contracts, designers cannot be held liable by contractors or sub-contractors, as they are not contractually bound to one another. This position conflicts with the collaborative nature of BIM, where project team members rely on each other's contributions via a shared model, thus creating a horizontal privity between contractors and design professionals. However, under the strict application of the doctrine, if an error occurs due to a designer's fault, parties such as the contractor or the quantity surveyor are not entitled to be compensated as there is no contractual relationship exist between them, even though in reality they depend on one another to complete the work. This situation may limit collaboration in BIM-based projects as working relationships are challenged by trust and liability concerns.

Recognising the implications of BIM on contractual relationships among project participants, countries such as the United Kingdom and the United States have introduced various technical guidelines and contractual supplements to support BIM implementation. However, the extent to which these documents adequately address privity-related issues and contractual risks remains underexplored. In the Malaysian context, several national BIM-related documents have been published (as shown in Table 1), however, the CIDB BIM Guide and Public Works Department (PWD) BIM Requirements have been criticised for failing to adequately address key contractual risks, particularly those related to data security, liabilities and legal responsibilities among project stakeholders (Alwee, et al., 2021; Raja Berema, 2021).

Table 1: Published BIM documents in the USA, the UK and Malaysia

Document Type	Countries		
	USA	**UK**	**Malaysia**
BIM Contract Guidelines	1. C106–2013 Digital Data Licensing Agreement 2. E203–2013 BIM and Digital Data Exhibit	1. CIC BIM Protocol (2013) (superseded) 2. UK BIM Framework Information Protocol (2022	N/A

Document Type	Countries		
	USA	**UK**	**Malaysia**
BIM National Technical Standards	1. The National BIM Standard-United States (NBIMS) Version 3 (2015). 2. The National BIM Standard-United States (NBIMS) Version 4 – Project BIM Requirements (2021-2022).	1. PAS 1192 Series (superseded) 2. BS EN ISO 19650 Series (Parts 1-5)	1. PWD BIM Requirements for Design and Build Projects 2016 2. MyBIM Guide Series CIDB
Best Practice Guides	1. National BIM Guide for Owners by NBIMS, 2. BIM Implementation: An Owner's Guide to Getting Started by The Construction Users Roundtable 3. Penn State BIM Project Execution Planning Guide (2022)	1. UK BIM Framework – Guidance Series (Parts 1-8, updated quarterly) 2. Government Soft Landings (Updated 2022)	1. CIDB BIM Guide 2. MyBIM Adoption Strategy 3. PWD BIM Guidelines, Standards and Manual Working Process

Therefore, effective BIM implementation in the construction industry requires relational contracting elements (RCEs), such as communication, cooperation and transparency, to be embedded within contractual arrangements (Panteli et al., 2020; Al-Ashmori et al., 2022; Liu et al., 2022). Relational contracting procurement methods, such as alliancing, partnering and join-venture, have the potential to shift contractual relationships from a purely transactional approach towards more collaborative engagements (Nwajei, 2021). However, a complete transition to relational procurement is unlikely to occur in the near future, as conventional forms such as design–bid–build (DBB) and design–and–build (D&B) remain dominant in industry practice. Hence, integrating RCEs into existing BIM-enabled contractual arrangements offers a more pragmatic governance alternative to address BIM-related contractual risks.

The theoretical foundation for RCEs is grounded in Relational Contract Theory (RCT), which views contracts not solely as legal instruments but as frameworks that shape long-term working relationships (Macneil, 1980). From this perspective, adversarial behaviour in construction can be reduced when contractual relationships incorporate behavioural norms such as reciprocity, flexibility and mutual trust (Rahman & Kumaraswamy, 2008). In the BIM context, where project delivery is highly interdependent and data-driven collaboration is required, RCEs enable cooperative decision-making, joint risk

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management and improved accountability among contracting parties (Nwajei, 2021; Liu et al., 2022). Accordingly, this study identifies the critical RCE factors needed to strengthen relational governance in BIM-based construction contracts.

RESEARCH METHODOLOGY

This study employed quantitative survey approach using a structured questionnaire distributed among construction professionals involved in BIM-based projects. Purposive sampling was adopted as the exact population size of BIM practitioners in Malaysia is unknown and the study requires respondents with adequate knowledge and experience in BIM. The aim of the survey is to identify significant BIM contractual risks and determine the key Relational Contracting Factors (RCFs) that support the integration of Relational Contracting Elements (RCEs) into BIM-enabled contractual arrangements to address these risks.

A total of 17 BIM contractual risks and 34 RCFs were initially identified from an extensive review of past studies on BIM contract governance and relational contracting (Panteli et al., 2020; Baharom et al., 2021; Liu et al., 2022). These items were used to develop the questionnaire. A total of 147 valid responses were obtained from construction professionals with BIM experience using purposive sampling, which is appropriate for studies requiring expert judgement and specialised knowledge (Etikan, 2016). The data were analysed using three statistical techniques: the Relative Importance Index (RII) was used to rank BIM contractual risks and RCFs according to their perceived significance; Exploratory Factor Analysis (EFA) was conducted to identify the underlying RCF components; and Confirmatory Factor Analysis (CFA) was employed to validate the measurement structure. Reliability and sampling adequacy were confirmed using Cronbach's alpha and the Kaiser–Meyer–Olkin (KMO) test prior to factor analysis.

RII was used to rank the BIM contractual risks and RCFs according to their relative importance using the following formula:

$$\mathbf{RII = \Sigma W / (A*N)}$$

where W is the weight assigned to each factor on a 5-point Likert scale, A is the highest possible weight, and N is the total number of respondents. The following relevant levels were assigned: high (H) ($0.8 \leq RII \leq 1$); high-medium (H-M) ($0.6 \leq RII \leq 0.8$); medium (M) ($0.4 \leq RII \leq 0.6$); medium-low (M-L) ($0.2 \leq RII \leq 0.4$); and low (L) ($0 \leq RII \leq 0.2$) (Chen, et al., 2010). Subsequently, EFA was conducted to identify the underlying structure of the RCFs and to reduce variables into meaningful components. In this regard, several recommended tests were done to aid the development of the proposed EFA model. As EFA alone

does not confirm the stability of the factor structure, CFA was then performed to validate the measurement model (Costello & Osborne, 2005). CFA complements EFA as it is a theory-testing model that offers a more practical method that can confirm the factorial validity of the EFA models (Yong & Pearce, 2013). The questionnaire consisted of three sections: Section A collected demographic information, Section B assessed 17 BIM contractual risks, and Section C measured 34 relational contracting factors (RCFs).

RESULTS AND DISCUSSION

A total of 147 responses were received from architects, engineers, quantity surveyors and other construction professionals involved in BIM-based projects. The reliability of the sample is supported by the fact that 88% of the respondents have more than five years of BIM project experience. The RII results for BIM contractual risks and RCFs are presented in Table 2 and Table 3, respectively.

Table 2: The RII for each category of BIM contractual risks

BIM Risk ID	BIM Contractual Risks	Relative Important Index	Overall Ranking	Importance Level
Information Management				
IM1	Fragmented and poorly coordinated information flow	0.782	1	H-M
IM3	Ambiguity in sharing information procedures	0.755	2	H-M
IM2	Lack of clarity on the role, responsibilities and liabilities of a BIM Information Manager	0.754	3	H-M
IM4	Contractual document prevalence	0.739	4	H-M
Liability				
LB1	Undefined roles and responsibilities of contractual parties	0.720	5	H-M
LB4	Loss and corruption of project data	0.701	7	H-M
LB2	Unclear liability for data amendments and modifications	0.699	8	H-M
LB3	Lack of clarity on the expected duty of care	0.693	10	H-M
LB5	Restrictions arising from the doctrine of privity of contract	0.667	14	H-M
Data Reliance				
DR2	Interoperability issues	0.713	6	H-M
DR3	Unclear procedures for data changes	0.699	9	H-M
DR1	Limited data reliance	0.661	15	H-M
Data Security				
DS2	Ambiguity in data access rights	0.683	11	H-M
DS3	Unclear data security procedures	0.683	12	H-M

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BIM Risk ID	BIM Contractual Risks	Relative Important Index	Overall Ranking	Importance Level
DS1	Breach/compromise data confidentiality	0.678	13	H-M
Intellectual Property				
IP1	Data infringement	0.654	16	H-M
IP2	Uncertainty ownership/copyright of data	0.642	17	H-M

Table 3: The RII for each category of RCFs

RCE ID	Relational Contracting Factors	Relative Important Index	Overall Ranking	Importance level
Communication				
CM4	Clearly defined information sharing procedures	0.856	1	H
CM6	Well-established procedures for data and information changes	0.848	3	H
CM3	Use of similar/compatible BIM software packages and version	0.827	10	H
CM5	Equal access to project information	0.790	20	H-M
CM1	Compromise on unclear issues in construction contract	0.788	21	H-M
CM2	Co-location of different organisations	0.725	26	H-M
Commitment				
CT2	The requirement for parties to practice role integrity in fulfilling duties	0.849	2	H
CT1	Active participation in discussions	0.839	6	H
Coordination				
CR2	Clear working structure	0.845	4	H
CR3	Clear tasks procedures	0.839	5	H
CR7	Early involvement of all parties	0.834	8	H
CR4	Pre-construction planning structure	0.833	9	H
CR5	Method statement in coordination with site team	0.811	13	H
CR1	Practical relational work plan	0.810	14	H
CR6	Quality-enhancement plan	0.792	19	H-M
Cooperation				
CO2	Joint problem-solving	0.838	7	H
CO3	Early involvement of top management from various parties	0.824	11	H
CO1	Joint decision-making	0.810	14	H
CO4	Resource sharing	0.804	17	H
Transparency				

RCE ID	Relational Contracting Factors	Relative Important Index	Overall Ranking	Importance level
TC3	Well-defined reporting method	0.833	9	H
TC1	Clear definition of roles, responsibilities and limitation of power	0.833	9	H
TC2	Comprehensive payment and claim procedures, mechanisms, terms and structures	0.800	18	H
Mutual Trust				
MT1	Training for collaboration knowledge and skills	0.815	12	H
MT2	Risk management workshop	0.807	15	H
MT3	Early warning systems to allow proactive risk allocation and mitigation	0.790	20	H-M
MT4	Contractual solidarity	0.770	23	H-M
Common Objectives				
CB1	Joint-declaration statement of achieving mutual objectives	0.805	16	H
CB3	Pre-agreed performance appraisal mechanism	0.777	22	H-M
CB2	Early partnership by establishing start up workshop	0.376	28	M-L
Flexibility				
FB1	Contract adjustment for unforeseen circumstances	0.788	21	H-M
Win-win principle				
WP2	Pain and gain sharing mechanism	0.752	24	H-M
WP4	Practicing liability waivers provision	0.735	25	H-M
WP3	Efficient conflict resolution	0.416	27	M
WP1	Incentives and bonuses for achieving agreed goals	0.272	29	M-L

As presented in Table 2, all 17 BIM contractual risks were perceived as having high to medium importance levels with RII values ranging from 0.642 to 0.782. Similarly, 91% of the RCFs were rated within high to medium importance level (see Table 3). Three RCFs recorded RII values below 0.5, namely *"efficient conflict resolution" (WP3),"early partnership by establishing start up workshop (CB2)"* and *"incentives and bonuses for achieving agreed goals" (WP1)*. As

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these factors fell below the acceptable threshold, they were excluded from further analysis, leaving 31 RCFs for subsequent testing. Subsequently, EFA tests were performed on 17 BIM contractual risks and the 31 RCFs using principal component analysis (PCA) with oblique-rotation. As presented in Table 4, all KMO and factor loading values were acceptable except for the determinant value. However, as only one test parameter was marginally below the recommended level, the analysis proceeded with all items to avoid premature elimination of variables (Habing, 2003).

Table 4: Results of EFA for BIM Contractual Risks and Relational Contracting Factors

EFA Assessments and Applied Test	Recommended value	Value acquired	
		BIM contractual risks	RCFs
Factor Rotation Method using Component Correlation Matrix	> 0.32, it requires an oblique-rotation	>0.32, thus oblique-rotation	>0.32, thus oblique-rotation
Determinant Factor based on Correlation Matrix's Determinant	> 0.00001	1.75E-008	9.975E-15
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy	KMO index ranges from 0 to 1, with ≥ 0.50 considered suitable for factor analysis	0.936	0.945
Bartlett's Test of Sphericity	Should be significant ($p<.05$) for factor analysis to be suitable.	0.000	0.000
Anti-Image Correlation Matrix	Diagonal value >0.5	>0.5	>0.5
Communalities	0.40-0.70	Range between 0.63 to 0.809	Range from 0.497 to 0.859
Cumulative Percentage of Variance and Eigenvalue	50%-60% and eigenvalue > 1	64.585%	56.586%

Subsequently, the remaining BIM contractual risks and RCFs underwent a factor refinement process following sequential steps recommended by Maskey et al. (2018): (1) the factor loading cut-off value is 0.40; (2) remove cross loading items with ratio exceeding 75% and retained if it is the opposite while removing the smaller coefficient, and; (3) each factor should consist of at least two items. As a result, one BIM contractual risk (LB3*)* and six RCFs (CM1, CO4, TC2, CB3, CM3 and FB1) were removed, leaving 16 BIM contractual risks and 25 RCFs for further analysis using CFA.

The preliminary results of the CFA show that both of the BIM contractual risks and RCFs are not fit as they do not fulfil the acceptable fit indices of the chi-square, Goodness-Of-Fit Index (GFI), Adjusted Goodness-Of Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), Normed Fit Index (NFI), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and Standardized Root Mean Residual (SRMR) (see Table 5). According to Hooper et al. (2008) and Schreiber et al. (2006), model modification is acceptable to improve model fit, provided it is conducted cautiously and guided by statistical and theoretical justification. Accordingly, model refinement was carried out based on: (1) elimination of low factor loadings (< 0.50); (2) correlation of error terms within the same construct; and (3) removal of items with Standardised Residuals (SR) above ±2.58. Although not all absolute and incremental fit indices were achieved, at least one acceptable index from each fit category was satisfied, which is considered adequate for model acceptance (Brown, 2006). Therefore, the modified models in Figure 1 and Figure 2 were considered to demonstrate acceptable construct validity and model fit.

Table 5: Results of Preliminary Analysis and Modified Analysis of CFA

Fit statistic		**Cut-off Criteria**	**Preliminary analysis**		**Modified analysis**	
			BIM Contractual Risks	RCF	BIM Contractual Risks	RCF
Chi-square		<5	3.573	2.913	3.102	2.260
Absolute fit	GFI	When N > 100, researchers may choose a GFI cut-off value of .93	.762	.696	.796	.762
	AGFI	> .95	.686	.637	.728	.709
	RMSEA	<0.08 is tolerable, <0.05 is good, 0.05-0.08 is acceptable, 0.08-0.1 is marginal, >1 is poor	.133	.114	.117	.093
Incremental fit	CFI	>0.9 (Stevens, 1996) or >0.95	.882	.848	.909	.902
	NFI		.844	.787	.870	.838
	TLI		.862	0.832	.892	.889
SMSR		When N> 100, < .08 is preferred	.0527	.0547	.0564	.0504

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The two-factor model of BIM contractual risks and the three-factor model of RCFs were subsequently subjected to construct validity assessment, as presented in Table 6. The results indicate that the two-factor model of BIM contractual risks demonstrated adequate convergent validity, meeting the threshold value of Average Variance Extracted (AVE ≥ 0.50) and Composite Reliability (CR ≥ 0.70). For the RCFs, one of the three relational contracting factors recorded an AVE value below 0.50; however, the construct was retained as its CR value exceeded 0.70 and its AVE was above 0.40, which is considered acceptable in social science research (Lam, 2012; Sharif et al., 2018). Moreover, the discriminant validity for both CFA models was established, as the AVE values for both constructs exceeded the Shared Variance (SV) values (Fornell & Larcker, 1981).

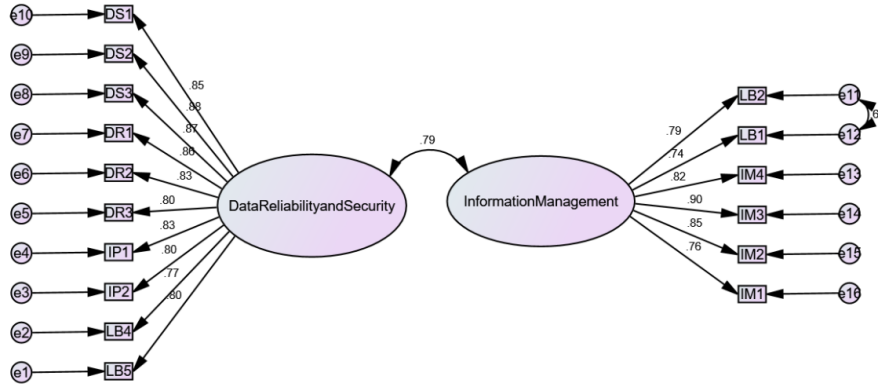


Figure 1: CFA Model for BIM Contractual Risks

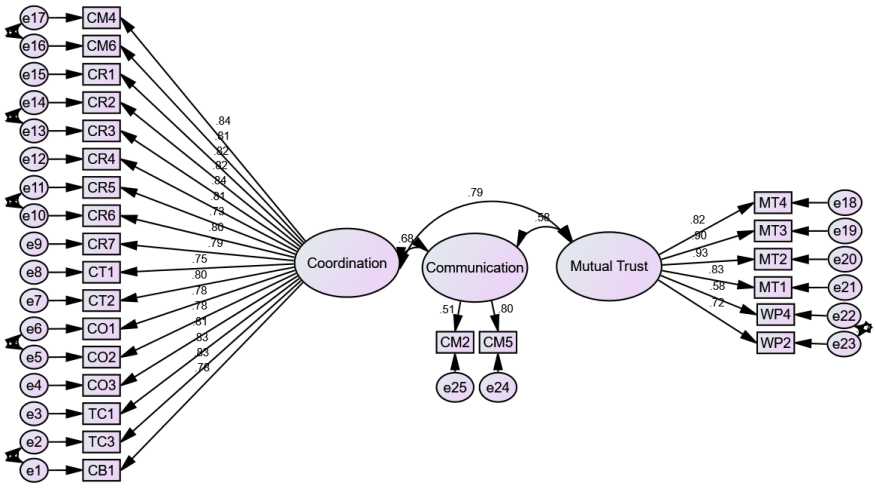


Figure 2: CFA Model of Relational Contracting Elements

Table 6: Results of Validity and Reliability Tests

Type of Construct validity	Recommended tests	Recommended cut-off value	Factors	Value acquired	
				BIM contractual risks	RCFs
Convergent Validity	Average Variance Extracted (AVE)	0.5 (Fornell & Larcker, 1981)	Factor A	0.69	0.64
			Factor B	0.66	0.65
			Factor C	-	0.45
	Construct Reliabilities (CRs)	0.6 (Fornell & Larcker, 1981)	Factor A	0.9	1.0
			Factor B	0.9	0.9
			Factor C	-	0.6
Discriminant validity	Shared Variances (SV)			0.63	0.62

Hence, the two-factor model of BIM contractual risks and three-factor model of RCFs are deemed acceptable. The identified latent factors for BIM contractual risks are "*data reliability and security*" and "*information management"* with each risk having high regression weights, ranging between 0.76 to 0.90 which reflects significant results. As for the three-factor RCFs model, there are three important relational contracting elements (RCEs) identified, namely *"coordination", "communication"* and *"mutual trust".* All factors in these categories consist of high regression weights except for "*co-location of different organisations"* (CM2). Table 7 presents the significant BIM contractual risks, RCEs and RCFs identified through this study.

Table 7: The identified significant BIM contractual risks, RCEs and RCFs

BIM Contractual Risks	
Data Reliability and Security	Loss and corruption of project data (LB4); Restrictions arising from the doctrine of privity of contract (LB5); Data infringement (IP1); Uncertainty ownership/copyright of data (IP2); Breach/compromise data confidentiality (DS1); Ambiguity in data access rights (DS2); Unclear data security procedures (DS3); Limited data reliance (DR1); Interoperability issues (DR2); Unclear procedures for data changes (DR3).

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BIM Contractual Risks	
Information management	Fragmented and poorly coordinated information flow (IM1); Lack of clarity on the role, responsibilities and liabilities of a BIM Information Manager (IM2); Ambiguity in sharing information procedures (IM3); Contractual document prevalence (IM4); Undefined roles and responsibilities of contractual parties (LB1); Unclear liability for data amendments and modifications (LB2).
Relational Contracting Elements and the Factors	
Coordination	Clearly defined information sharing procedures (CM4); Well-established procedures for data and information changes (CM6), Practical relational work plan (CR1); Clear working structure (CR2); Clear tasks procedures (CR3); Pre-construction planning structure (CR4); Method statement in coordination with site team (CR5); Quality-enhancement plan (CR6); Early involvement of all parties (CR7); Active participation in discussions (CT1); The requirement for parties to practice role integrity in fulfilling duties (CT2); Joint decision-making (CO1); Joint problem-solving (CO2); Early involvement of top management from various parties (CO3); Clear definition of roles, responsibilities and limitation of power (TC1); Well-defined reporting method (TC3); Joint-declaration statement of achieving mutual objectives (CB1).
Communication	Co-location of different organisations (CM2) Equal access to project information (CM5)
Mutual trust	Incentives and bonuses for achieving agreed goals (WP1); Pain and gain sharing mechanism (WP2); Training for collaboration knowledge and skills (MT1); Risk management workshop (MT2); Early warning systems to allow proactive risk allocation and mitigation (MT3); Contractual solidarity (MT4).

CONCLUSION

This study identified 16 critical BIM contractual risks and 25 Relational Contracting Factors (RCFs) that support the integration of Relational Contracting Elements (RCEs) in BIM-enabled contractual arrangements. From the overall analysis, issues related to information coordination and flow among project stakeholders emerged as the most significant contractual risk, reflecting persistent challenges in managing shared BIM data. In terms of relational solutions, coordination and communication were revealed as the strongest RCE dimensions, while mutual trust, although important, demonstrated lower factor strength and therefore requires deliberate contractual support mechanisms to operationalise effectively. These findings highlight the potential of relational governance to

reduce adversarial behaviour in BIM projects and improve collaboration. Future research should assess industry acceptance and contractual feasibility of embedding these RCEs into BIM project agreements and test their impact in real project settings.

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ASSESSING COURTYARD DESIGN: KEY FACTORS INFLUENCING STUDENTS SOCIAL INTERACTION IN HIGHER EDUCATION INSTITUTION

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Abstract

Social interaction holds a critical role in enhancing the overall experience of students in higher education institution, especially for those in the built environment disciplines where collaborative group works are essential. In a campus environment, students need conducive outdoors spaces for them to socialise and have effective social interaction. Hence, in the context of social space and in the effort to promote social interaction among students, this research aims to assess courtyard design, evaluating the key factors influencing students' social interaction in higher education institution. The main objectives of the study are to identify factors of courtyard design that contribute to social interaction among students and to recommend courtyards attributes which could enhance students' social interaction for future campus planning development. This research utilises both qualitative and quantitative approaches, where observational analysis of a courtyard is undertaken as a case study, and survey questionnaires are used to evaluate factors of courtyard design that can contribute to social interaction among students. The findings highlight the prominent factors that contribute to social connectivity, and recommendations of courtyard design in campus planning for enhancing social interaction among students are also discussed.

Keywords: Courtyard Design, Campus Planning, Social Interaction, Social Space, Campus Courtyards, Outdoor Environment

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INTRODUCTION

Research has shown that there is a strong relationship between the physical environment and social interaction among students. Hence, it is imperative for schools and campus planning to consider providing conducive learning environment that could foster positive social behaviours (Shamsuddin et. al, 2012). In higher education institution, social interaction is a vital component of students' lives due to its vast impact on students' mental health, academic performance and overall well-being (Kahu, 2013). Mental health, especially depressive disorder, has almost become a frequent case in the world, including Malaysia. The issues have a significant impact on the personal, family, and social life of youth (Ni, Li & Wang, 2020). However, this concerning issue has not been widely discussed in scholarly discourses. Since the scenario of mental illness is common after the Covid-19 pandemic, it is becoming essential to highlight the issue to ensure remedial effort would be considered for campus planning, management, and maintenance. Providing conducive physical planning development and implementing social programs would be the driving forces to ensure positive development of students' mental empowerment (Omar, Othman & Mohd Yusoff, 2016), so that they could efficiently contented to be the leaders of the future.

Good physical campus planning may give big impact to students' wellbeing and influence their mood to interact with each other. Having this conducive space quality in a campus environment that encourages social interaction is considered an indicator of successful campus design, that leads to good quality of students' lives (Ervits, 2024). In this educational setting, physical environments are vital in ensuring students could have social interaction (Cantero, Mira & Lopez, 2016). Outdoor physical environments, such as courtyards, could serve as multifunctional spaces for students to have positive social interaction. Students could use courtyards for working collaboratively, socializing leisurely and stress-free studying. The positive impacts of students' wellbeing are obvious with the provision of green open space for social interaction (Kaczynski & Henderson, 2007).

In the case of higher education institution, the provision of courtyards on campus are highly important as they provide spaces where students can meet and engage to enhance their social interaction. Besides, courtyards are additional recreational areas for students, which helps to improve the environmental quality of the university (Cantero, Mira & Lopez, 2016). However, the spatial requirement for courtyards in campus environment may have differed from public courtyard (Almhafdy, et. al., 2013). There are several design considerations to be examined to comply with spatial requirements and students' satisfaction, especially in the provision of places for students to socialize. In addition, recent

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studies suggest that a good courtyard can provide motivation for students and contribute to their happiness and comfort (Salameh & Touqan, 2020).

Hence, this study aims to evaluate courtyard design factors contributing to social interaction among students in tertiary educational learning environments. The main objectives of the study are to identify factors of courtyard design that contribute to social interaction among students and to recommend courtyards attributes which could enhance students' social interaction for future campus planning development.

LITERATURE REVIEW

Definition of Social Interaction

Social interaction tends to have a wide range of definition. The term social interaction reflects the myriad ways of connection between human beings, on how people engage, communicate, and respond to each other (King & Morris, 2022). Based on the psychological aspect, social interaction could be defined as any process that involves mutual engagement and reciprocal behaviour or stimulation between two or more people (Diaz, 2022). Social interaction is very important in constructing good mental health and to prevent any issues regarding psychological-related issues such as stress, depression and anxiety (Umberson & Karas Montez, 2010).

Social interaction is a fundamental aspect of human behaviour, particularly for students. Social interaction becomes a very crucial part of daily visual experience (McMahon & Isik, 2023). Students usually engage in social interaction on campus due to the variety of communication styles. Social interaction among students encompasses a wide range of communication together with behavioural responses towards each other (McMahon & Isik, 2023) and social interaction among students often occurs within their social context.

The Concept of Social Interaction

Social interaction involves dynamic and mutual engagement between two or more individuals. The impression of social interaction is a construction of visual information and how students process the constructive information cognitively. According to McMahon & Isik (2023), social interaction ranges from a very simple daily communication to more formal or complex conversation with family or friends. The key components to social interaction perceived by visual social primitive. Visual social primitive involves a distance between two people with their "facingness and contingent motion" (McMahon & Isik, 2023).

Hence, social interaction is very important for students not only to boost their confidence but to improve their daily community engagement. Moreover, social interaction has its core components, which are named as "Physical

Interaction, Communicative Interaction and Goal Compatibility." Goal Compatibility is furthered categorises into "helping and hindering." Figure 1 shows McMahon's and Isik's (2023) illustration of Visual Social Primitive between individuals and the core components of Social Interaction.

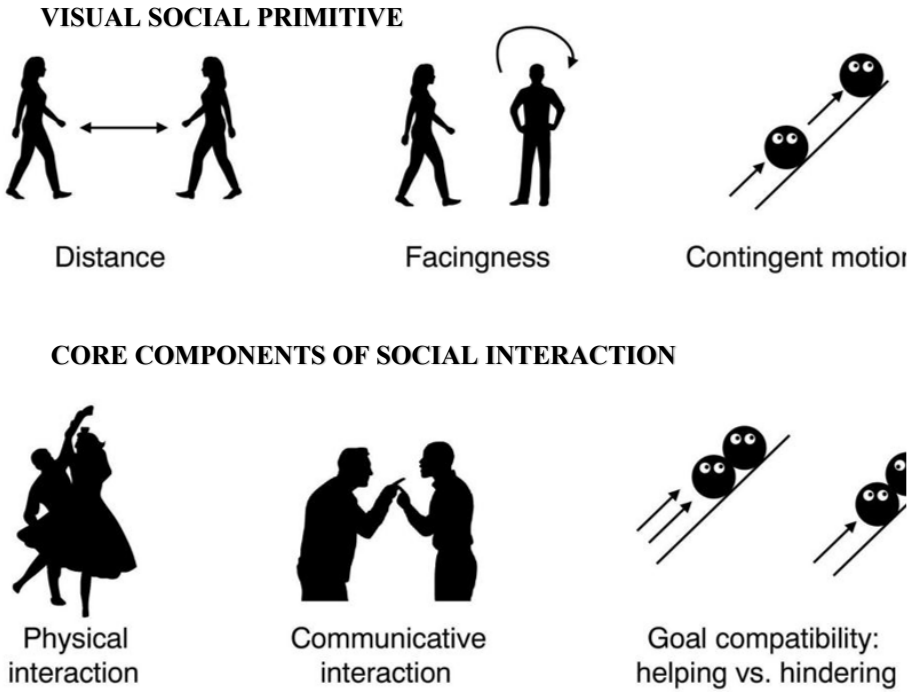


Figure 14: Visual Social Primitive and Core Components of Social Interaction, as described by McMahon and Isik (2023)

Factors Contributing to Social Interaction Issues

Issues with social interaction among students are instigated by several factors of circumstances resulting in the feeling of isolation, disconnection and loneliness which will then lead to mental health problems such as stress and anxiety (Hall & Goldberg, 1977). The factors contributing to social interaction issues are identified as technology overuse, lack of shared space, transitions of adjustment and cultural and socioeconomic behaviours (Mofatteh, 2020).

Recently, the situation has turned worse as covid-19 phenomenon leads to drastic increase on distant learning and online correspondence with peer and

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class instructors. The long lock-down during the Covid19 pandemic, and the continual remote studying have a devastating impact of the way students learn and the way knowledge is delivered. These circumstances influence the development of students' social interaction, where being cut-off from their peers is among the most challenging aspect of studying. Consequently, many students are diagnosed of having mental health-related issues or stress, and some even receiving treatment for stress related problems. Generally, the perceived stress among students which leads to mental health issues comes from social, environmental, and psychological aspects. In Malaysia alone, Arifin et al., (2023) state that majority of students experience moderate to high levels of psychological distress, often linked to social adjustment difficulties, academic pressures, and limited coping resources (Arifin et al., 2023). of depression, anxiety, and stress among Malaysian universities students incurred due to a drastic change in the education system especially in teaching delivery. A recent study indicates that students in higher education institutions have experienced elevated levels of depression, anxiety, and stress, due to the rapid transformation of the education system, particularly in the methods of teaching and learning delivery (Kumaran, et. al., 2022).

In the context of higher education institutions, the lack of shared space has been the main factor for lack of social interaction among students. Communal space is supposed to be a facility for community engagement. Shared space consists of several types such as parks, courtyards, greenery, front yards, recreation fields, and lakes (Chen, Liu Xie & Marusix 2016). The absence of these shared spaces can result in the limitation of informal social interaction among students.

Courtyard Characteristic as Factor for Social Interaction

One of the key elements in enhancing social interaction among students in campus environment of higher education institutions is the design character of physical spaces (Kahu, 2013). In this context of study, there are a few characteristics of courtyards that can encourage social interaction among students. The courtyard creates an environment that provides a pleasant space for living and relaxation with the presence of several prominent characters (Safarzadeh & Bahardori, 2005). The most prominent element comes from the courtyard's spatial layout and other interesting characteristics of courtyards are the presence of natural elements, seating arrangement and environmental factors.

Natural elements in courtyard setting gives positive benefits to students as the quality of the learning environment is affected the student's learning performances. Considered as outdoor, courtyards connect the parameters between the outdoor learning environment and student's learning activities (Yaman, et. al., 2018). The courtyards can provide progressive outcomes in

physical, psychological and emotional wellbeing of students in higher education institutions. tertiary educations. Courtyard characteristics are very important to be considered in the campus landscape design as they influence the way students interact during the period of learning, educating, meeting, exploring and relaxing.

Courtyard Design Factors for Social Interaction

Originally, courtyards are considered as prominent architectural typology, utilised for cultural, environmental, social, and educational benefits, aimed at creating comfortable spaces for users, especially employed in Middle Eastern countries (Ibrahim, Al Badri, Mushtaha, Omar, 2022). Historically, courtyards underscored the Arab cultural significance and pivotal role in shaping the Arab countries identity as a social hub (Ezzeddine and Kashwani, 2019).

In all regions of the globe, courtyard is simply defined as an outdoor space surrounded by walls from all sides, but the impact of the courtyard is beyond just a space (Zhong, Schroder & Bekkering, 2022). The characteristics of the courtyard bring many values in terms of aesthetics, functions, and visuals. Therefore, the courtyard is a special area which gives relief to their inhabitants. Courtyards can give a sense of calm and ease (Kaczynski & Henderson, 2007) that could be considered suitable for students especially in higher educational levels. The result of having a good courtyard environment can improve students' mental health, self- esteem and their social participation (Vahid & Ibrahim, 2013). The courtyard can help in reducing stress and provide a connection with nature which makes a better quality of life for students.

Several studies have been conducted to identify courtyard design factors for social interaction of students in higher education institutions. Courtyards in higher education institutions have the goal to promote social interaction among students. A good courtyard is one that can function as a leisure space and also enhance social interaction among people. Courtyards in universities provide ample space for students to foster social communication among themselves. Courtyards can also be a spontaneous meeting point, discussion zone among classmates and recreational zone to take a break from class. The presence of the courtyard in campus environment enables the promotion of a healthy lifestyle, as students have a nearby space to release their stress (Saadatjoo, Badamchizadeh and Mahdavinejad 2023). The access to nature and outdoor spaces can help students to focus more on their mental and physical well-being rather than stay on the phone or going to any secluded building.

Conclusively, courtyard holds a variety of design features that can facilitate social interaction among students. Courtyard stands among one of the oldest architectural footprints that have been implemented in many buildings from previous years until today (Almhafdy, Ibrahim, Ahmad & Yahya, 2013). Courtyard creates an environment that provides a pleasant space for living and

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relaxation with the presence of several prominent elements (Safarzadeh & Bahardori, 2005).

Table 1: Attributes of courtyard design for students' social interaction

Category	Attributes	Description / Importance	Sources
A Amenities	Gathering spaces	Areas that support both small and large group interaction, discussions, and community events.	Almhafdy et al., 2013; Saadatjoo et al., 2023
	Seating arrangement	Comfortable, varied seating promotes relaxation and informal meetings.	Safarzadeh & Bahardori, 2005
	Outdoor amenities	Inclusion of shelters, pergolas, or café-style areas enhances usability.	Almhafdy et al., 2013
	Water features	Encourage calmness, aesthetic pleasure, and reduce stress.	Safarzadeh & Bahardori, 2005
	Lighting	Adequate and warm lighting extends usability and ensures safety at night.	Almhafdy et al., 2013
B Design	Spatial layout	Open yet defined spaces encourage movement, visibility, and accessibility.	Zhong, Schroder & Bekkering, 2022
	Natural elements	Greenery and landscaping connect users with nature and improve well-being.	Yaman et al., 2018
	Visual connection	Visibility between buildings and courtyard enhances awareness and safety.	Kahu, 2013
	Human scale & proportion	Comfortable spatial dimensions encourage intimacy and interaction.	Ibrahim et al., 2022
	Architectural identity	Reflects local culture and institutional character, enhancing belonging.	Ezzeddine & Kashwani, 2019
C Function	Multipurpose use	Supports diverse activities—study, recreation, events, and exhibitions.	Saadatjoo et al., 2023
	Accessibility	Centrally located and connected to pedestrian routes for frequent use.	Chen, Liu, Xie & Marusix, 2016
	Informal learning space	Enables outdoor discussions and collaborative learning experiences.	Yaman et al., 2018
	Spontaneous interaction	Facilitates unplanned encounters that build social networks.	Vahid & Ibrahim, 2013
D Comfort	Thermal comfort	Shading, trees, and ventilation regulate temperature for usability.	Safarzadeh & Bahardori, 2005
	Acoustic comfort	Minimizes disruptive noise while maintaining social vibrancy.	Kaczynski & Henderson, 2007
	Psychological comfort	Provides calm, secure, and relaxing atmosphere that reduces stress.	Vahid & Ibrahim, 2013
	Safety and maintenance	Clean, visible, and well-lit areas promote user confidence.	Almhafdy et al., 2013
E Others	Cultural & social inclusivity	Encourages interaction among diverse groups and supports inclusiveness.	Kahu, 2013; Arifin et al., 2023
	Environmental sustainability	Uses eco-friendly materials and landscape promoting biodiversity.	Zhong, Schroder & Bekkering, 2022
	Connection to wellbeing	Reduces isolation and supports mental and physical health.	Hall & Goldberg, 1977; Mofatteh, 2020
	Adaptability	Flexible design accommodates evolving student needs and activities.	Saadatjoo et al., 2023

Courtyard is also usually found in public buildings or private houses that serve as meeting places for people to engage and to hold communal activities with family or friends (Almhafdy, Ibrahim, Ahmad & Yahya, 2013). The design feature of courtyard should have all these amenities: gathering space, open layout, outdoor amenities, outdoor lighting, water features, and accessibility. Based on the cited scholars' discourse, researchers have formulated Table 1, to summarise the attributes of good courtyard design for students' social interaction in campus environment.

RESEARCH METHODOLOGY

The Research Design

This study originally adopted a mixed-methods approach, as depicted in Figure 2. However, due to the article length limitations set by most journal publishers, the interview findings are not included in this discussion. Instead, the article highlights selected components of the overall research framework that are most relevant to the scope of this publication.

Henceforth, the discussion of this article focuses on qualitative approach of observational analysis of the case study, and the quantitative approach of survey questionaries. A qualitative approach has been chosen as part of the method employed in this study because the approach could assist researchers in seeking knowledge and understanding the assumption from theories (Ghanad, 2023). Besides, observational case study of a courtyard is beneficial to provide input on how physical layout encourage different types of social interaction (Ahmad, Ullah, & Zobia, 2024). The method also the actual, spontaneous and intended uses of courtyard social space (Madihah Mat Idris, Magda Sibley, Karim Hadjri, Azhani Abd Manaf, 2021). Nurul Syuhada Badrul Halim et. al, (2025) suggest that photos or layout views of the existing courtyard should be included
allow comparison between student feedback and actual design features, thus strengthening the findings.

Meanwhile, for quantitative research approach, a survey questionnaire leads to the descriptive analysis of factors of courtyard design that can contribute to social interaction among students. The survey-questionnaires was distributed to KAED's students to gain information on their perception towards KAED courtyard. The survey includes recommendations to enhance better design for KAED courtyard. Survey questionnaire serves as the primary data collection method in this study. The structured questionnaire helps in establishing data on courtyard factors that can contribute to social interaction among students in tertiary education institutions. This research also utilizes content analysis of literature from previous research papers as secondary data to support data collection.

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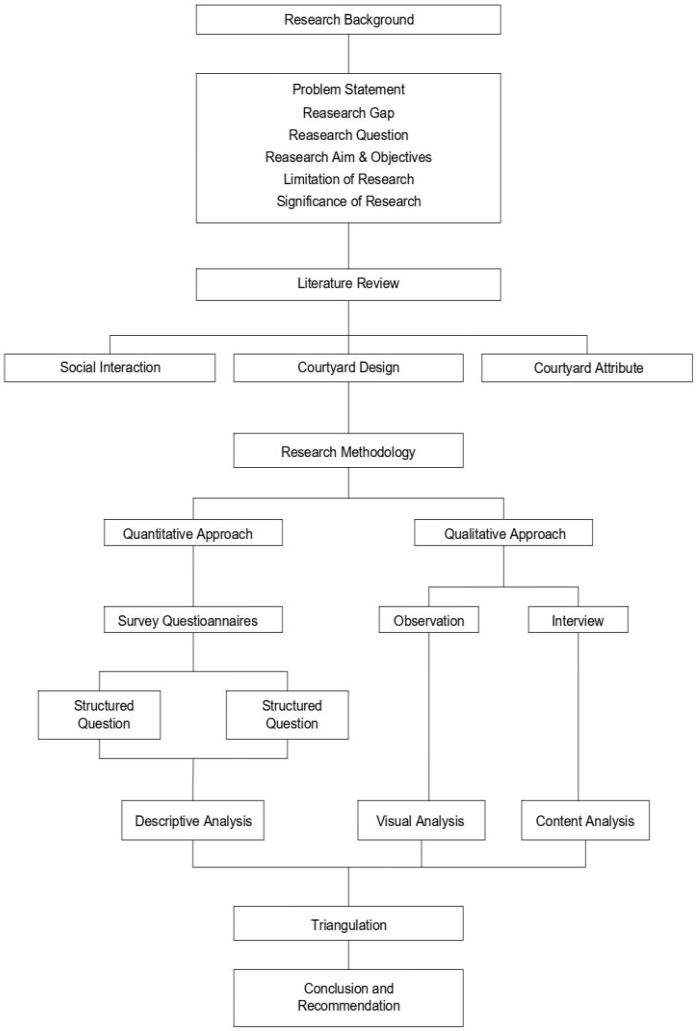


Figure 2: The Initial Research Framework

The survey questionnaire consists of five parts of structured questions, as shown in Table 2. Survey questionnaires help in the process of collecting data from students of tertiary institutions for more accurate results. This survey questionnaire was distributed to a total of 105 students from a tertiary institution from International Islamic University of Malaysia, Gombak branch. All the data collected was interpreted and analysed descriptively. The secondary data on the

other hand offers comprehensive review from previous research papers. This method helps in interpreting and analysing characteristics of courtyard design that can encourage social interaction and gives solid foundation towards this topic (Krippendorff, 2018).

Table 2: Structure of Survey Questionnaires

No.	Section	Description
1	Section A	Demographic Information
2	Section B	Attribute of KAED Courtyard to Social Interaction
3	Section C	Understanding Student's Activity and Social Interaction in KAED Courtyard
4	Section D	The Level of Comfort in KAED Courtyard
5	Section E	Perceptions, Recommendations and Comments

The Case Study

This research was conducted in the campus courtyard of the Kulliyyah of Architecture and Environmental Design (KAED) at the International Islamic University Malaysia (IIUM). The selection of KAED's courtyard as the case study site was based on the university's strong incorporation of Islamic architectural principles in its physical planning. The Gombak campus prominently features courtyards as a central design element in nearly all its buildings, reflecting the traditional Islamic emphasis on spatial harmony, community engagement, and contemplation. Historically, the courtyard in Islamic architecture serves as a space for social interaction, self-reflection, and communal gatherings. Figure 3 shows KAED Building of IIUM, and Figure 4 shows an aerial view of the IIUM Gombak campus with highlighted KAED building.

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Figure 3: KAED Building of IIUM



Figure 4: An aerial view of the IIUM Gombak campus, with highlighted KAED building.

International Islamic University Malaysia (IIUM) is a public university in Malaysia. The study was conducted at the Kuala Lumpur campus in Gombak. IIUM Gombak campus has 14 faculties in total and they are called *Kulliyyahs*. Gombak campus accommodates the university administration, the Centre for Language and also Pre-University Academic Development.

Kulliyyah of Architecture and Environmental Design (KAED) was established on 1st June 1996. It was built to fulfil the demand for professional courses in a built environment. KAED offers unique programs and interesting

educational approaches in the built environment profession. KAED accommodates the following departments, as listed.

- Department of Architecture
- Department of Applied Arts and Design
- Department of Quantity Surveying
- Department of Urban and Regional Planning
- Department of Landscape Architecture

KAED has two courtyards, located at east and west of the building. The two courtyards are enclosed with seminar and lecture rooms. Specifically, one of the KAED courtyards was chosen because it accommodates students of architecture and environmental design, who are among individuals who possess a deeper appreciation of the courtyard's architectural, cultural, and environmental significance within the built environment.

The observation was conducted together with checklist items, formulated based on knowledge gained from review of literature. This method confirms that KAED courtyard provides all the necessary characteristics for the courtyard to serve as a space for social interaction among students. The west wing courtyard was not included in the research due to its inconducive environment, in front of timber, brick and concrete workshop. Figure 5 show the location of case study courtyard, highlighted with red coloured boxes, within the KAED building, and figure 6 shows the floor plan of KAED Building, showing the location of east courtyards.



Figure 5: KAED Building of IIUM the location of case study courtyard within KAED's building.

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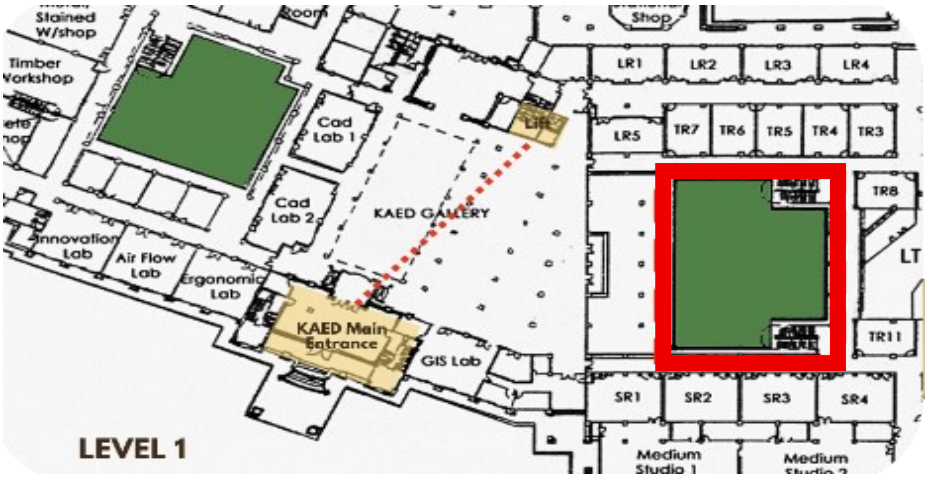


Figure 6: Floor plan of KAED Building, showing the location of courtyards.

ANALYSIS AND DISCUSSION

Analysis of Observation

KAED courtyard is one prominent space and centre of attention in the building. Each of the KAED courtyard is located at the East and West wing. The estimated area of the KAED courtyard is 25m X 30m. The layout of KAED courtyard is very straightforward; it is a rectangle layout with an open plan concept. No other wall or window attached to it apart from the main wall of KAED building. Figure 7 shows Partial Ground Floor Plan of KAED building, with the courtyard in the middle and highlighted access corridors. The plan shows the chosen KAED courtyard which is surrounded by classes, seminar rooms and design studios.

In terms of lighting and ventilation, KAED courtyard does not have to use any exterior lighting. It is an open courtyard where it receives natural ventilation and daylighting without having a roof. Figure 8 shows natural lighting illuminates the corridors along KAED courtyard in daylight. Since it is located in the middle of KAED building, KAED courtyard is mainly shaded except from the main part where it has all the natural features.

KAED courtyard is spacious enough for students to hold events or any activity involving a large number of students. In addition to that, KAED courtyard is directly facing the main hall of KAED building, hence it is very noticeable and most events will optimize the space at KAED courtyard. This shows that KAED courtyard holds an important role in making sure KAED building functionally good.

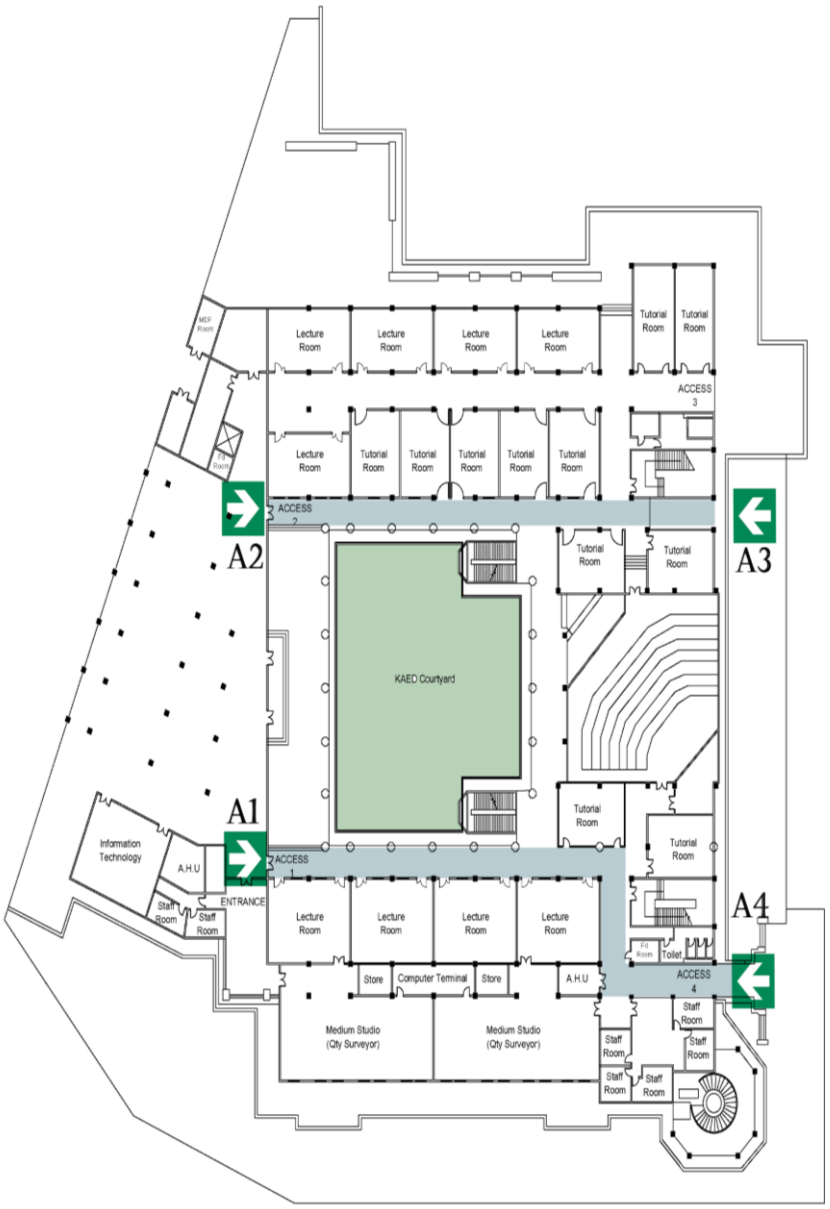


Figure 7: Partial Ground Floor Plan of KAED building, with the courtyard in the middle.

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Figure 8: Partial Ground Floor Plan of KAED building, with the courtyard in the middle.

The access to KAED's courtyard is very simple. Students can enter from every corner of the building that leads to the parking area. Figure 9 shows the access for KAED courtyard. From the parking area, they will not be directly attached to the courtyard; however, they need to enter the KAED building until they find a door leading to the middle area. There are two doors which are available at one side of the courtyard separating it from KAED main exhibition hall. The other access is from another two sides which are semi open to the walkway heading to the back parking lot and centre of IIUM. Nonetheless, all access functions as they should and it is clear that KAED courtyard is very much accessible and easy to find.

The overall access to KAED courtyard is very easy to navigate due to the simple layout design. Figure 9 and 10 show the two accesses from the main entrance to KAED courtyard. KAED courtyard can accommodate people with disabilities to reach the courtyard which KAED building provides ramp at the entrance and also at one of the doors before entering KAED courtyard. However, no ramp was provided connecting the inner walkway and the centre of the courtyard.

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KAED courtyard is located in the educational building which is accessible to all KAED's students hence, the social interaction of students can be seen. Furthermore, it is significant to the population of this study which is to measure the social interaction among higher education students. The accessibility and permeability of KAED courtyard are very high making it easy to observe for site investigation. Figure 11 shows the current condition of the KAED courtyard for the study.

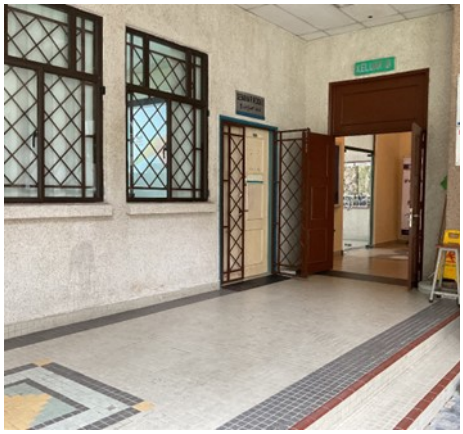


Figure 9: Access 1 to KAED Courtyard



Figure 10: Access 2 to KAED Courtyard

KAED courtyard is located in the educational building which is accessible to all KAED's students hence, the social interaction of students can be seen. Furthermore, it is significant to the population of this study which is to measure the social interaction among higher education students. The accessibility and permeability of KAED courtyard are very high making it easy to observe for site investigation. Figure 11 shows the current condition of the KAED courtyard for the study.

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Figure 11: the current condition of the KAED courtyard

Assessing this courtyard helps to develop a proper understanding of what a courtyard should offer. It is also to measure the level of social interaction happening daily in institutional buildings. KAED courtyard probably offers distinctive insight into this main theme of the topic.

Analysis of Survey Questionnaires

This section presents and analyses the data collected through survey questionnaires. The analysis aims to discuss and interpret the findings in relation to the study's objectives. Specifically, it addresses the effectiveness of courtyard design attributes in fostering social interaction among students within the KAED building.

A total of 105 students (n = 105) from the International Islamic University Malaysia (IIUM), Gombak Campus, participated in the survey. The questionnaire was designed to assess students' perceptions of the factors that influence social interaction within the courtyard space. This research has a small sample size and non-random sampling because it does not intent to generate generation. Rather, this research findings is still significant to provide a foundation for institution-specific policies of campus planning.

A total of 105 students has submitted responses to these questionnaires. Figure 12 illustrates the percentage of students who agree their campus's courtyard is a good place for social interaction.

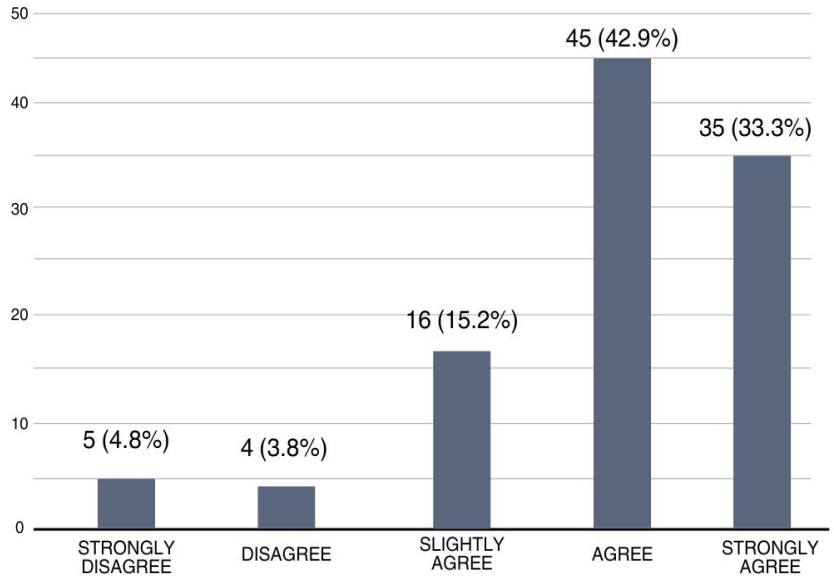


Figure 12: Bar Graph for Social Interaction

Figure 12 presents positive student responses on the courtyard as a social space. However, the analysis relies only on perceptions. Including photos or layout views of the existing courtyard would allow comparison between student feedback and actual design features, thus strengthening the findings.

The bar chart from figure 12 illustrates a visual presentation for the response of students towards their campus courtyard. The largest response group has recorded a total of 80 students who agree the campus courtyard is a good place for social interaction. This result suggested that the courtyard has successfully implemented features attracting more students to socialize.

The primary aim of this research is to evaluate the factors that contribute to social interaction among students. Hence, the high vote obtained probably because the courtyard has all the characteristics mentioned in a good courtyard design, such as the presence of natural elements, seating arrangement, accessibility and spatial design. The data in figure 12 specifically influenced by the positive response from students on their perception towards their campus's courtyard. Meanwhile, table 1 shows the rate of agreement from students towards the courtyard accessibility, seating areas, natural features and the gathering layout

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which is strongly related with the response from figure 12. Table 3shows data collected with a high percentage of agreement from students towards every characteristic of the courtyard.

Table 3: Level of Agreement towards Attribution of Courtyards to Social Interaction

Easily Accessible	Sufficient Seating Areas	Good Natural Features	Good Layout for Gathering
92.4% (Agree)	46.7% (Agree)	95.3% (Agree)	75.3% (Agree)
7.6% (Disagree)	53.3% (Disagree)	4.7% (Disagree)	24.7% (Disagree)

Upon examining the results, it shows that most students agree the courtyard is good for social interaction because it is highly accessible, has sufficient seating area, provides good natural elements and good layout for gathering. Most students with the percentage of 92.4% agree the courtyard is easily accessible and only 7.6% disagree, indicating that students have no problem accessing the courtyard making it easier for them to socialize. Hence, the results prove that accessibility, seating areas, natural features and layout are vital for designing a good courtyard that can encourage social interaction among students.

Findings on Perception and Recommendation

This section presents the data collected, to acknowledge respondents' opinion on their perception, recommendation and comments on the courtyard. This section shows design features that students prefer the most to be provided in the courtyard that can enhance their social interaction.

Figure 13 illustrates students particularly prefer seating areas the most in the courtyard followed by shaded areas and ICT facilities. The data indicates that to have a comfortable and functional courtyard, one needs to have a proper and sufficient seating area. The seating area is very important especially to enhance social interaction as students mostly come in groups and they need a comfortable place to gather and communicate among themselves. The next most important feature is the shaded area. Considering Malaysia’s hot and humid weather, it is important for a courtyard to provide a shaded area so that people can gather and socialize whenever they want without having to worry about the weather. Hence, if these elements are implemented, the chances for social interaction among students in tertiary educational institutions is higher.

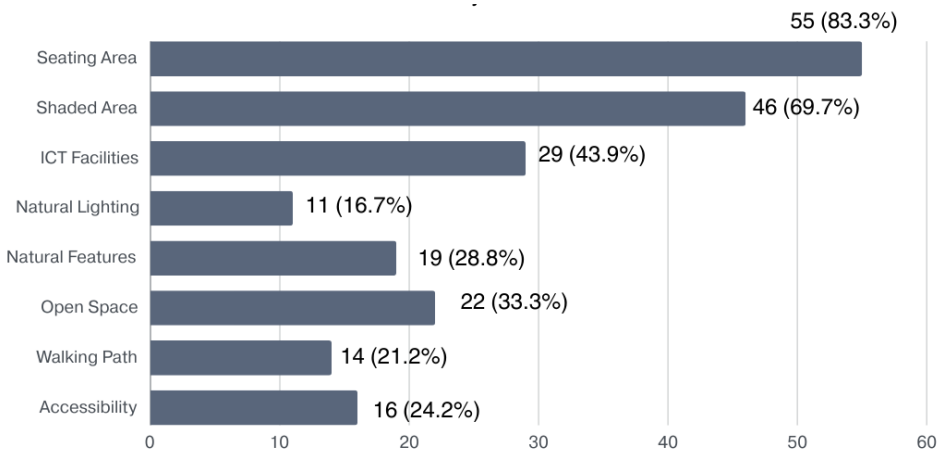


Figure 13: Bar Graph for Recommendation Survey

Discussion on Overall Survey Questionnaires

Courtyard has been a pivotal part of architectural design serving tranquility throughout the building. According to data collection and analysis, a courtyard can heavily influence social interaction among students. Courtyards should be designed with the needs of the users' mind as to serve the purpose of providing space for social interaction and not just aesthetically pleasing.

Based on the analysis of survey questionnaires, courtyard has the impact of providing a space that encourages collaboration for group work. Courtyards that offer spacious space, good seating areas and providing shaded areas can encourage students to engage in group work outside lecture rooms more often. Hence, this proves that courtyard design can be a factor contributing to social interaction among students in tertiary educational institutions. This result of the analysis can be a steppingstone for the courtyard to be provided with enough seating to attract students to come in within their break time to gather, relax and engage in conversation with their friends and even mutual friends from other departments. A good courtyard does have attribution to promote and enhance social interaction.

The overall results from data collection confirms with Kahu's ideas that the design character of physical spaces, specifically the courtyard, has a big impact on students' social interaction. The characteristics of the courtyard bring many values in terms of aesthetics, functions, and visuals and this can be proven by the result from students' preferences for elements to be provided in the courtyard.

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CONCLUSION

In conclusion, this study emphasizes the critical role of social interaction among students in tertiary educational institutions and identifies the key factors that contribute to it. The findings highlight the significance of a well-designed and functional courtyard as a central spatial feature that fosters social engagement among students. Implementing essential design elements—such as adequate seating areas, the presence of natural features, and an effective spatial layout—is vital in creating a courtyard that supports both formal and informal social activities.

Specifically, the study underscores the importance of courtyard design in enhancing social interaction among students within the KAED building. A well-integrated courtyard equipped with natural elements, flexible seating, and shaded zones can significantly improve students' social dynamics. Beyond serving as a space for physical activity, the KAED courtyard acts as a social and recreational hub that positively contributes to students' psychological well-being.

Based on the findings, several design improvements can be introduced in the KAED courtyard to enhance social interaction among students. Future studies should be conducted to further evaluate and strengthen the courtyard's relevance as a social and communal space within the academic environment. Drawing from the literature and research outcomes, several design recommendations and considerations are proposed to create a more engaging and student-friendly courtyard experience:

- Incorporate interactive green spaces and flexible seating arrangements to provide students with personalized seating clusters while allowing them to enjoy the natural ambiance of the courtyard.
- Integrate interactive technological features such as wider Wi-Fi coverage and accessible USB charging ports to support both social and academic activities.
- Introduce more distinctive and architecturally appealing shaded areas to improve comfort, aesthetics, and usability throughout the day.

Moreover, proper maintenance of the courtyard's existing features is essential to ensure safety, functionality, and comfort. Although the current design of the KAED courtyard possesses notable strengths, there remains room for improvement to further enhance user experience and strengthen social interaction among KAED students.

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AN ASSESSMENT OF CORRUPTION FACTORS AND IMPACT FROM THE PERSPECTIVE OF PROFESSIONAL BODIES IN THE BUILT ENVIRONMENT

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Abstract

The built environment sector is highly vulnerable to corruption due to its complex processes, multiple stakeholders, and large financial flows. This study examines the factors and impacts of corruption from the perspective of registered members of professional bodies in the built environment sector in Malaysia. It adopts a quantitative approach where an online survey was distributed among members of the professional bodies, yielding 417 valid responses. Relative Importance Index analyses revealed that the main factors driving corruption are the need "To obtain approval quickly" and "Low ethics and integrity." Respondents also agreed that "Poor reputation of professional bodies/the sector" and "Non-compliance with standards" as the most significant impacts of corruption. The results also suggest that corruption is less about external pressures and more linked to systemic weaknesses and individual ethical failings. Hence, the study recommends the professional bodies to undertake rigorous awareness campaigns and continuous training for both new and long-serving members, and to adopt Organisation Anti-Corruption Plan as a platform to embed anti-corruption initiatives and integrity values in their organisational culture as well as among members. The study also suggests for a more streamlined and simplified project approval process to reduce corruption risks.

Keywords: corruption risks, built environment, corruption factors, corruption impacts.

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INTRODUCTION

Corruption in the construction industry and broader built environment sector has been widely recognised as a pervasive global issue with severe economic and developmental consequences. Studies have consistently shown that corruption-related leakages, fraud, and kickbacks can significantly inflate project costs, with Okereke (2020) reporting increases of 10–30% of project value and the World Bank (2018) estimating that approximately 5% of infrastructure investment and maintenance expenditure is lost to corrupt practices. Beyond the direct financial losses, procurement studies have highlighted that red flags such as single bidding and limited competition are strongly correlated with corruption risks, particularly in high-value infrastructure sectors like transport and public works (Fazekas & Tóth, 2018). These practices undermine transparency and accountability in project delivery, diverting resources away from development goals and reducing value for money in public investment. The global nature of this challenge is further emphasised by Transparency International, which consistently identifies construction as one of the most bribery-prone sectors, underscoring its systemic vulnerability to corruption.

The persistence of corruption in this sector points to a deeper structural problem. The complexity of construction processes, the involvement of multiple stakeholders, and the scale of financial flows create environments where collusion, bribery, and state capture thrive, ultimately compromising project integrity and sustainability. Evidence from advanced economies, such as the Royal Institution of Chartered Surveyors (RICS, 2021) survey showing that 97% of UK construction companies felt exposed to bribery and money-laundering risks, illustrates that this is not only a developing country issue but a global concern. The consequences are profound: inflated costs, project delays, abandonment, substandard outputs, and even risks to public safety through compromised building quality. These recurring outcomes indicate a critical gap between governance frameworks and industry practices, raising the problem statement that despite existing regulations and professional codes of conduct, corruption continues to undermine efficiency, accountability, and trust in the built environment sector. Addressing these challenges requires a deeper understanding of the underlying drivers of corruption, their systemic impacts, and the urgent need for more effective anti-corruption strategies tailored to the sector's unique vulnerabilities.

This paper intends to achieve the following objectives, which are; i) to analyse the factors that leads to corruption to occur in the built environment sector, ii) to assess the impact of corruption to the built environment.

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LITERATURE REVIEW

Professional Bodies in Built Environment

In Malaysia, practitioners in the built environment sector are required to register with their respective professional bodies as a regulatory condition for practice. This requirement is intended to ensure that professionals possess the necessary competence, credibility, and commitment to deliver their responsibilities effectively and ethically. Membership in a professional body reflects adherence to established standards of quality, integrity, and accountability, thereby reinforcing public confidence in the profession.

Professional bodies, which are statutory organisations established under specific legislative acts, carry wide-ranging responsibilities, including maintaining registers of members, assessing membership applications, accrediting academic programmes at higher education institutions, conducting professional examinations and training to uphold competency, and formulating codes of conduct to guide ethical practice. Within this framework, professional bodies and their members play a central role in combating corruption in the built environment sector by promoting transparency, safeguarding accountability, and upholding public interest in project delivery. This underscores the importance of registered professionals not only in maintaining technical and professional standards, but also in understanding corruption and its associated offences as outlined in Malaysian Anti-Corruption Commission Act 2009 [Act 694], thereby strengthening integrity across the sector.

Factors Contributing to Corruption in the Built Environment

Generally, the built environment sector is highly competitive as it involves numerous stakeholders striving to secure project contracts and tenders. The limited availability of projects, shaped by development needs and market demand, further intensifies this competition. In such circumstances, some parties may resort to unethical practices, including corruption, to gain advantage and secure project opportunities (Nordin et al., 2012; Sohail & Cavill, 2006).

Lee (2019) provides a detailed examination of the factors contributing to corruption in the built environment sector. He argues that the inherent characteristics of the sector itself are the primary drivers behind its high susceptibility to corrupt practices. The complexity of construction projects, which often involve multiple stakeholders, substantial financial investments, intense competition, and close relational networks, creates numerous opportunities for corrupt activities to emerge. This perspective is well supported in the literature, where scholars have consistently highlighted the structural and relational features of the built environment sector as critical enablers of corruption (Gunduz & Önder, 2013; Bowen et al., 2012; Kenny, 2009; De Jong et al., 2009; Sohail & Cavill, 2006; Zou, 2006).

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The built environment sector is often characterised by lengthy and complex processes, which make project coordination and monitoring particularly challenging. According to Nordin et al. (2012), the multiple phases of construction, coupled with the diverse interactions and psychological behaviours of practitioners, frequently result in inconsistent standards and information flows. Such circumstances create opportunities for corruption and fraudulent practices to take place (Tabish & Jha, 2011).

Another major contributing factor is the pursuit of financial gain. The large sums of money typically involved in construction projects render the sector especially vulnerable to corrupt practices. As noted by Zou (2006), Sohail and Cavill (2008), and Zhang et al. (2017), the temptation of financial rewards can lead individuals to exploit the system for personal enrichment. Given that capital is essential to advance any project, and that construction projects generally involve significant financial allocations, corruption becomes an attractive avenue for unscrupulous actors seeking illicit income within a short period of time (Olusegun et al., 2011; Sohail & Cavill, 2006; Nordin et al., 2011).

The payment system itself has also been identified as a factor contributing to corruption. Lee (2019) argues that because payment distribution is tied to project milestones, and varies depending on the actors involved, the system often lacks clarity and transparency. Contractors' claims typically pass through multiple parties, which blurs lines of accountability and opens opportunities for unethical actors to exploit the process by betraying professional trust and engaging in corrupt practices.

While fragmented processes can create gaps in communication among project participants, this does not imply that relationships within the industry are weak. On the contrary, Lee (2019) highlights that overly close personal ties between clients, consultants, and contractors, beyond the bounds of professional interactions, can foster nepotism and collusion, particularly in matters relating to contracts and tenders (Le et al., 2014; Sohail & Cavill, 2006).

Moreover, Sohail and Cavill (2006) contend that the absence of a strong professional culture further exacerbates the problem. Although professional bodies establish codes of conduct and ethical standards, many practitioners in the built environment sector tend to disregard these principles, prioritising profit maximisation over integrity. As Bowen et al. (2012) emphasise, this tendency weakens the role of ethical norms in guiding practice, thereby enabling corruption to persist.

Impacts of Corruption to the Built Environment

Corruption in the built environment sector poses significant threats to the overall success of project delivery, particularly with respect to cost, time, quality, and safety. One of the most direct and visible consequences is the escalation of project

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costs, where funds are diverted to cover bribes, kickbacks, and other irregularities rather than being allocated to project improvements (Le et al., 2014; Nordin et al., 2011; Sohail & Cavill, 2006; Kenny, 2009). Such diversions undermine financial integrity and result in outputs that are often incomplete, substandard, or even unsafe for end users (Nordin et al., 2011; Kenny, 2009; Sohail & Cavill, 2006). Corruption also disrupts planned processes, leading to frequent delays and project abandonment. Projects that are completed may be uninhabitable or structurally defective, with issues such as cracks and collapses linked to the use of poor materials and non-compliance with standards (Lee, 2019). Consequently, corruption has been widely associated with the rising number of abandoned projects and wasted investments, leaving communities and governments to bear the long-term consequences of such failures (Doraisamy et al., 2014; Olusegun et al., 2011).

Beyond financial losses and project failures, corruption significantly reduces productivity and efficiency in built environment sector. As Le et al. (2014) observe, poor contractor performance is often linked to corrupt practices, where contractors tender for multiple projects without adequate resources, relying on bribery to secure contracts. This behaviour contributes to inefficiency, reduced output, and diminished work quality. Nepotism and collusion in project allocation further weaken competition, allowing underqualified or resource-limited firms to win projects, which exacerbates inefficiencies across the sector. The cumulative effect of these practices is an industry environment where personal gain overrides professional integrity, leading to systemic inefficiencies, poor-quality infrastructure, and reduced trust in the industry.

According to the World Bank (2018), corruption in the built environment sector generates significant downstream impacts, most notably in the form of poor infrastructure quality, frequent delays, inadequate maintenance, and heightened risks to public safety, including cases of substandard construction, premature deterioration, and even structural collapse. Beyond these immediate effects, corruption also produces broader economic and social consequences by reducing the efficiency of public investment, lowering infrastructure returns, and distorting project selection processes. Furthermore, the diversion of resources away from essential maintenance exacerbates long-term vulnerabilities, leading to declining service delivery and undermining overall development outcomes.

RESEARCH METHODOLOGY

This study adopts a mixed-method research design, combining both qualitative and quantitative approaches to comprehensively address the research objectives (Johnson & Schoonenboom, 2017). The qualitative component involved an extensive review of literature, including journal articles, published and

unpublished reports, government statistics, relevant legislation, and professional guidelines. This review served to strengthen the study's theoretical framework, guide the research design, and establish a broad understanding of the topic. Insights obtained from the literature review informed the development of the survey instrument, with key aspects incorporated into the questionnaire for subsequent quantitative testing to achieve the study objectives. A semi-structured questionnaire was therefore designed to collect responses from targeted participants, specifically registered members of selected professional bodies within the built environment sector.

For the quantitative phase, respondents were sampled from the registered professional members of major built environment professional bodies in Malaysia, as detailed in Table 1. Stratified random sampling was employed to ensure adequate representation from each professional body. Using the formulae proposed by Yamane (1967) and Cochran (1977), it was determined that for a population size of 1,000 or more, a sample of 385 is sufficient to achieve a 95% confidence level with a 5% margin of error. Considering the total population of registered professionals across the targeted professional bodies and the acceptable tolerance level for error, this study established a minimum sample size of 390 respondents. Table 1 presents the distribution of the target sample for each professional body.

Table 1. Sampling target based on professional bodies

Professional bodies	Target sample	
	No	**%**
i.Board of Architects Malaysia	65	16.7
ii.Board of Quantity Surveyors Malaysia	65	16.7
iii.Land Surveyors Board	65	16.7
iv.Board of Engineers Malaysia	65	16.7
v.Board of Town Planners Malaysia	65	16.7
vi.Institute of Landscape Architects Malaysia	65	16.7
Total	**390**	**100**

Data collection was administered through the Google Forms platform, which served as the primary tool for distributing and gathering responses from the targeted sample of professional body members. As noted by Creswell (2014), the use of online survey instruments has become increasingly prevalent due to their efficiency, accessibility, and ability to streamline the data collection process. The final survey was conducted between 5 July 2024 and 30 September 2024, during which the questionnaire link was disseminated through the secretariats of the selected professional bodies. These secretariats were requested to circulate

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the survey link among their registered members and to re-share it periodically to encourage higher participation. Ultimately, a total of 417 valid responses were collected, exceeding the minimum target sample size, thereby ensuring a robust dataset for analysis.

The data obtained through the online survey were analysed using the Statistical Package for the Social Sciences (SPSS) software. The analyses encompassed both descriptive and inferential statistics. Descriptive analysis, presented in the form of tables, diagrams, and the Relative Importance Index (RII), was employed to summarize and rank respondents' perceptions across various aspects of the study. The RII was calculated using the formula RII = ΣW / (A × N), where ΣW represents the sum of weights assigned by respondents, A denotes the highest weight on the scale, and N is the total number of respondents. A higher RII value indicates greater relative importance attributed to the corresponding aspect. In addition, inferential statistical methods such as Spearman's rho correlation were applied. Spearman's rho was used to measure the strength and direction of associations between ranked variables, thereby enhancing the depth of the study's findings.

ANALYSIS AND DISCUSSION

Figure 1 below shows the membership of respondents to professional bodies. From the findings, 50.6% of respondents were registered members of the Board of Town Planners Malaysia, followed by 24.5% members of the Board of Quantity Surveyors of Malaysia, and 12.7% members of the Board of Architects of Malaysia. Respondents from the Board of Engineers Malaysia and the Land Surveyors Board were rather low despite several reminders by the secretariats for members to participate in the survey.

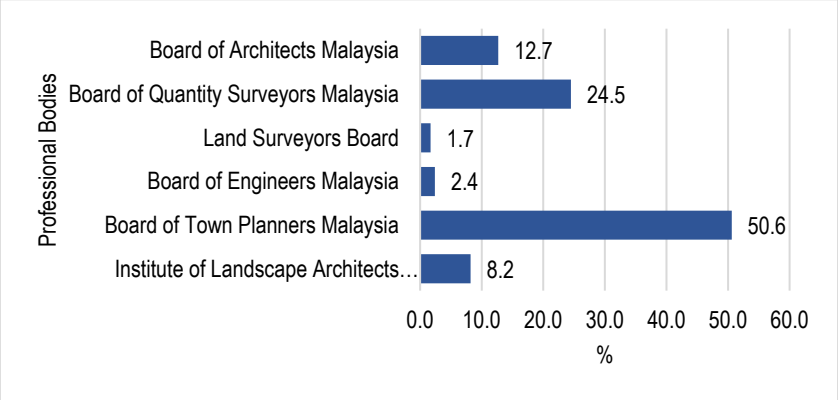


Figure 1: Distribution of respondents by professional bodies
Source: Online survey (2024)

In terms of working experience, Figure 2 shows that 51.8% of the respondents have working experience of between 6 years to 20 years, while 38.6% have working experience of more than 20 years in the built environment sector. Only 9.6% stated that they have worked in the sector for 5 years or less.

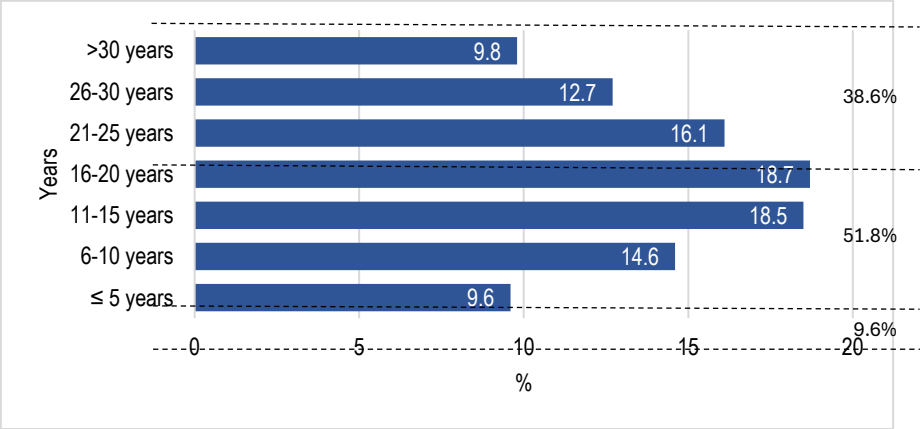


Figure 2: Years of working experience
Source: Online survey (2024)

Meanwhile, Figure 3 below shows that almost half of the respondents work in the private sector (48.7%), followed by 36.9% in the public sector and 11.3% who are self-employed. In addition, 2.2% are retirees, while 1% indicated that they were either not working or pursuing further studies.

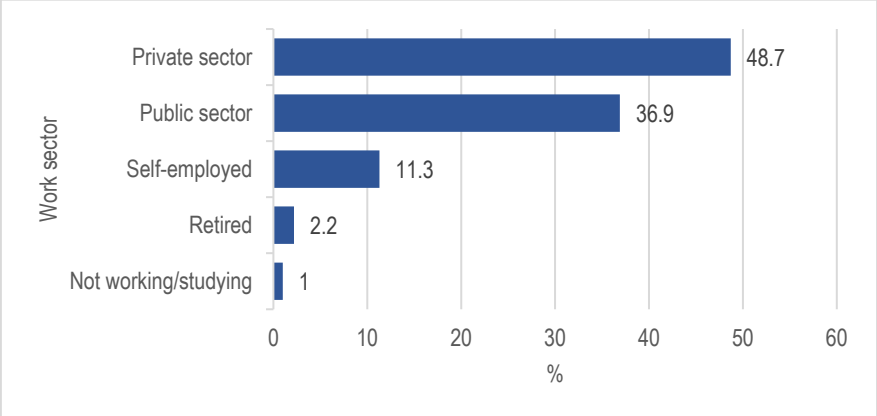


Figure 3: Working sectors
Source: Online survey (2024)

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In terms of factors contributing to corruption risks in the built environment sector, respondents were asked to rate their agreement according to the scale of 1 to 4, where 1 denotes 'Very Disagree' while 4 represents 'Very Agree'. From the result, the Relative Importance Index (RII) was calculated based on the number of responses for each scale. Figure 4 below presents the result of the RII calculation, in which the higher the RII value indicates the higher the agreement of respondents on those factors.

As shown in Figure 4 below, 'To obtain approval quickly' and 'Low ethics and integrity' received high agreement as the most important factors causing corruption in the built environment sector (RII=0.87170). This was followed by 'Seeking personal gains' (RII=0.87110) in second place and 'Greed' (RII=0.86091) in third. On the other hand, 'Lifestyle beyond means' (RII= 0.73561) received the lowest agreement followed by 'Pressure from superiors/colleagues' with a RII of 0.75420.

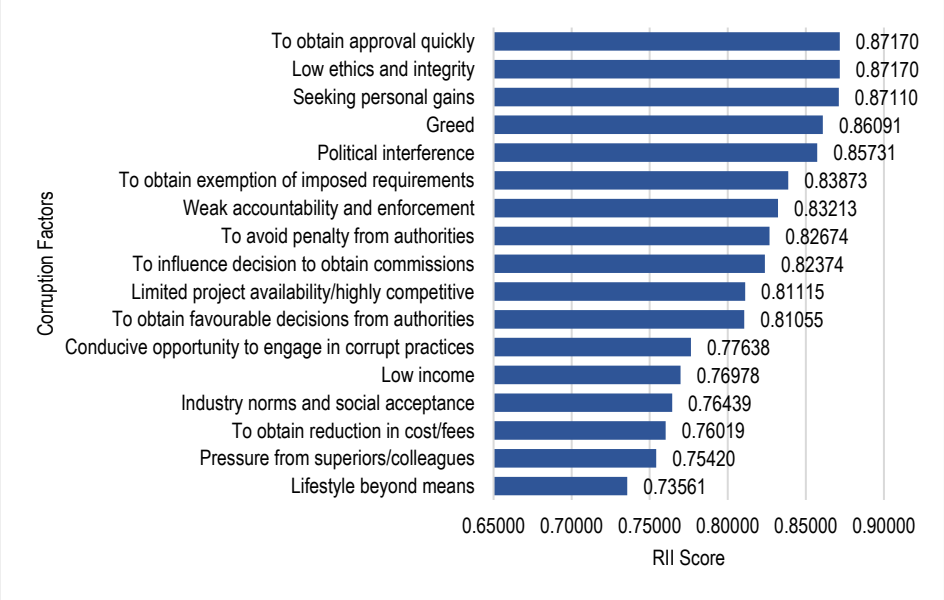


Figure 4: RII analysis of perceived corruption factors in the built environment sector
Source: Online survey & author's calculation (2024)

Next, the Spearman test was conducted to examine the relationship between respondents' backgrounds and their feedback. Through the Spearman test, the direction and value of the correlation between the variables tested can be identified, and thus providing insights into the factors influencing the feedback

given by the respondents. The results of this Spearman test are as shown in Table 2.

Table 2: Spearman Rho analysis of perceptions of corruption factors based on respondents' background

Factors	**Age**		**Years of working experience**		**Year first registered as member**	
	p-value	cc	p-value	cc	p-value	cc
1) To obtain approval quickly	**-0.206****	**0.000**	**-0.201****	**0.000**	0.059	0.231
2) To obtain reduction in cost/fees	**-0.107****	**0.030**	**-0.097***	**0.047**	0.027	0.588
3) To obtain exemption of imposed requirements	**-0.153****	**0.002**	**-0.156****	**0.001**	0.053	0.278
4) To obtain favourable decisions from authorities	**-0.190****	**0.000**	**-0.161****	**0.001**	**0.097***	**0.047**
5) To avoid penalty from authorities	**-0.184****	**0.000**	**-0.178****	**0.000**	0.023	0.636
6) To influence decision to obtain commissions from suppliers/ contractors/ designers	**-0.140****	**0.004**	**-0.132****	**0.007**	0.053	0.284
7) Political interference	-0.049	0.321	-0.060	0.221	0.033	0.507
8) Low income	**-0.160****	**0.001**	**-0.145****	**0.003**	**0.140****	**0.004**
9) Lifestyle beyond means	**-0.120***	**0.014**	**-0.130****	**0.008**	**0.136****	**0.005**
10) Greed	-0.072	0.143	-0.068	0.164	0.071	0.148
11) Seeking personal gains	**-0.109***	**0.026**	**-0.097***	**0.048**	0.053	0.279
12) Low ethics and integrity	-0.073	0.134	-0.069	0.161	0.041	0.409
13) Limited project availability/highly competitive	**-0.181****	**0.000**	**-0.177****	**0.000**	0.064	0.193
14) Weak accountability and enforcement	**-0.105***	**0.031**	**-0.104***	**0.035**	0.004	0.942
15) Pressure from superiors/colleagues	**-0.161****	**0.001**	**-0.157****	**0.001**	**0.098***	**0.046**
16) Industry norms and social acceptance	**-0.222****	**0.000**	**-0.212****	**0.000**	**0.121***	**0.014**
17) Conducive opportunities to engage in corrupt practices	**-0.147****	**0.003**	**-0.143****	**0.003**	0.069	0.161

Source: Author's calculation

Referring to Table 2, there is a p-value result tested less than 0.05 between the variables of age, years of working experience and year of first registration as a member in a professional body with their perception of corruption factors in the built environment sector. Therefore, the null hypothesis

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that states that there is no effect or relationship between the variables tested can be rejected.

The Spearman test also shows that there is a low and negative correlation between the age and years of working experience of the respondents with their responses to corruption factors in the built environment sector. This negative correlation relationship shows that younger respondents and those with less working experience were more likely to agree or strongly agree that of the corruption factors in the built environment sector. On the other hand, there is a low and positive correlation between the year first registered as a member in a professional body with the perception of corruption factors in the built environment sector. This positive correlation shows that respondents with longer professional body membership were more likely to agree that 'To obtain favourable decisions from authorities' (cc=0.097*), 'Low income' (cc=0.140**), 'Lifestyle beyond means' (cc=0.136**), 'Pressure from superiors/colleagues' (cc=0.098*) and 'Industry norms and social acceptance' (cc=0.121*) are corruption factors in the built environment sector.

Respondents were also asked regarding their level of agreement on impacts of corruption. A scale of 1 to 4, namely, 1 Strongly Disagree, and 4; Strongly Agree was used. Based on the responses given, the RII was calculated, and the results are as shown in Figure 5 below

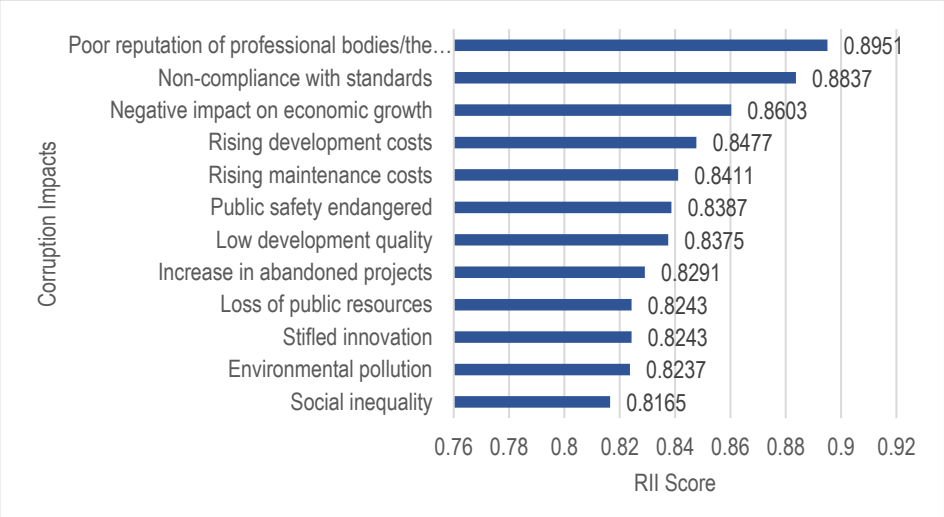


Figure 5: RII analysis of perceived impact of corruption on the built environment sector
Source: Online survey & author's calculation (2024)

Referring to Figure 4 above, the most agreed upon effect of corruption by respondents with the highest RII score is 'Poor reputation of professional bodies/the built environment sector' (RII=0.8951), followed by 'Non-compliance with standards' (RII=0.8837) and 'Negative impact on economic growth' (RII=0.8603). On the other hand, the least agreed-upon impact of corruption is 'Social inequality' (RII=0.8165), followed by 'Environmental pollution' (RII=0.8165) and 'Stifled innovation' (RII=0.8243).

CONCLUSION

The findings of this study reaffirm that corruption in the built environment sector is primarily driven by systemic weaknesses and individual ethical failings. The high RII score for factors such as "To obtain approval quickly" and "Low ethics and integrity" suggest that both institutional loopholes and personal misconduct create fertile ground for corrupt practices. This is further reinforced by the prominence of "Seeking personal gains" and "Greed" as underlying motivations. Interestingly, lifestyle pressures and external influences, such as "Lifestyle beyond means" and "Pressure from superiors/colleagues," received comparatively lower levels of agreement or RII scores, indicating that corruption is less about external compulsion and more about deliberate opportunism. The Spearman correlation analysis deepens this insight, showing that younger professionals and those with less work experience tend to perceive corruption factors more strongly, possibly reflecting greater awareness or sensitivity to integrity issues among newer entrants to the profession. Conversely, long-serving members of professional bodies exhibit a stronger tendency to associate corruption with structural and cultural factors, such as income levels, authority pressures, and industry norms. These patterns highlight that perceptions of corruption are not homogeneous but shaped by demographic and professional experience, offering an important dimension for targeted anti-corruption strategies.

Given that the most significant perceived consequence of corruption is the "Poor reputation of professional bodies/the built environment sector", followed closely by "Non-compliance with standards" and "Negative impact on economic growth," it is evident that corruption not only undermines project quality but also erodes institutional credibility and national progress. In light of these findings, several recommendations can be proposed. First, professional bodies should strengthen ethical training and integrity-focused continuous professional development (CPD), particularly for younger and newly registered members, to nurture a culture of accountability from the outset of professional practice. Continuous training must also be enhanced to those long-serving members to refresh their awareness, understanding and values in relation to

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corruption. Second, Regulatory frameworks governing project approvals should be streamlined to enhance transparency and incorporate digital monitoring systems, thereby minimising opportunities for rent-seeking and reducing corruption risks. Simplifying overly complex procedures would also accelerate the approval process and further mitigate corruption vulnerabilities. Finally, professional bodies should develop and implement an Organisation Anti-Corruption Plan (OACP) to institutionalise anti-corruption initiatives and embed integrity within their organisational culture and among their members. The formulation and adoption of an OACP would also strengthen the public perception of professional bodies as institutions committed to transparency, integrity, and ethical governance. These proposed measures would not only mitigate corruption but also strengthen public confidence in the integrity and professionalism of the built environment sector.

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COASTAL TOURISM THROUGH A MUSLIM WOMEN'S GAZE: INSIGHTS FROM MALAYSIA

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Abstract

Tourism is not only a movement of people but also a socially constructed way of seeing shaped by culture, religion, and gender. Coastal tourism is often associated with open bodily display and carefree leisure, which may conflict with Muslim women's expectations of modesty, safety, and family orientation. While Malaysia positions itself as a leading Muslim-friendly destination, limited research has centred Muslim women's voices in beach-based tourism. This study addresses this gap by applying and extending Urry's tourist gaze theory through the development of a Muslim Women's Tourist Gaze Framework (MWTG). Using a qualitative, interpretive single-case design, Port Dickson (PD) was studied through 25 semi-structured interviews with Muslim women tourists and key stakeholders, supported by on-site observations. Thematic analysis revealed that women's coastal experiences are organized around three interlinked logics: (1) ethical-spiritual, viewing nature as a site of gratitude and reflection; (2) family-collective, prioritizing safety, modesty, and kinship roles; and (3) environmental stewardship, valuing cleanliness and preservation. Findings extend the tourist gaze beyond Eurocentric assumptions by embedding faith, family, and ecological care into coastal leisure. Practically, the study highlights the importance of modesty-supportive infrastructure, halal assurance, and sustainability in strengthening Malaysia's coastal tourism appeal.
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Keywords: tourist gaze, Muslim women, Islamic tourism, coastal tourism, Port Dickson, Malaysia

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INTRODUCTION

Tourism is commonly described as people moving for leisure or other purposes, but it is also a social process shaped by norms, media images, and local meanings. The idea of the "tourist gaze" explains how visitors are guided to look at places and practices in certain ways, not only by personal interests but also by culture, class, gender, and religion (Urry, 1990; Urry & Larsen, 2011). In coastal settings, this gaze often assumes open bodily display and carefree leisure, which may not align with modesty expectations and family-oriented routines found among many Muslim communities. Recent work suggests the need to reconsider the gaze through non-Western perspectives to avoid a one-size-fits-all model and to capture diverse experiences in tourism (Cohen & Cohen, 2019). This article follows that direction by centring Muslim women's perceptions and practices in Malaysian coastal destinations, where everyday devotion, safety concerns, and kin responsibilities interact with beach leisure.

The focus on Muslim women is important for both theory and practice. In Malaysia, Muslims (mostly ethnic Malays) form the majority population, and coastal tourism is a key segment of national tourism development and branding (World Travel & Tourism Council (WTTC), 2021). At the same time, the halal travel economy is expanding, and women are increasingly visible as decision-makers in travel planning, yet their voices remain limited in studies of beach-based leisure (Mastercard & CrescentRating, 2021; Yang, Khoo-Lattimore, & Arcodia, 2017). Islamic principles such as modesty and privacy shape how women time visits, choose facilities, and manage visibility in mixed-gender spaces (Battour & Ismail, 2016; Rahman et al., 2019). By examining how these factors influence perceptions, expectations, and on-site experiences, this paper refines the tourist gaze concept beyond Eurocentric assumptions and offers practical implications for inclusive coastal design, marketing, and management in Malaysia. Accordingly, this study develops the Muslim Women's Tourist Gaze (MWTG) framework and evaluates it in Port Dickson (PD). Specifically, this study focuses on understanding the tourist gaze from the perspective of Muslim women, particularly in the context of coastal destinations. The purpose is to explore how these women perceive, expect, and experience coastal tourism, considering their unique cultural and religious backgrounds.

LITERATURE REVIEW

This paper examines how the tourist gaze framework has developed and how it can be read together with Islamic tourism concepts to understand Muslim women's travel, especially in coastal settings of Malaysia. The tourist gaze, first systematized by Urry (1990; Urry & Larsen, 2011), explains that tourism is not only movement but also a socially organized way of seeing places through signs, media, and cultural expectations. At the same time, Islamic tourism scholarship emphasizes Shariah-aligned practices, halal services, and modesty-related needs

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that shape travel choices and on-site conduct (Battour & Ismail, 2016; Henderson, 2016). Bringing these two lenses together helps to describe how Muslim women form preferences, navigate space, and evaluate facilities in beach destinations where dominant leisure scripts can conflict with privacy and religious duty. This section proceeds by outlining the evolution and core elements of the tourist gaze, then turning to Islamic tourism and its applications, before considering gendered implications, and finally synthesizing themes related to Muslim-friendly coastal development in Malaysia.

Theoretical framework: Tourist gaze and Islamic tourism

The gaze is a cultural pattern for looking, guided by anticipation, media imagery, and institutional signposting (Urry, 1990, 2002). It emphasizes semiotics (Culler, 1981), the social organization of leisure, and contrasts with ordinary life. Later work added useful dichotomies: romantic vs collective, historic vs modern, authentic vs staged (Jenkins, 2000). Over time, critiques noted Eurocentric biases and called for broader cultural grounding (Franklin & Crang, 2001; Bianchi, 2009). Empirical studies showed culturally distinct gazes. For example, Chinese relational or reverential forms, and Asian collectivist orientations (Li, 2005; Fountain et al., 2011).

In parallel, Islamic tourism frameworks systematize faith aligned travel: halal food assurance, prayer access, modest dress norms, gender sensitive spaces, and avoidance of haram activities (Battour & Ismail, 2016; Rahman et al., 2019). Institutional models such as Malaysia's Muslim-Friendly Tourism and Hospitality (MFTH) or Muslim-Friendly Accommodation Recognition (MFAR) and the Global Muslim Travel Index (GMTI) operationalize standards for destinations (Islamic Tourism Centre, 2024; Mastercard & CrescentRating, 2024). These frameworks rest on Shariah's objectives (*maqasid*), position travel as permissible/valuable when obligations are met and connect leisure to reflection (*tafakkur*) and remembrance (*tadabbur*) in nature (Kamali, 2003; Nasr, 1996).

Integrating the two frameworks allows us to see how gaze is filtered by modesty, family orientation, and prayer routines, and how destination infrastructures, services, and media images co-produce what women consider feasible, respectful, and enjoyable.

Evolution and applications of the tourist gaze

Early formulations linked gaze to socially organized leisure, spectacle, and the reading of signs (Urry, 1990; 2002). Anticipation is built via film, TV, advertising, and digital media, narrowing visitors to a few "nodes" and familiar viewpoints (Urry, 1995). As the concept was applied in new regions, researchers showed culturally specific gazes that do not map neatly to Western individualism: collectivist travel patterns (Lee, 2001), different human nature relations (Li, 2005), and reverential practices at sacred sites (Urry, 2002). More recently, the

subject of gazing widened from tourists to hosts and co-visitors (mutual, reverse, local, intra-tourist gazes), highlighting how performance and observation are reciprocal in crowded destinations (Lin & Fu, 2020). In coastal contexts, this reciprocity connects to visibility and gendered scripts: the camera phone culture, beachwear expectations, and staged promotional photography all shape what is "worth seeing," while visitors adjust routes, timing, and group composition to manage exposure (Kim & Fesenmaier, 2022).

Two distinctions are useful for this study: collective gaze versus personal perception. The gaze frames shared norms of viewing; perception refers to individual, sensory-cognitive interpretation during the trip (Stepchenkova & Li, 2019). In practice, women arrive with gaze shaped expectations about beaches, then refine or resist those expectations through lived experience such as cleanliness, crowding, safety, staff behaviour).

Islamic tourism: Principles, behaviour, and gendered needs

Islamic tourism literature identifies consistent travel considerations:

- Faith compliance in food and hospitality: halal certification, alcohol-free options, avoidance of prohibited entertainment (Henderson, 2009; Battour et al., 2011; Dinar Standard & CrescentRating, 2020).
- Prayer and ablution access across transport hubs, malls, resorts, and attractions (Henderson, 2010; Wilson, 2014).
- Modesty and privacy: gender-segregated recreation where feasible (e.g., women-only beaches or time slots) and designs that screen facilities and mark Qibla in rooms (Stephenson, 2014).
- Family orientation: large share of family travel, need for integrated facilities that respect intergenerational routines (Mastercard & CrescentRating, 2019).

Recent industry frameworks add new layers. The RIDA model (Responsible, Immersive, Digital, Assured) links faith services with sustainability, cultural immersion, and technology-enabled planning and assurance (Mastercard & CrescentRating, 2024). In practice, this means clean coastal environments, accessible prayer scheduling, halal discovery tools, multilingual wayfinding, clear dress etiquette, and women focused service features.

Gender focus on the other hand identified Muslim women's mobility blends safety, modesty, and social roles. Evidence shows rising financial independence and planning authority among younger cohorts; however, comfort and trust still depend on visible safety protocols, gender-aware service, and reliable signals of cultural fit (Mastercard & CrescentRating, 2024; UNWTO, 2019, 2022). Rather than a homogeneous segment, women vary by age, locale, religiosity, and group composition (Yang, Khoo-Lattimore, & Arcodia, 2017).

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Intersection: Islamic tourist gaze in coastal settings

When the tourist gaze meets Islamic tourism, beaches become sites of careful negotiation between leisure and piety. For many women, the 'default beach script' (mixed crowds, minimal clothing, pervasive photography) does not fully align with modesty and privacy norms. As a result, women adapt through:

- Timing and routing to avoid peak visibility.
- Layered swimwear choices, with social agreements on photography.
- Group travel that distributes care work and provides a protective buffer.
- Site selection favouring screened facilities, clean changing areas, and clear etiquette guidance.

From a service perspective, the Islamic tourist gaze is not only about facilities but also about representation. Marketing that normalizes modest swimwear, highlights family scenes without objectifying bodies, and shows privacy gradients (quiet coves, screened showers) reduces uncertainty and labour of self-management (Han et al., 2019; Stephenson, 2014;). Scholars caution that mere 'halal signalling' without genuine respect for spiritual intent can feel instrumental (Mohsin & Ryan, 2016). Thus, ethical implementation matters as much as checklists.

Spiritually, travel may invite contemplation of nature as *ayat* (signs), making coastal experiences opportunities for remembrance and reflection, not only for entertainment (Al-Qur'an 3:190–191; 29:20). This spiritual dimension complements the semiotic gaze: the same sunset can be both a visual attraction and a moment of *tafakkur*, shaping what counts as "good leisure" for observant travellers (El-Gohary, 2016; Jafari & Scott, 2014).

Figure 1 outlines the study's theoretical framework, which integrates the Tourist Gaze with Islamic tourism tenets to account for how Muslim women perceive, anticipate, and experience coastal destinations. Building on Urry's idea of socially constructed vision and the interpretation of signs, the framework positions destination engagement within culturally embedded meanings and visual cues (Urry, 1990; Urry & Larsen, 2011). It also incorporates Islamic considerations that often guide travel decisions such as the availability of halal food, access to prayer facilities, modesty and privacy requirements, and avoidance of prohibited activities which is highlighted in Islamic tourism scholarship (Battour et al., 2020). Together, these components form the lens that guides the study's research questions and its interview-led analytical approach.

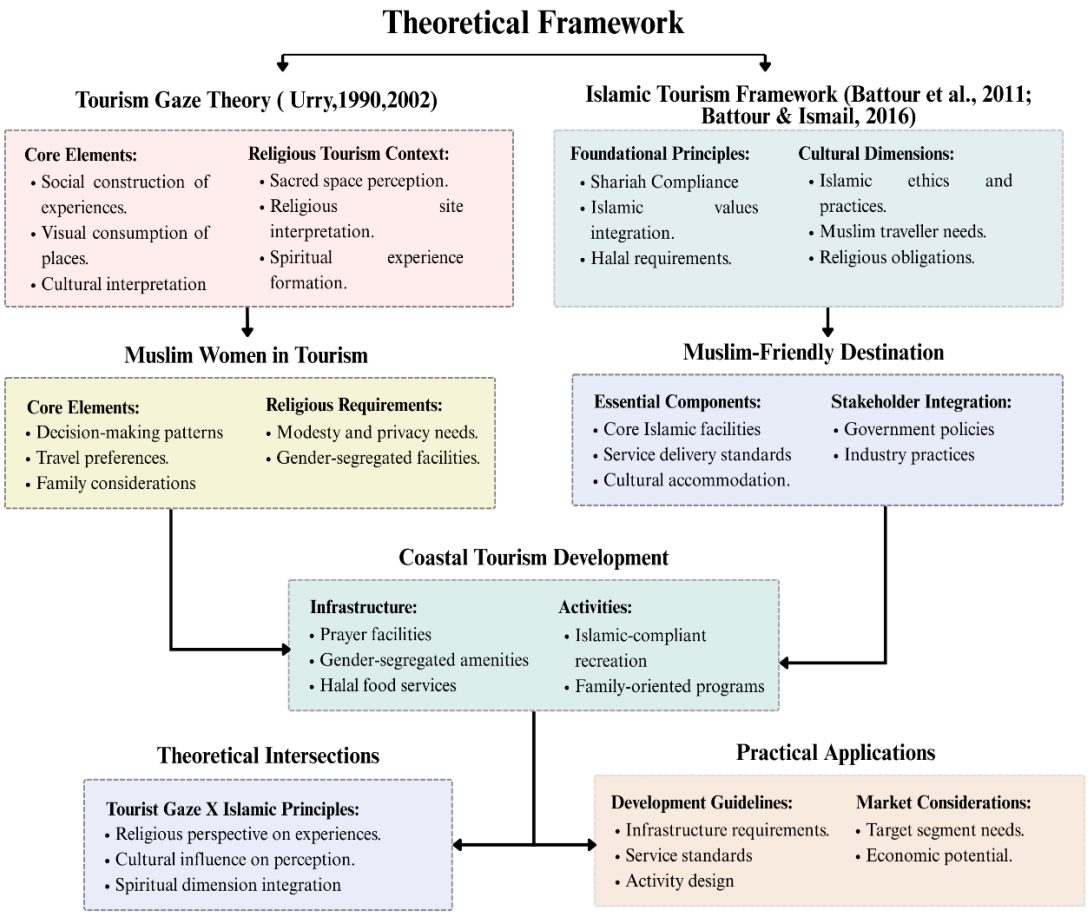


Figure 1: The Islamic Tourist Gaze Theoretical Framework

Muslim-friendly coastal tourism development

In terms of infrastructure, international practice shows workable patterns: women only beaches in parts of Turkiye (for example, resorts in Alanya, Turkiye, provide secluded women-only beaches (Figure 2 below), prayer access across Indonesian island resorts, and Muslim-friendly amenities in Malaysian coastal destinations (Samori et al., 2016; Battour et al., 2011; El-Gohary, 2016). Key features include:

- Discreet screening and proper circulation around changing/shower areas.
- Separate or time-sliced pools and recreation, with female lifeguards/instructors where possible.
- Halal supply chain integrity, not only restaurant-level certification.

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- Multilingual signage, including Qibla indicators and prayer-time information.

Adjustments on recreation part such as family zones, women only hours, and modesty-friendly equipment enable participation in water activities without compromising safety (Henderson, 2010; Stephenson, 2014). Cultural programming can include heritage interpretation, nature learning with conservation ethics, and scheduled prayer breaks during longer excursions.



Figure 2: Women Only Beach Facility with Privacy Screens at Adin Beach Hotel, Alanya, Turkiye.
Source: Imran (2024)

Sustainability conversely is a core expectation and an Islamic ethical duty (*khalifah, amanah, taharah*). Coastal development must protect water quality, habitats, and biodiversity while managing carrying capacity (UNWTO, 2018; Torres-Díaz et al., 2024). Case examples from Malaysia and Indonesia show how resorts partner with NGOs on reef and turtle conservation, creating educational, value-aligned experiences (Mohd Salleh et al., 2024). Certification, monitoring, and local participation help maintain standards and trust (Global Sustainable Tourism Council (GSTC), 2016).

Policy often moves faster than enforcement; consistent halal and MFTH standards, staff training, and monitoring are recurrent needs from stakeholders (Razzaq et al., 2016; Hall & Prayag, 2020). Community-based roles are important for authenticity and acceptance, provided residents understand visitor needs and benefit from tourism (Battour & Ismail, 2016). Private sector credibility depends

on transparent standards rather than self-declared "Muslim-friendly" labels (Khan & Callanan, 2017).

Malaysia context and research implications

Malaysia hosts a Muslim majority and positions itself as a leading Muslim-friendly destination, with repeated top rankings in GMTI (Islamic Tourism Centre, 2024). Coastal tourism is central to the national offer; however, environmental quality, facility consistency, and service reliability vary by site, which can affect women's satisfaction (Baloch et al., 2023). Port Dickson and other coastal locales face trade-offs between development and environmental care. Women's reported needs such as cleanliness, privacy, safety, predictable prayer access are good indicators for service quality in these settings (Battour et al., 2018; Hanafiah et al., 2021). This review identifies several gaps: first, a lack of qualitative research on how Muslim women recalibrate the coastal gaze in everyday practice beyond generic "Islamic tourism" categories; second, the under specification of micro infrastructures such as screening, circulation, and signage that could reduce visibility burdens; third, representation issues in marketing materials and the influence of social photography norms on beach discomfort; and fourth, persistent challenges in maintaining consistency of service delivery outside flagship destinations.

These gaps justify focused fieldwork linking representations (media and on-site guidance), infrastructures (facilities and flows), and practices (dress, timing, group choreography) to describe an Islamic coastal gaze that is careful, relational, and situational.

Drawing on the theoretical foundations and the synthesized gaps, Figure 3 sets out the study's research framework, linking the identified problems to the overarching aim, the three research questions, and their corresponding objectives. It also specifies the qualitative approach employed, whereby interviews steer both data collection and analysis. Moreover, the framework outlines the intended contributions: theoretically, it expands the tourist gaze discourse to incorporate Muslim and other non-Western perspectives (Urry, 1990; Urry & Larsen, 2011); practically, it informs Muslim-friendly planning and management for Malaysia's coastal destinations (Battour et al., 2020).

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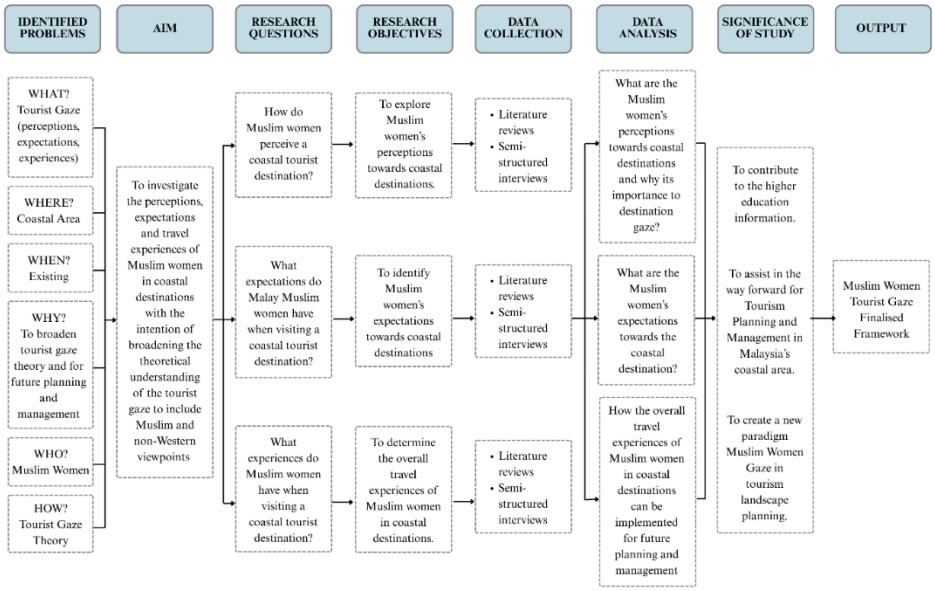


Figure 3: Research Framework - Linking Gaps, Aims, RQs, Methods, and Contributions.

This theoretical synthesis informed a qualitative, interpretivist single-case design in Port Dickson, with semi-structured interviews and on-site observations focusing on modesty or privacy, halal and prayer access, family orientation, and environmental care.

RESEARCH METHODOLOGY

This study used a qualitative, interpretive design to understand how Muslim women construct and manage their tourist gaze in coastal settings, with Port Dickson (Negeri Sembilan, Malaysia) as the instrumental case. The approach combined exploratory inquiry with a single-case study to capture culturally embedded meanings that emerge from the intersection of religion, gender, and place. The interpretive paradigm guided the work, assuming multiple socially constructed realities and privileging participants' perspectives in context. Primary data were collected through semi-structured, face-to-face interviews over six months (March till August 2024). In total, 25 interviews were completed: 15 with Muslim women tourists and 10 with stakeholders (MOTAC, Islamic Tourism Centre, tourism operators, community leaders).

Interview guides were iteratively developed and refined after four pilot interviews, ensuring clarity, cultural sensitivity, and alignment with the study aims. Questions focused on: (a) Muslim women as a market segment, (b) destination factors, and (c) the Muslim women tourist gaze. Interviews lasted 50 to 90 minutes, were audio-recorded with consent, and conducted by female

interviewers for women participants. Participants chose preferred language (Malay or English) and venues. Inclusion criteria for tourists required being Muslim, at least 18 years old, leisure visitation to Port Dickson (minimum one night), and use of at least one Muslim-friendly facility. Stakeholders were purposively selected for direct involvement in policy, management, or service delivery relevant to Muslim-friendly tourism. Sampling followed a purposive snowball hybrid until thematic saturation.

On-site observations served a supporting role to contextualize interview findings such as prayer facilities, halal food access, spatial use, using field notes, mapping, and ethically approved photography. Ethical protocols included informed consent (written or culturally appropriate verbal consent), anonymity via coding, secure data storage, and respect for religious norms (scheduling around prayer, appropriate dress). Cultural sensitivity was maintained throughout.

Data preparation involved verbatim transcription and certified translation of Malay transcripts with back-translation checks. Thematic analysis followed Braun and Clarke's six-phase procedure, supported by ATLAS.ti for systematic coding, memoing, code co-occurrence, and thematic mapping. Both inductive and deductive coding were applied to connect emergent patterns to Islamic tourism and tourist gaze frameworks. Figure 4 below showing example of coding process followed a three-stage approach as recommended by Saldana (2021).

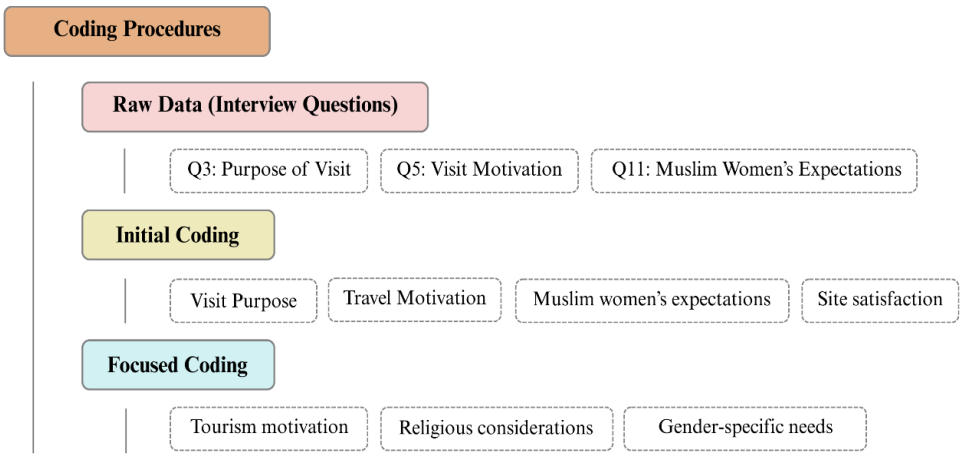


Figure 4: Example of Thematic Coding Procedure (De-identified)

Triangulation across tourists and stakeholders, peer debriefing, and member checks strengthened credibility. While generalizability is limited by

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qualitative design and single-site focus, the study provides culturally grounded insights into Muslim women's coastal tourism experiences.

ANALYSIS AND DISCUSSION

Overview and Analytical Framing

Guided by the MWTG framework, this section presents findings aligned with aim and research questions. This discussion explains the main findings in relation to the study objectives and connects them with relevant literature and practical tourism realities. The analysis focuses on Muslim women's coastal travel in Port Dickson (PD) and how their behaviour, on-site experience, and tourist gaze are shaped by religious identity, gender, family roles, and destination supply. The interpretation follows a thematic logic and is guided by the Muslim Women's Tourist Gaze (MWTG) framework developed for this study, together with qualitative rigor through thematic analysis (Braun & Clarke, 2006). While the case is PD, many patterns are recognizable in similar Muslim-friendly coastal sites in Malaysia and the region. Still, some findings are context-specific and should be transferred with caution (Yin, 2018; Hanafiah et al., 2021). Table 1 below summarizes how the research objectives map onto the MWTG dimensions and themes.

Table 1: Alignment of research objectives with MWTG framework

Objective	Tourist Gaze Dimension	Main Themes	Representative Codes
To explore women's perceptions towards coastal destination	Tourist/Self-Oriented	Muslim-friendly environment ;	Privacy, safety, halal availability, Islamic values; family beach time, water play;
To identify Muslim women's expectations towards coastal destination	Tourist/Self-Oriented; Destination/ Other-Oriented	Recreational activities; Accessibility ; Facilities; Spiritual experience	Highway connectivity, parking, public transport; Cleanliness, public toilets, changing rooms, prayer spaces; divine connection, gratitude, tranquillity
To determine the overall travel experiences of Muslim women in coastal destination	Destination/ Other - Oriented; Social/Interpersonal-Oriented	Environmental concerns; Tourists' perceptions	Clean beach, greenery, preservation; relaxation, safety, moderate expectations, improvements, spiritual contemplation

Behavioral Orientations Toward Coastal Travel

Muslim women's travel orientation to PD is usually pragmatic and value conscious. Safety and privacy come first, followed by halal assurance and family suitability. This means women look for places where modesty is manageable (e.g., not overly revealing atmosphere), halal food is easy, prayer is convenient, and children have safe play options. PD's proximity to Klang Valley, highway access, and established basic infrastructure make it attractive for short breaks and multigenerational groups. In this sense, access and convenience reduce planning effort and perceived risk, which are important triggers for women who coordinate family logistics.

Recreational interests are present, but they are filtered through religious and family norms. Many activities are low risk, and family based such paddling at shore, beach picnics, sunset watching, casual water play but requests for more private or gender-sensitive amenities (such as more enclosed pools, designated women and children time slots) show a consistent preference for modesty supportive environments. These patterns fit literature that Muslim-friendly attributes increase destination choice and reduce travel anxiety, especially for women who carry responsibility for dependents (Islamic Tourism Centre, 2023; Mazlan et al., 2023).

On-site Experiences: Facilities, Meanings, and Environment

At the destination, facilities remain the most tangible element shaping women's overall experience. For many Muslim women, comfort begins with clean toilets, enclosed changing areas (refer Figure 4), prayer spaces (refer Figure 5) and visible halal food options. These are not merely service features but moral assurances that leisure can coexist with religious observance (Battour & Ismail, 2016; Rahman et al., 2019). When such amenities are well-maintained and located close to main activity areas, they reduce stress and enable women to participate in beach activities with ease. The presence of shaded seating, family huts, and ramps for elderly or child strollers further strengthens feelings of inclusivity and safety. In contrast, poor maintenance or missing facilities quickly diminish satisfaction and trust, a pattern consistent with previous findings that basic infrastructure reliability underpins destination quality (UNWTO, 2022; Islamic Tourism Centre, 2023).

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Figure 5: Enclosed Changing/Shower Area That Supports Modesty Management for Women and Families.



Figure 6: Prayer Facilities Within Short Walking Distance of Main Activity Zones in PD Reduce Self-Monitoring and Enable Longer Stays.

Beyond functionality, women attach layered meanings to their experiences. The beach is not only a recreational landscape but also a space for *tafakkur* (contemplation) and *shukr* (gratitude). Many participants described moments of peace and reflection while listening to waves or watching the horizon, interpreting these as signs of divine creation. As one of the respondents expressed "*Listening to the sound of the waves at sunset makes me feel grateful and calm, it reminds me of the grandeur of God's creation*." Such experiences link directly with the ethical-spiritual dimension of the Muslim Women's Tourist Gaze, where leisure becomes an act of remembrance rather than escapism (Urry & Larsen, 2011; Stephenson, 2014). The ability to enjoy natural beauty while maintaining modesty reinforces a sense of moral equilibrium, allowing women to experience both joy and spiritual renewal.



Figure 7: Sunset Scene as a Moment of Quiet Reflection and Gratitude

Environmental conditions complete this trio of experience. Clean beaches, shaded greenery, and clear water contribute to relaxation and a sense of order, while litter and crowding disturb both comfort and reflection. Participants associated environmental cleanliness with moral and spiritual purity, echoing Islamic teachings on stewardship (*khalifah*) and trust (*amanah*). Many appreciated visible conservation efforts and community participation,

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interpreting these actions as signs of shared responsibility for creation (Mazlan et al., 2023; UNWTO, 2022).

Taken together, facilities, meanings, and environment illustrate that Muslim women's coastal experience is holistic and value laden. Functional amenities provide the structure for modest leisure; spiritual reflection gives emotional depth; and environmental care sustains tranquillity. When these dimensions align, the beach becomes a restorative, inclusive, and faith-congruent environment a setting where leisure, devotion, and ecological ethics naturally converge.

These results concretely extend the 'socially organised way of seeing' into an Islamic coastal context. What women look for and how they behave at the beach are shaped by signs, images, and crowd norms, but they are also actively adjusted to fit Shariah-aligned practices. Clear halal indicators, accessible prayer spaces, and modesty-friendly design features act as reassurance, turning anticipation into relaxed participation. In contrast, for example when dress expectations are unclear or facilities lack adequate screening, women tend to self-monitor more and adjust where or when they move around the beach. In practice, what feels "right" or "appropriate" is co-produced by the symbolic environment and faith requirements. For example, halal services and modesty needs directly influence destination choices (for instance, which beach or food court tourists select, namely those that clearly offer halal food, prayer facilities, and an atmosphere consistent with modest dress codes) and on-site conduct (such as activity selection, timing, and group coordination). This synthesis operationalises the extension of the tourist gaze in the findings.

The Muslim Women's Tourist Gaze

The gaze here is not one thing; it combines several logics:

1) Ethical spiritual logic: The visitor looks at landscape through religious meanings; signs of creation, gratitude, inner calm, and gentle reminders of life purpose. This logic protects modesty and seeks environments that respect Islamic values.
2) Family collective logic: The gaze is relational. Women often travel with children, spouses, or elders. They judge spaces by child safety, group privacy, easy movement, and shared enjoyment. The suitable beach environment is the one where everyone can relax without moral discomfort.
3) Environmental stewardship logic: The gaze also evaluates ecological care. Cleanliness, preservation, and greenery are not only aesthetic; they relate to responsibility toward nature, which is harmonized with religious duty.

Together, these layers extend the classic tourist gaze by emphasizing modesty, moral comfort, and relational wellbeing, in addition to scenery and leisure. In short, Muslim women's gaze integrates ethics, care, and nature appreciation into everyday relaxation.

Stakeholder Interpretations and Supply-side Readiness

Stakeholders in PD generally recognize that Muslim women are a growing and economically influential segment. They note that women often initiate travel plans, lead group decisions, and influence friends through word of mouth. The supply side response emphasizes three areas:

- Muslim-friendly tourism initiatives: Halal certification, reliable prayer spaces near attractions, women-friendly time slots or zones in aquatic facilities, and family-oriented products. Some stakeholders also mention wellness or "healing" experiences and shopping as important draws.
- PD's positioning as a coastal hub: Easy access, multiple beaches, diverse lodging, and attractions. At the same time, stakeholders acknowledge environmental pressure and the need to manage peak periods, waste, and coastal erosion.
- Service quality and collaboration: The need for maintenance, cleanliness, and clear signage; and more coordination among municipal authorities, operators, and community groups to maintain standards.



Figure 8: Visible Halal Indicators at Restaurant Enhances Trust

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Their narrative shows a relatively good market understanding but highlights operational gaps that matter a lot to women visitors, especially cleanliness, predictable halal assurance outside hotels, and privacy-sensitive design.

Practical Implications for Port Dickson

For Port Dickson (PD), the priority is to make the essential services highly dependable and easy to find. Toilets, changing rooms, and prayer spaces should be kept very clean, well illuminated, and placed close to main activity areas so that women and families do not need to walk far or feel unsafe. Clear multilingual signs and simple wayfinding reduce confusion and decision stress, which in turn encourages longer stays and higher comfort. In addition, small design features that support modesty can make a big difference. Pilot women and children time slots for swimming, provide semi-screened edges near family zones, and arrange seating clusters that allow a sense of privacy. These are not expensive interventions, but they can strongly improve perceived suitability for Muslim women visitors.

Product assurance and place ambience also need attention. Outside hotels, halal assurance should be standardized and visible by encouraging certification for popular food courts and beach vendors, and by publishing simple halal maps, with QR codes for quick checks on a smartphone. At the same time, the beach should be maintained as a spiritual and reflective landscape, not only a leisure site. This means moderating noise levels in family sections, preserving shade trees that support comfort and contemplation, and planning loud events away from prayer times and from special vantage points such as sunrise or sunset areas. These actions respect how many Muslim women integrate relaxation with religious mindfulness during coastal visits.

Cleanliness and reputation must be sustained through shared governance. Operator service standards, municipal cleaning schedules, and community participation. For example, monthly family beach clean-ups) should be combined to keep conditions stable even in peak periods. Transparent public reporting via simple notice boards or a basic app on cleanliness and maintenance builds trust and shows accountability. Marketing should communicate with cultural sensitivity, highlighting modesty, family bonding, and wellness rather than only thrill-seeking. Because word-of-mouth among women's networks is very influential, the most effective promotion is reliable, repeatable quality on the ground. These recommendations are consistent with international guidance that emphasises visitor satisfaction, repeat visitation, and sustainability outcomes as core success measures (Islamic Tourism Centre, 2023; Mazlan et al., 2023; UNWTO, 2022;

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Theoretical Implications

This study advances theory on the tourist gaze by showing that Muslim women's coastal travel is organized by a layered logic that is not only visual or individual but also normative and relational. The gaze integrates three interlinked elements: an ethical spiritual orientation (modesty, halal assurance, prayer access, gratitude and contemplation), a family collective orientation (safety for children, shared privacy, easy coordination for multigenerational groups), and an environmental stewardship orientation (clean beaches, greenery, preservation). In this way, what women "look for" and "look at" includes moral comfort and relational wellbeing alongside scenery and services. This extends classic tourist gaze arguments by foregrounding how faith practice and care responsibilities shape perception and evaluation in everyday leisure contexts (Urry & Larsen, 2011).

The study also operationalizes the Muslim Women's Tourist Gaze (MWTG) (Figure 5 below) by aligning concrete themes Muslim-friendly environment, recreational activities, accessibility, facilities, environmental concerns, and tourists' perceptions with self, destination, and social or interpersonal oriented gaze dimensions. This structure clarifies mechanisms linking destination cues to subjective states and behaviours. For example, halal food availability and proximate prayer spaces act as an assurance bundle that reduces cognitive load, supports modesty, and opens space for spiritual contemplation; reliable cleanliness further stabilizes comfort, which encourages longer stays and positive word-of-mouth. The framework thus offers a transferable scaffold for examining how faith related values interact with family roles and environmental quality to produce distinctive coastal experiences (Islamic Tourism Centre, 2023; Mazlan et al., 2023).

Finally, by triangulating visitor narratives with stakeholder views, the study contributes a supply and demand synthesis to gaze research. It introduces the idea of 'modesty supportive design' in coastal environments: small spatial and temporal adjustments (women and children swim hours, semi-screened family zones) can meaningfully shift perceived fit for Muslim women, without changing the core beach product. As one participant noted, *"If there are dedicated women and children time slots, I feel more confident to join water activities."* This contributes to service design theory in religiously sensitive destinations by identifying privacy, halal assurance, and cleanliness as foundational hygiene factors rather than mere amenities. Finally, evidence from the Port Dickson case clarifies the boundary conditions for Muslim-friendly coastal tourism, showing that accessibility, routine cleanliness, and visible compliance signalling are required for the MWTG dynamics to function as intended.

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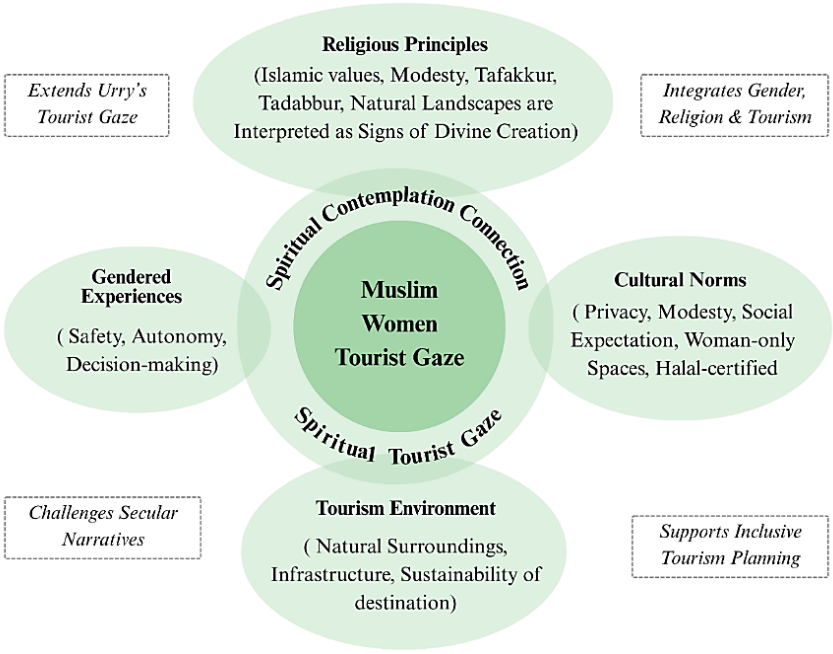


Figure 9: Operational Muslim Women Tourist Gaze Framework (MWTG) - Dimensions, Themes, and Mechanisms.

CONCLUSION

This study shows that Muslim women's coastal leisure in Port Dickson is shaped by religious obligations, family roles, and destination infrastructure. Reliable halal and prayer access, privacy- and safety-supportive spaces, and consistent cleanliness operate as non-negotiable baselines; where present, the tourist gaze shifts from cautious to confident and restorative. Recreational choices favour family-centred, modestly managed activities, with the coast often prompting gratitude and contemplation extending the tourist gaze toward a normative–relational, faith-inflected interpretation.

Port Dickson's value proposition for Muslim women rests on four mutually reinforcing pillars: (1) dependable Muslim-friendly infrastructure (halal, prayer, privacy, safety); (2) gentle product diversification that preserves calm character; (3) inclusive mobility and clear, multilingual information; and (4) visible environmental care. Priority actions include standardizing halal and prayer signage, expanding shade and enclosed changing facilities, piloting women-and-children swimming time windows, improving public transport links and wayfinding, and foregrounding sustainability in operations and marketing.

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HUMAN-CENTRIC PLANNING OF TRADITIONAL ISLAMIC SETTLEMENTS: A SPACE SYNTAX STUDY OF ITCHAN KALA, KHIVA

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Abstract

Traditional Islamic settlements reflect a sophisticated integration of spirituality, social organization, and spatial planning, yet few studies have examined these qualities at the scale of entire urban environments using analytical tools such as space syntax. This study investigates the fortified city of Itchan Kala in Khiva, Uzbekistan, to uncover how Islamic values are embedded within its urban planning and spatial configuration. Through axial and visibility graph analysis (VGA) using depthmapX, the research evaluates visibility, integration, and controllability at both global (R=n) and local (R=3) scales to explore the balance between openness, privacy, and movement regulation. The findings reveal a spatial structure that is compact yet hierarchically layered, supporting both communal interaction and seclusion. The highly integrated main market street, anchored by the central Juma Masjid, exemplifies the Islamic planning ideal of harmonizing commerce and worship. In contrast, residential quarters demonstrate low visibility and high controllability, fostering privacy and local stewardship. Madrasas, now repurposed as museums, occupy transitional zones mediating between public and private realms. As Itchan Kala continues to function as a living city with active residential, commercial, and institutional establishments much as it did a thousand years ago, its enduring spatial organization demonstrates the lasting effectiveness of Islamic planning principles across generations, socio-political transitions, and technological changes. Modern neighborhood planning can draw valuable lessons from Itchan Kala's integrated urban fabric—where residential, commercial, and institutional zones coexist harmoniously within a walkable and sustainable environment—offering a timeless model for holistic, resilient, and human-centered urban development.

Keywords: Space Syntax, Islamic Urbanism, Human-Centric Planning, Itchan Kala, Spatial Integration.

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INTRODUCTION

The Space syntax analysis has been widely applied to traditional houses and masjids in Muslim civilizations; however, there are limited studies focusing on traditional settlements or towns within these civilizations (Asif et al., 2018; Sun, 2013). From the dawn of Islam in 623 CE in Madinah to the end of the Ottoman Caliphate in 1924, numerous cities and towns were established across the Islamic world. Unlike contemporary urban design approaches, which often neglect local culture and practices, Muslim settlements were shaped by local traditions and customs while adhering to the core principles of the revealed scriptures and the traditions of the Prophet Muhammad (PBUH) (Hillenbrand, 2004).

As a result, Muslim settlements—from Al-Andalus (present-day Spain) in the west to the far reaches of Indonesia in the east—despite their cultural differences, exhibit remarkable similarities. These commonalities are rooted in their shared adherence to the principles of the Qur'an and Sunnah.



Figure 1: Itchan Kala, Khiva, Uzbekistan (Source: 24th Heritage Studies, KAED)

This paper focuses on the fortified city of Itchan Kala in Khiva, Khorazm, Uzbekistan, with the intention of examining how Islamic principles are embedded within its urban fabric through the application of space syntax. Using visual interpretation of axial and visibility graphs, together with basic correlational observation, the study seeks to uncover the underlying spatial logic that shaped movement, privacy, and communal interaction in this historic settlement.

In the context of rapid transformations driven by artificial intelligence, revisiting human-centric planning becomes necessary—not only for Muslim societies but for broader discussions on sustainable urban futures. By grounding

itself in principles of dignity, privacy, and social cohesion, this study suggests that the spatial organisation of places like Itchan Kala continues to offer relevant insights for contemporary planning across different contexts and periods.

LITERATURE REVIEW

Islamic Principles in Traditional Urban Planning

Islamic sharīʿah, rooted in the Qur'an and Sunnah, establishes core principles that guide individual and communal life in Muslim societies. These principles form a coherent social framework expressed across scales—from the individual and family to the neighbourhood and wider community (Kamal et al., 2023). Although neither source provides explicit urban planning codes, Islam promotes a built environment aligned with moral and social objectives. Consequently, the values and aims of sharīʿah inform the spatial organisation and development of Muslim settlements (Mortada, 2003).

a) Human-Centric and Inclusive Urbanism

Traditional Muslim settlements exemplify inclusivity by fostering peaceful coexistence between different socioeconomic groups. Unlike the stark segregation common in capitalist or socialist models, Islamic settlements encouraged balance and mutual respect. Every individual, regardless of wealth, retained the right to property and social dignity, as emphasized in the Qur'an: *"Do not devour one another's wealth by false and illegal means"* (Qur'an 2:188) (Sahih International, 2004). Fair markets and just economic practices were embedded in urban life, reinforcing equity and opportunity.

b) Educational Integration and Intellectual Life

The Islamic built environment traditionally prioritized education by embedding madrasahs within the urban fabric. These institutions not only promoted knowledge acquisition but also encouraged scholarly interaction within daily urban life. Planners and builders who shaped these environments often possessed deep religious and ethical understanding, ensuring that architectural decisions resonated with Islamic values (Omer, 2002).

c) Commercial Accessibility and the Role of the Masjid

Markets (*suqs*) were centrally located and distributed throughout residential quarters, ensuring equitable access to daily necessities. This layout fostered a walkable, community-oriented environment. In close proximity to these commercial hubs, the masjid served as a spiritual anchor, reinforcing the integration of worldly needs with religious duties—especially the observance of the five daily prayers (Omer, 2010).

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d) Privacy in Residential Design

Privacy—particularly for families and women—holds significant importance in Islamic tradition. Accordingly, urban design avoided configurations that allowed commercial activity to intrude upon domestic spaces. For instance, shops were discouraged from facing residential units directly, protecting the sanctity of private life (Mortada, 2003).

e) Hierarchical Spatial Structure

Traditional Islamic urban layouts displayed a distinct spatial hierarchy, transitioning from public to private spaces. Broad, communal roads led to narrower alleys, semi-private lanes, and finally private courtyards. This progression not only reflected the principle of privacy but also fostered a sense of belonging and layered social interaction (Rasdi, 2010).

f) Organic Growth Over Gridded Uniformity

Contrary to the Roman grid-iron model prevalent in many modern cities, Islamic settlements typically evolved organically. This growth pattern reflected both spiritual guidance and practical responsiveness to community needs. The resulting morphology enhanced connectivity, equity, and a strong sense of place—attributes often lacking in contemporary vehicle-centric urban designs.

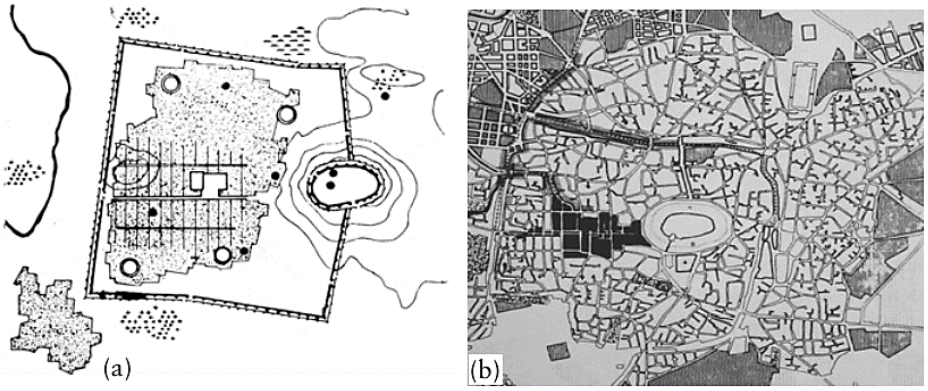


Figure 2: Maps of Aleppo in the beginning of the eighth century AD, showing the gradual transformation of the urban pattern from (a) the Roman grid to (b) organic as a result of the inhabitants' response to Islamic teachings according to Mortada (2003).

Khiva's Cultural Heritage and the Influence of Islam

Before Islam, Khiva's cultural and religious identity was shaped by Zoroastrian traditions that honored fire, air, water, and earth. The Arab expansions of the 7th and 8th centuries brought Islam to the region, leading to a flourishing of knowledge and culture during the Islamic Golden Age. The Khorezm region,

where Khiva is located, became a major center of scholarship and science, producing figures such as Al-Khwarizmi, Al-Biruni, and Ibn Sina. Supported by over sixty madrasahs, Khiva thrived as a hub of learning, philosophical dialogue, and artistic creation. (Durdieva et al., 2020). Rather than existing in isolation, these madrasahs were deeply embedded within the broader urban landscape, underscoring the Islamic ideal of integrating knowledge with community life (Niri, 2017). Khiva's distinct cultural character also persists in its artisanal crafts, including ceramics, silk production, and decorative painting—many of which remain closely tied to religious and communal architecture. Contemporary artisans continue to practice these time-honored techniques, echoing the rich heritage that once adorned the city's mosques, palaces, and schools (McClary, 2020).

Itchan Kala: Spatial Manifestation of Islamic Urban Values

At the heart of Khiva stands Itchan Kala, the fortified inner city and UNESCO World Heritage Site. Enclosed by earthen walls and measuring about 650 by 400 meters, it served as the political and religious center of the Khiva Khanate from the 17th century onward. Early accounts, including those by the 10th-century geographer al-Maqdisi, describe Khiva as a canal-fed settlement centered around a major mosque, likely the Juma Masjid. Within its dense, walkable grid, religious, educational, residential, and commercial spaces blend seamlessly, reflecting Islamic ideals of mixed use and spatial balance. (Gaipova, 2021; Yusupova, 2012). This study applies space syntax analysis to examine Itchan Kala's urban structure, with the aim of identifying how foundational Islamic principles—such as privacy, interconnectedness, equity, and human-oriented design—are articulated in its spatial logic. Through a close reading of its urban form, the research seeks to offer insights relevant to both historical understanding and the contemporary discourse on sustainable, human-centric Muslim urbanism.

Space Syntax Analysis for Spatial Studies

Space syntax has become an essential analytical tool for understanding spatial configuration and human movement in built environments. It enables researchers to quantify spatial relationships, visibility, and accessibility, offering insight into how spatial form influences social behavior. Rauof and Al-Qemaqchi (2019) applied space syntax techniques to hospital layouts to enhance visual connectivity and improve user navigation (Rauof & Al-Qemaqchi, 2022). Nes (2002) used angular step-depth analysis to measure the permeability of urban route networks, demonstrating how spatial configuration shapes movement patterns (van Nes, 2021). Similarly, another study utilized space syntax in urban plaza design to evaluate spatial integration and user experience (Sedki & Iaali, 2020). These studies highlight the versatility of space syntax, supported by tools such as

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DepthmapX, in analyzing spatial logic across different architectural and urban contexts.

METHODOLOGY

This study explores the traditional city of Itchan Kala using space syntax analysis to examine visual integration, connectivity, and controllability, as well as the interrelationships between these variables at both global and local spatial scales. Space syntax provides a systematic method to quantify spatial relationships and movement potential, revealing how the built environment influences accessibility, visibility, and social interaction patterns.

DepthmapX as a spatial analysis tool

The visibility analysis was carried out using *Visibility Graph Analysis (VGA)* in DepthmapX, which converts the spatial layout into a network of intervisible points to evaluate how visual fields are connected across the urban fabric. The results were visualized as gradient maps superimposed on the base map of Itchan Kala, allowing identification of areas with higher or lower visual accessibility. The base map was sourced from *OpenStreetMap* (openstreetmap.com).

Connectivity was assessed through *Axial Map Analysis*, where the longest and fewest lines representing potential movement paths were generated to analyze spatial integration and control. The axial map was analyzed at two radii:

- **R = n** for calculating *global integration* and *controllability*, representing citywide spatial relationships, and
- **R = 3** for assessing *local integration*, which reflects spatial characteristics relevant to pedestrian-scale movement (Hillier, 2007).

The analytical results were supported by descriptive interpretation to highlight the spatial characteristics of the traditional city. In addition, a quantitative correlation between integration and controllability was examined to identify the underlying spatial logic embedded within the settlement. A broader discussion of these findings is presented in the following section.

FINDINGS

- **Spatial layout of Itchan Kala**

Itchan Kala, the inner fortified city of Khiva, is enclosed within robust earthen walls and accessed through four main gates, strategically positioned at each cardinal point (Figure 3). Among these, the Ota Darvoza (West Gate) serves as the primary entrance today, welcoming most visitors into the city. On the opposite

side, the Palvon Darvoza (East Gate) functions as a secondary entrance, historically significant for its proximity to trade routes. Once inside, a central axial street runs longitudinally through the settlement, forming the city's main commercial spine. This bustling corridor is now lined with small shops and market stalls, where locals sell traditional crafts such as silk, ceramics, and carved wood items—preserving the legacy of Khivan artistry.

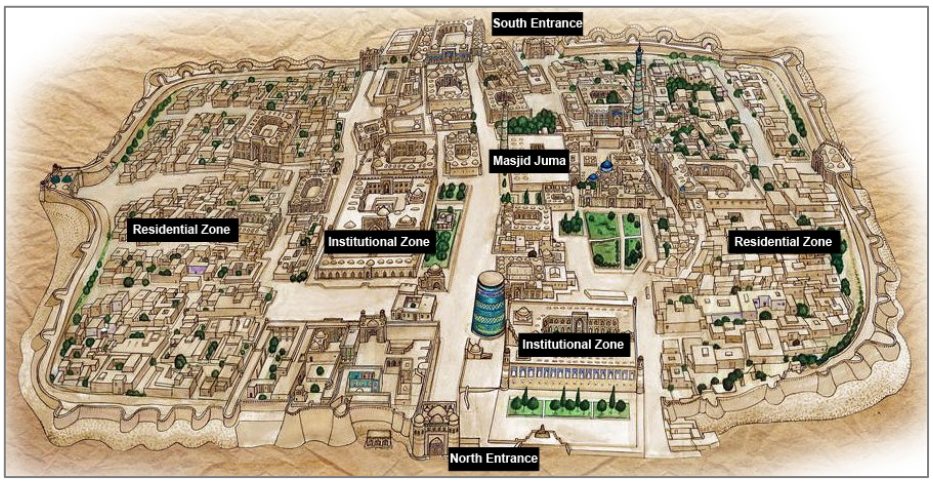


Figure 3: Layout of Itchan Kala (Source: https://apkpure.com/visit-khorezm/com)

At the heart of this street network stands the Juma Masjid, the Friday Mosque, acting as both a spiritual and spatial anchor. Its central location and architectural prominence reflect its significance in the daily lives of residents and the Islamic planning ethos of placing religious functions at the core of communal life. From the main street, a series of secondary streets and narrow lanes branch out, leading to numerous museums and heritage buildings tucked deeper into the urban fabric. These include former madrasahs, palaces, and caravanserais, now repurposed to showcase the city's rich cultural and intellectual history. A bit further removed from the commercial thoroughfare, several boutique hotels and guesthouses are discreetly situated, offering accommodation within quieter pockets of the city, in line with the traditional spatial hierarchy that balances public activity with private retreat.

- **Visual Connectivity**

The results of the visibility graph analysis reveal that the most visually connected area within Itchan Kala is concentrated along the main market street, which functions as the spinal axis of the present-day city. This thoroughfare accommodates the majority of local shops, where artisans sell traditional craft

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items, along with several small restaurants serving authentic Uzbek cuisine. Strategically positioned at the midpoint of this spine is the Juma Masjid, exemplifying two fundamental principles of traditional Islamic urbanism: the placement of the mosque at the heart of the settlement and its proximity to the marketplace, fostering both spiritual and social cohesion (Figure 4).

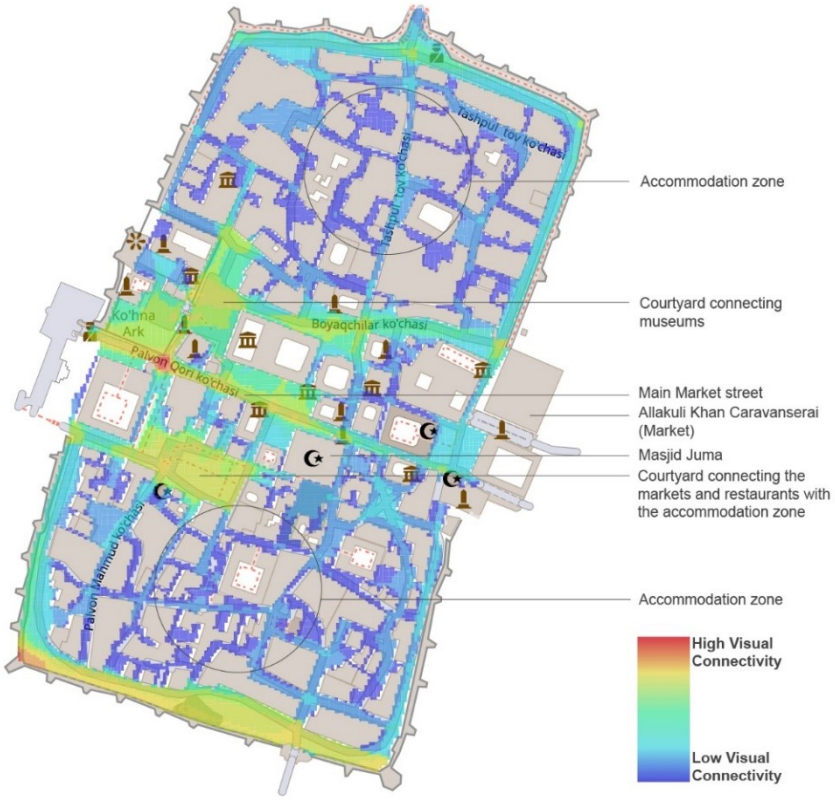


Figure 4: Visual Connectivity of Itchan Kala

In contrast, the city's museums—many of which are former madrasas adapted for contemporary use—are accessible via secondary streets, offering a quieter and more contemplative setting. This spatial placement preserves the educational and reflective character of the original madrasas while creating a suitable ambiance for museum functions. The least visually connected areas are occupied by hotels and guesthouses, typically located on the periphery of the visual network. This reflects another key tenet of Islamic spatial planning: the provision of privacy and tranquility within residential zones, ensuring seclusion without complete detachment from the communal core of the settlement.

- **Visual Integration**

The visual integration analysis further reinforces the findings of the visual connectivity graph, highlighting the main market street as the most visually integrated path within Itchan Kala (Figure 5).

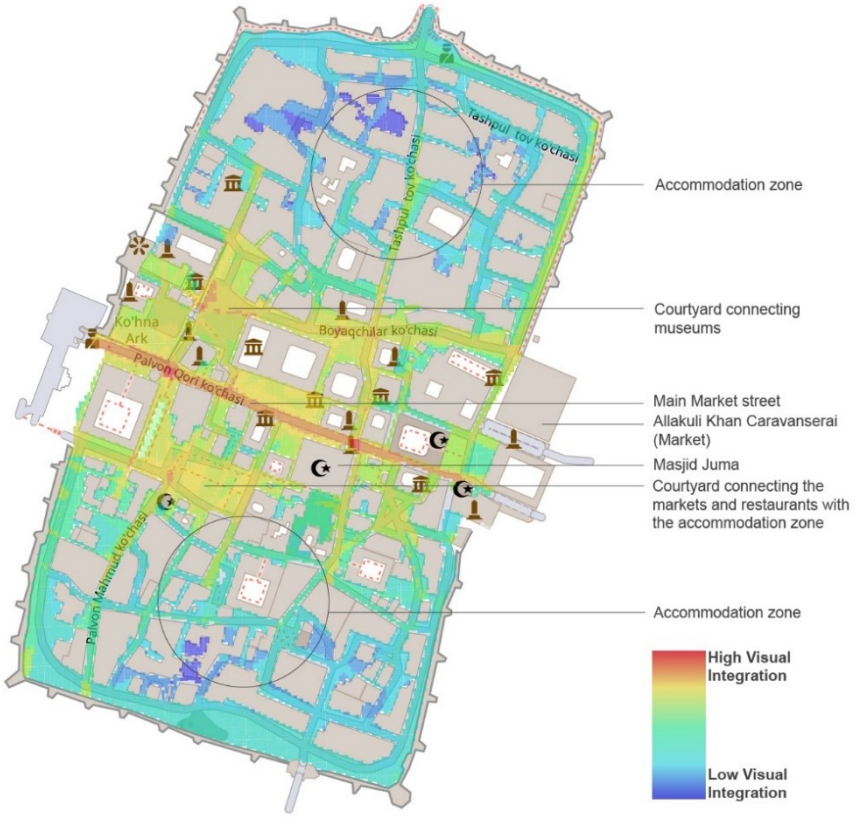


Figure 5: Visual Integration of Itchan Kala

One particularly noteworthy observation is the presence of a caravanserai, or covered market, near the Pavlon Gate, the back entrance of the city. While its location may appear secluded at first glance, the integration analysis reveals that the caravanserai is, in fact, well embedded within the spatial fabric. Positioned between a primary and a secondary street, it enjoys multiple points of access, making it functionally integrated despite its peripheral location. This clever placement exemplifies the ingenuity of organic urban development, where the spatial growth of the settlement responds to functional needs rather than imposed geometry (Figure 5).

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Additionally, the analysis highlights two key courtyards on either side of the main street, both demonstrating high levels of visual integration. The northern courtyard connects to a cluster of museums, while the southern courtyard links to the accommodation zone. These well-integrated yet spatially distinct zones illustrate a hierarchical arrangement of spaces characteristic of traditional Islamic urbanism. Here, residential areas are afforded a sense of privacy, while maintaining effective spatial connectivity to central communal and cultural functions—reflecting a thoughtful balance between seclusion and accessibility.

- **Spatial Integration**



Figure 6: Axial map analysis of Itchan Kala

The axial map analysis of Itchan Kala's Street network reveals an insightful spatial configuration. In addition to the main market spine, which dominates the integration values, there exists a prominent secondary street

running perpendicular to the main axis. This secondary street is well integrated within the overall network and plays a vital role in linking the accommodation zones at the northern and southern ends of the city directly to the Juma Masjid. This configuration reflects a core principle of traditional Islamic urbanism: residential areas are purposefully connected to the central masjid, ensuring ease of access and walkability for daily communal prayers.

Moreover, as seen in Figure 6, the axial analysis supports a visible zoning gradient based on privacy and function. As one moves away from the main street, the spatial arrangement gradually shifts from public to more private realms. Madrasas and museums, typically located just beyond the commercial spine, act as a buffer between the bustling marketplace and the quieter residential quarters. This layered spatial hierarchy illustrates the Islamic planning concept of graduated privacy, where different zones serve varying communal, educational, and private functions while maintaining a coherent and connected urban fabric.

- **Controllability**



Figure 7: Controllability of Itchan Kala

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The controllability analysis of Itchan Kala (Figure 7) provides valuable insight into how the spatial configuration supports or restricts regulation and surveillance within the walled city. In this context, controllability is understood as a global spatial property—reflecting how easily movement can be guided or overseen based on the structure of the urban layout. Interestingly, the main market street exhibits low controllability, primarily due to its high connectivity and multiple entry and exit points along the spine. The street accommodates a variety of functions, including shops, eateries, and public institutions, which naturally invite high pedestrian flow and diverse movement patterns. The linear but visually permeable form, with several intersecting routes, makes it less suitable for spatial control or surveillance, thus reducing its controllability despite being a central space.

In contrast, the accommodation zones, particularly those located toward the north and south peripheries of the city, demonstrate relatively higher controllability. These areas are structured with fewer route options, limited access points, and a more segmented and hierarchical street layout, allowing for easier regulation of movement. The lower visibility and limited intersections enhance the privacy of these zones, aligning with traditional Islamic urban principles where residential areas are designed for seclusion and controlled access. This spatial arrangement supports not only physical privacy but also social cohesion and community management, reflecting a thoughtful integration of cultural values into urban morphology.

- **Correlation Between Integration and Controllability**

The correlation analysis between spatial integration and controllability reveals meaningful patterns that align closely with the underlying logic of traditional Islamic urban design. At the global scale (R=n), the correlation between integration and controllability is weakly negative (R = –0.205) (Figure 8). This indicates that the more a space is globally integrated within the overall urban fabric, the less controllable it tends to be. This pattern is evident in the main market street of Itchan Kala, which is highly connected and accessible from multiple directions, making it ideal for open public activities such as trade, communal gathering, or religious processions. However, this also implies limited control or surveillance, as the space offers many route choices and fewer restrictions on movement — a feature consistent with the design of central public routes in traditional Islamic cities, which aim to promote accessibility and interaction rather than control.

Conversely, at the local scale (R=3) — suitable for pedestrian-based analysis — the correlation between integration and controllability is slightly positive (R = +0.149) (Figure 9). This suggests that locally well-integrated spaces are also somewhat more controllable. These areas, typically composed of smaller

street networks and neighborhood clusters, offer tighter spatial configurations with fewer route options and more defined boundaries. In Itchan Kala, this is particularly true in the residential quarters, where such layout supports both privacy and local social regulation. These zones are not only visually and physically quieter but also more manageable, reflecting the Islamic urban principle of fostering self-contained, watchful communities within a larger, open urban system.

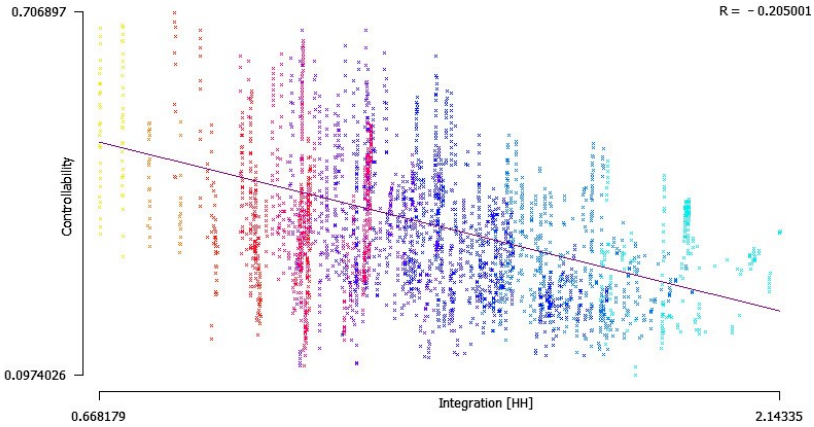


Figure 8: Integration (Global) vs Controllability

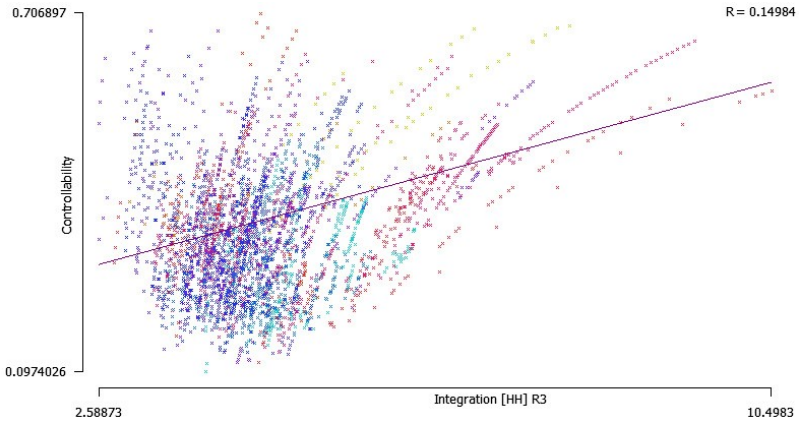


Figure 9: Integration (R3) vs Controllability

Taken together, these results highlight a fundamental spatial hierarchy in Itchan Kala — and by extension, in traditional Islamic cities — where public openness and private seclusion are carefully balanced. While main streets invite openness and free flow, residential areas prioritize control, community, and privacy. The urban layout is not random but reflects a deliberate cultural logic

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that accommodates both collective social life and individual privacy through nuanced spatial design.

CONCLUSION

The space syntax analysis of Itchan Kala reveals the underlying planning intelligence of traditional Islamic urbanism, where space is not merely functional but structured around social values and human needs. The city presents a compact physical form while offering a psychologically expansive environment — one in which spatial depth sustains privacy, intimacy, and social regulation within a dense urban fabric. At its core, Itchan Kala shows a careful balance between openness and privacy. The main market street—highly visible and well-connected—acts as the public route linking trade and faith through the Juma Masjid. This reflects the Islamic planning idea of harmonizing daily life with spiritual purpose. In contrast, residential areas and guest houses shift into zones with lower visibility and more control, using narrow lanes and limited access to protect privacy and family life. The city's layout shows a natural hierarchy where public spaces, madrasas, and homes support different ways of living—commerce, learning, worship, and rest. Positioned between public and private areas, madrasas once connected reflection with community life. The link between integration and control shows an important planning idea: open, connected spaces are less restricted, while local neighbourhoods maintain independence through enclosure. This decentralized form of city life reflects Islamic values of modesty, clear boundaries, and community responsibility.

The findings affirm that Itchan Kala is not just a preserved historic city but a living example of Islamic urban planning that still works today. Its layout supports both community life and personal privacy, creating a balance between public spaces and private areas. The design effectively guides movement, shapes social interaction, and reflects cultural and moral values through simple but thoughtful spatial arrangements. In contrast, many modern neighbourhoods are car-centric, separate residential and commercial areas, and often lack social interaction, making them unsustainable in the long run. Even after a thousand years, Itchan Kala remains active and functional, proving that Islamic planning principles can stand the test of time and offer valuable lessons for creating modern neighbourhoods that are walkable, sustainable, and people centred.

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EMPLOYEES' PSYCHOLOGICAL WELL-BEING IN ARCHITECTURAL FIRMS IN KLANG VALLEY, MALAYSIA: IMPLEMENTING HEALTH INDUCED ENVIRONMENT

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Abstract

In architectural firms, where employees spend most of their time indoors, addressing stress and psychological well-being through supportive workplace environments is essential to prevent mental health issues and enhance productivity. This study examines employees' psychological well-being by exploring how space quality factors, such as spatial arrangement, furniture design, noise, lighting, and nature, affect behaviours, productivity, and space efficiency. Thus, to achieve the research objective, a study was conducted using a qualitative method, comprising a questionnaire survey, observations, and computer simulations. The findings reveal that employees value spacious, well-arranged, and private layouts, ergonomic furniture, quiet workspaces, sufficient lighting, and access to fresh air and greenery. They adopt a combination office layout that balances connectivity and collaboration with privacy and reduced distractions to support a health-inducing work environment. Suppose an architectural firm considers these aspects in creating a health-inducing climate. In that case, employee mental health can be protected, leading to a more significant impact on employees, who will, in turn, experience increased productivity and improved work performance.

Keywords: Employees, Psychological Well-Being, Health-Induced Environment, Sustainable

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INTRODUCTION

Employees, especially those in Architectural firms, spend a significant amount of their time indoors, which affects their psychological well-being and influences their productivity and work performance. Many perceive that psychological well-being, such as physical and mental health problems, only refers to those who are insane or mad. Still, the fact is, depression and emotional disturbance can also lead to serious mental illness if not dealt with properly. National Institute of Occupational Safety and Health (NIOSH) Chairman, Tan Sri Lee Lam Thye, proposed that employers at each organisation take into account the risks of stress and psychological well-being aspects of employment, and implement plans to reduce psychological well-being risk so that employees can play a role in creating a healthy work environment (Geraldine, 2017). Employees' satisfaction with the working environment can be improved by minimising aspects that cause mental health problems. Any organisation, regardless of the extent to which people work remotely, needs to consider the well-being of its employees as it implements more flexible working practices and an environment (Neuert, PhD, 2018).

Tan Sri Lee Lam Thye also pointed out that there are five categories of health risks at the workplace – physical, chemical, biological, ergonomics and psychosocial – adding that stress falls under the psychosocial category (Geraldine, 2017). Anxiety is one of the psychological illnesses that was stimulated by some of the risks in the workplace. One of the risks is that employees can feel like they are in an invisible cage, keeping them a prisoner on their sofa, unable to move for fear of something they cannot quite identify (Newman, 2018). Tim Newman, in Medical News Today (2018), stated that the health ministry can carry out such psychological assessments, and the results can be used to plan and implement sustainable programs to address mental health issues. He proposed that employers at each organisation take into account the risks of stress and psychosocial aspects of employment, and implement plans to reduce psychosocial risk so that employees can play a role in creating a healthy work environment. Managing stress and psychosocial risks at work creates a healthy work environment, where workers feel valued and the workplace culture is more positive, consequently improving productivity and business performance (Bernama, 2017).

The study was conducted to gain an understanding of the underlying knowledge of psychological well-being, including the basic understanding of employees' behaviour, its determinants, and consequences. A literature review was conducted to determine the objective of this paper, which is to identify the variables of space quality, including furniture design, surrounding noise, direct and indirect lighting, and their preferences for improving work productivity and space efficiency in a specific environment by implementing a health-inducing environment.

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RESEARCH BACKGROUND

Based on the literature review, four aspects can impact the creation of a health-inducing environment. The four aspects are discussed below;

1) Impact of the 'Living' building concept

In this context, a building should be 'Living' when it achieves some imperatives: 1) It has to generate its own energy on site using renewable sources, 2) Capture and treat its own water, 3) Be constructed of non-toxic and sustainable sourced materials, 4) Use only previously developed sites and,5) Be beautiful and inspiring to its inhabitants (Hagezy, 2017). Some factors influence employee performance (Lauby, 2017). In the organisation, the employer might want to compartmentalise the areas differently: organisational processes, physical resources, data and information, individual abilities, motivation, and job knowledge.

2) Impact of good ventilation and lighting

The stack effect may encourage the natural ventilation system of a house, but it may also bring hot and humid air from tropical climate countries into the building. This proper design solution can preserve and improve the temperature of indoor air while simultaneously encouraging air movement to balance the humidity level (Wahab, 2015). Other passive and energy-efficient measures are: the orientation of the building, the use of appropriate building colours, an open plaza between the two blocks to facilitate natural ventilation, and motion sensors for lighting and rain detection to moderate energy and water usage. The use of artificial indoor lighting is minimised by light shelves that reflect daylight deeper into the building, helping to illuminate interior spaces. This eco-design will influence and improve human activities, comfort, and energy (Mutuli, 2016).

3) Impact of connection with nature

Environmental Education (EE) has a substantial impact in reconnecting today's adults with the natural environment, thereby contributing to the creation of more ecologically responsible citizens. The traditional conservation education approach has often disconnected ecosystems and society by protecting species, ecosystems, and landscapes from human negative impacts (Wahab, 2015), rather than recognising that human societies are part of nature and highly interconnected with ecological systems (Sida, 2016). According to Yeang (2016), the building's environmentally friendly design was created with the intention of maximising the advantage of local bio-climatic conditions and minimising the environmental impact on the building. This strategy will improve the building spaces and give social benefits. Due to this opportunity, it can also maximise the effect of natural ventilation by adding greenery around the buildings.

4) Impact of office layout (shop-lot office) on employees' behaviour

There are four types of office layouts (Awang, 2018): 1) Taylorism, 2) Cellular, 3) Open Plan, and 4) Combination office layouts. The cellular office was introduced in the 1950s and could accommodate up to 4-6 employees (See Figure 2). Due to the high demand for productivity and services in the 60s, an open-plan office layout was designed that could accommodate more than 20 employees (See Figure 3). In the late 1960s, the group office (office landscape) was applied in office layouts with ergonomic work environments that could accommodate 6-20 employees in one area. This approach is used to create a more open and collaborative office environment that encourages communication and discussion among employees. In the 1980s, the Combination office layout was widely used, as it provides a communicative space structure that incorporates cellular offices accommodating multi-function spaces and is intended to offer more privacy for employees, especially from noise and visual distractions (See Figure 4).



Figure 1 'Taylorism' office style, where all the employees are monitored by their bosses from an enclosed office. *Source: (LABS, 2017)*



Figure 2 A Cellular office was introduced that could accommodate up to 4-6 employees. *Sources: (Khanna, 2019)*



Figure 3 An open-plan office was designed to accommodate more than 20 employees. *Sources: (LABS, 2017)*

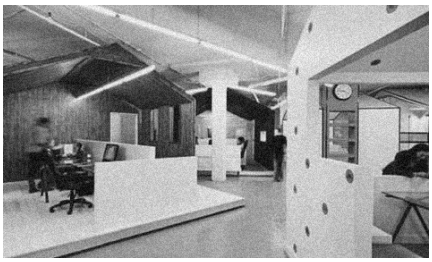


Figure 4 A Combination office layout was widely used as it provides a communicative space structure. *Sources: (Khanna, 2019)*

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METHODOLOGY

The methodology used for data collection and analysis in this research was determined through a review of literature studies from various researchers and authors. Survey questionnaires, observation, and computer simulation were the methodologies employed throughout this paper.

Survey questionnaires were administered using a non-random sampling technique, ensuring that every employee in the firm had an equal chance to answer the questions. This survey utilises 150 questionnaire samples. The information was then evaluated using graphical representations and diagrammatic data, which were subjected to statistical analysis. Next, observations were recorded to detect the occupant's behavioural patterns in the actual setting during office hours. This approach is systematic, outlining what to observe and record.

Lastly, a computer simulation by Space Syntax was implemented after site data collection. An office-based model was built to stimulate and examine the relationships between users and the space layout. The Space Syntax result validation process comprised several stages. The spatial configuration was first analysed using key space syntax measures, including visual connectivity and integration. Empirical observations of user movement and interaction were then conducted to obtain behavioural data. Statistical analyses were performed to assess correlations between spatial metrics and observed behaviour, followed by cognitive validation through user feedback on perceived spatial qualities. Finally, the results were cross-checked with comparable studies to confirm reliability and generalizability. This simulation enables the designer to predict findings through data collection and facilitates users in specifying their requirements. The significance of using computer simulation and evaluation methods, such as Space Syntax Analysis, lies in the fact that the software enables clients to specify their requirements and architects to make informed decisions on allocating activities.

In selecting the case studies, architectural firms were chosen based on a shop-lot typology with a 3-storey height. This typology is chosen because most architectural firms in the Klang Valley areas were set up in shop-lot buildings, thus they will carry the same characteristics to be compared with. Three firms were selected, namely Firm A (ATSA Architects), Firm B (TRHY Sdn Bhd), and Firm C (Archicentre Sdn Bhd). This research used a paper-based questionnaire to evaluate two firms, Firm A and Firm B, and an Online Questionnaire for Firm C, due to time constraints and the firm's regulations. Respondents were asked a few questions using a four-point Likert scale, ranging from "Strongly Disagree" to "Strongly Agree."

The collected data were analysed using cumulative percentages and frequency distributions of comfort levels. Graphical and statistical analyses were

then applied to interpret the findings and derive practical insights for promoting health-induced environments in architectural firms.

RESULTS

Questionnaire Analysis

Based on the questionnaire data collection, the results and analysis are presented in Table 1, Table 2, and Table 3.

Table 1 The table shows the main components of the questionnaire with their variables.

No.	Components	Variables
1.	Component 1	**Spatial Arrangement**
2.	Component 2	**Furniture**
3.	Component 3	**Noise**
4.	Component 4	**Lighting**
5.	Component 5	**Preference**

Table 2 Spatial Arrangement, Furniture, Noise and Lighting Survey Summary by selected 3 Firms.

No	Description	Agreed Percentage	Disagreed Percentage
1.	**Spatial Arrangement**		
	I like the position of my current workstation.	75.8 %	24.2 %
	I have enough space to move around and to store my personal belongings.	65.2 %	34.8 %
	I can move easily from one space to another space without obstacles.	62.1 %	37.9 %
	I am comfortable with my workstation arrangement that gives enough privacy.	60.6 %	39.4 %
	The spatial arrangement affects my psychological well-being.	57.6 %	42.4 %
	The spatial arrangement affects my productivity negatively.	47.0 %	53.0 %
	The spatial arrangement affects my work performance negatively.	42.4 %	57.6 %
2.	**Furniture**		
	The furniture is comfortable enough to do work without getting tired the whole day.	74.3 %	25.7 %
	The ergonomics of my workstation never affect my health problem.	62.2 %	37.8 %
	My current workstation does not affect my productivity.	60.6 %	39.4 %
	The size of my workspace is sufficient enough for me to do my work even when large drawings need to be referred to.	40.9 %	59.1 %
3.	**Noise**		
	I prefer to work comfortably with noise barrier.	72.8 %	27.2 %
	I prefer to work in quiet and calm environment.	72.7 %	27.3 %

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No	Description	Agreed Percentage	Disagreed Percentage
	I can work more productively by listening to music while working.	72.3 %	27.2 %
	Noise or music does not affect my concentration.	57.6 %	42.4 %
	Noise doesn't affect my work performance and productivity.	50.0 %	50.0 %
	My workstation has many noise distractions.	40.9 %	59.1 %
4.	**Lighting**		
	My workstation is provided with sufficient lighting to complete my task.	84.9 %	15.1 %
	I prefer to obtain fresh air and lighting for me to conduct my work comfortably.	83.4 %	16.6 %
	Ample amount of lighting and openings at my workspace is appropriate.	77.2 %	22.8 %
	Lighting provided doesn't affect my work performance and productivity.	40.9 %	59.1 %

The analysis of workplace environmental factors reveals a positive perception of spatial arrangement, with most respondents agreeing with the availability of space (65.2%), unobstructed circulation (62.1%), and workstation location (75.8%). However, between 42.4% and 57.6% reported negative effects on work performance, productivity, or psychological well-being, indicating spatial issues despite overall adequacy. For furniture, comfort (74.3%) and ergonomic adequacy (62.2%) were positively rated; however, 59.1% found the workspace size inadequate for large-format tasks. Noise was identified as a significant concern, with 59.1% citing frequent distractions; nonetheless, a majority preferred quiet environments (72.7%), noise barriers (72.8%), or music to improve productivity (72.3%). Lighting received the highest ratings, with 84.9% confirming that it provided sufficient illumination, 77.2% noting that it had appropriate openings, and 83.4% valuing access to natural light and ventilation. However, 59.1% indicated that lighting conditions still impacted their performance. These results suggest that while ergonomic and lighting conditions are largely satisfactory, targeted improvements in spatial configuration and acoustic control may be required to enhance both productivity and employee well-being.

Table 3 Preferences Survey Summary by selected 3 Firms.

No	Description	Agreed Percentage	Disagreed Percentage
5.	**Preference**		
	Natural greenery has a restorative effect and keeps me more focused.	95.9 %	6.1 %
	I prefer to have some green/plants in my workstation area.	92.4 %	7.6 %

No	Description	Agreed Percentage	Disagreed Percentage
	Indoor humidity gives positive impacts on both my comfort and productivity.	92.4 %	7.6 %
	I feel more active and fresher when I have directly or indirectly access towards plants.	90.9 %	9.1 %
	Presence of interior plants will actively affect my performance positively.	84.9 %	15.1 %

Table 3 shows the preference for the presence of greenery within employees' workspace areas. 92.4% of employees preferred to have plants/greenery at their workstations, and 84.8% of them believed that the presence of interior plants would positively affect their performance. 92.4% of the respondents from the three firms agreed that indoor humidity has a positive impact on both their comfort and productivity, and that natural greenery has a restorative effect, keeping them more focused. 90.9% of them also stated that they feel more active and fresher when they have direct or indirect access towards plants. These findings suggest that greenery plays a significant role in promoting both psychological well-being and work performance.

Observation Analysis

Based on observation data collection, the results and analysis are as shown in Table 4.

Table 4 The table below shows the summary of observation of 3 Case Studies

Observations	Firm		
Space Requirements	**A**	**B**	**C**
Lobby	/	/	/
Design Studio Areas	/	/	/
Manager Offices	/	/	/
Storage Area	/	/	/
Pantry	/	/	/
Photocopy/ Printing Area	/	/	/
Filing Area	/	/	/
Meeting Area	/	/	/
Discussion Area	/	/	/
Material and Sample Area	/	/	/
Spatial Problems			
Not enough personal Storage	/	o	o
Not enough storage for drawings	/	/	/
Not enough space for common area	/	o	o

Legend: / = Provided o = Not provided

Upon observation, all three firms compartmentalise the areas differently: lobby, workstation, director's room, meeting area, pantry, and storage

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area. The observation shows that all three firms meet their basic space requirements for an architectural firm's office. It also shows that most of the offices have insufficient space for larger drawings. Only Firm A has personal storage and common area problems for employees.

Simulation Analysis

Based on simulation data collection, the results and analysis are as shown in Figure 5, Figure 6 and Figure 7.

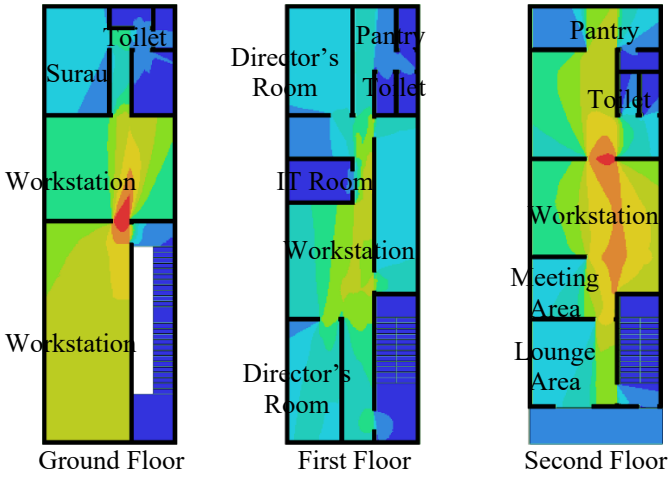


Figure 5 Floor plans for Firm A

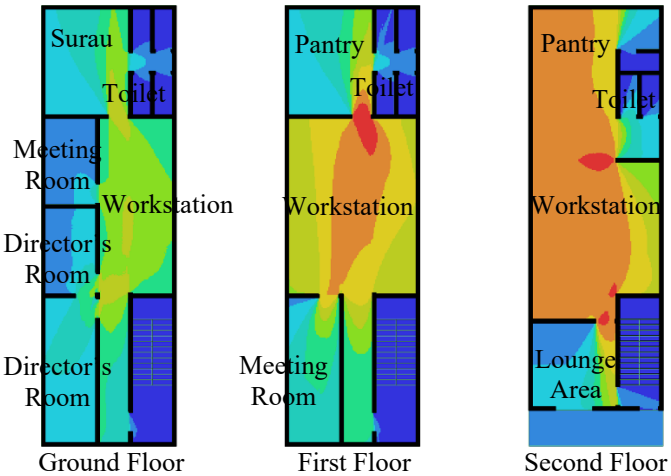


Figure 6 Floor plans for Firm B

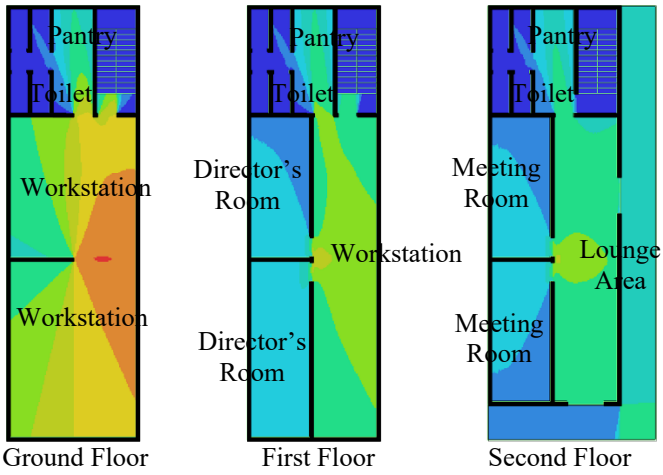


Figure 7 Floor plans for Firm C



Figure 8 Legend for Space Syntax Analysis

Figure 6 shows that Firm B has the most connectivity among employees due to its open plan arrangements, which have the highest density of spaces on the Second and First Floors. However, a lower density on the Ground Floor, followed by Firm C (Figure 7), where the high density happens on the Ground Floor. In contrast, low density occurred on the First and Second Floors. As for Firm A (Figure 5), due to the office layout, which utilises partitions and drywall, low density is observed on the Ground Floor and Second Floor, with the lowest density found on the First Floor.

DISCUSSION

From the questionnaire data collection, several aspects were evaluated by the respondents. The findings show that, in terms of spatial arrangement, a high percentage of employees agree that having enough work space with good circulation, arrangement, and a more private layout will positively affect them and improve their well-being. In terms of furniture, a high percentage of employees agree that the workspace needs to provide a comfortable and ergonomic workspace. However, they perceive that this will not have a high impact on their work productivity. While in terms of noise, it has been found that employees have an equal percentage of opinion that noise affects their work

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performance, but most of them prefer a quiet ambience with a noise barrier workspace. In terms of lighting, a high percentage of employees agree that the workspace needs to provide a sufficient amount of lighting, as it promotes comfort, and inadequate lighting can affect work performance. While in terms of preference, the findings show a high percentage of employee agree that humidity (fresh air) and the presence of greeneries (interior plants) either directly or indirectly within the workspace area will help them to keep focus, feel active and fresh, have a restorative effect, which has an impact on the comfort level and their productivity.

Upon observation, it was found that all three firms implemented a combination office layout, as this layout offers a combination of multifunctional spaces with cellular offices. The office plan layout supports this result, as each of the firms compartmentalises the areas differently: lounge area, workstation, director's room, meeting area, pantry, and surau. A combination office layout aims to encourage communication and discussion among employees by providing connectivity, as proven by the findings of Space Syntax simulation. In the workstation area, high-density circulation was observed in the open-plan office layout, whereas low-density circulation occurred in the partitioned office layout. However, an open-plan layout offers more connectivity among employees, while a partitioned office layout provides a quieter and more private environment. This combination type of office layout is an efficient approach to creating a health-inducing environment through enhanced communication among employees, while also providing a workspace with greater privacy from noise and visual distractions.

Findings from the questionnaire, observation, and Space Syntax analysis show a clear correlation between spatial layout and employee well-being. A combination office layout balancing open and partitioned spaces supports both connectivity and privacy. Adequate space, comfort, lighting, and noise control enhance well-being and focus, indicating that balanced spatial and environmental design indirectly improves work performance.

CONCLUSION

This study found that environmental factors, including spatial arrangement, furniture, noise, lighting, and greenery elements, influence employees' psychological well-being and productivity. Adequate space for movement and storage, comfortable workstations, and sufficient personal space, especially for large-format tasks, were linked to higher work productivity. Adequate lighting and availability of fresh air were also valued for enhancing comfort, efficiency, and performance. Meanwhile, a combination office layout suits the aim of creating connectivity while also providing privacy, emphasising the importance of health-inducing environments in architectural firms.

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ASSESSMENT OF CLIMATE CHANGE AWARENESS AMONG RURAL FOREST COMMUNITIES

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Abstract

This study assesses the awareness of climate change among rural forest communities, focusing on how socio-demographic profiles influence perceptions of climate-related phenomena. Using quantitative data collected from local respondents, the analysis examined the relationships between awareness of climate impacts including heat waves, temperature variations, rainfall changes, and flooding and respondents' characteristics, including gender, religion, education, occupation, and district location. The results revealed that religion and district were the most significant factors influencing awareness of heat waves and temperature changes, while gender and religious education also showed notable effects. In contrast, awareness of rainfall and flooding was relatively uniform across groups, suggesting shared experiences of these recurrent events. The findings suggest that climate change awareness and understanding require enhancement through appropriate content and effective communication channels. Overall, the findings demonstrated a moderate level of awareness of climate change among rural forest communities.

Keywords: Awareness, climate change, rural forest communities, knowledge, perceptions

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INTRODUCTION

Climate change can be defined as changes in the state of a climate that can be identified (e.g., using a statistical test) by changes in the mean and/or variability of its properties, and that persist for an extended period, typically decades or longer (The Intergovernmental Panel on Climate Change, 2007). According to the IPCC AR6 Summary (2021), the global mean temperature for 2020 was 1.2 ± 0.1°C above the 1850–1900 baseline, making it one of the three warmest years on record. The report also indicated that, with 2020 being one of the three warmest years on record, the past six years (2015–2020) were the six warmest on record. The last five-year (2016–2020) and 10-year (2011–2020) averages were also the warmest on record.

The 26th UN Climate Change Conference (COP26) was held in November 2021 in Glasgow, United Kingdom, to discuss updated climate action plans (United Nations, 2021). To achieve the mission of reducing the global temperature to 1.5℃, 17 Sustainable Development Goals (17 SGDs) were developed to improve the natural environment supporting food production and propose climate action to restore the ecosystem, particularly under SDG13. This study focuses on Target 13.3 of SDG13, which aims to build knowledge and capacity to meet climate change by improving education, awareness-raising, and human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning. These global commitments remain crucial as climate change has affected communities at the local scale, including through water scarcity and reduced agricultural production.

Kuala Lumpur, the capital of Malaysia, is one of the country's largest cities and is facing the impact of climate change due to rising carbon emissions (Zawawi, Asmawi, and Zen, 2024). In the Malaysian context, Kuala Lumpur City Hall (KLCH) has published a climate action plan for the Kuala Lumpur Climate Action Plan 2050 (Kuala Lumpur City Hall, 2021). Other related initiatives include Local Agenda 21 (LA21), KLCH Carbon Management Plan 2017–2022, and the Kuala Lumpur Low Carbon Society Blueprint 2030 (KL LCSBP 2030), which also direct better carbon emission strategies. Beyond urban centres, Malaysia's engagement in climate change adaptation programmes has also increased alongside growing public awareness regarding adaptation necessity. At the national level, these programmes include the US Support Programme to the Coral Triangle Initiative to manage coastal and marine resources with biological and economic significance.

Climate change in Malaysia manifests through various events, with rapid urbanisation serving as the key driver. Urbanisation causes the urban heat island effect (UHI), which produces extreme heat, particularly in Kuala Lumpur during the summer months (IPCC, 2022). The loss of green spaces such as parks and forests further exacerbates the UHI effect in the city. Beyond urban impacts,

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climate models demonstrate a continuous warming trend for Malaysia, which varies depending on the emissions scenario. While precipitation projections show high variability, projected rainfalls, as well as the intensity of extreme rainfall events, have increased (World Bank Group, 2021).

Given these climate impacts, understanding community awareness and perception becomes crucial for effective adaptation. Awareness serves as an important indicator, as greater awareness among rural communities toward climate change indicates preparedness to face numerous hazards resulting from climate change (Mohamed Shaffril et al., 2015). If people are not aware of the nature of climate change and how it will affect them, they will never be emotionally concerned about the whole issue (Pandve et al., 2011). Understanding community awareness can lead to actual action towards climate change, hence mitigating the problem. Therefore, people would be better equipped with preparedness skills to confront the challenges and threats posed by climate change to their living conditions. Perception is defined as the way in which climate change and variability are regarded, understood, or interpreted by local people. Perception is of particular interest because of its ability to enhance solutions to risky climatic events (Maddison, 2006).

This study examines rural forest communities, who are among the groups most vulnerable to climate change impacts. Their vulnerability stems from direct dependence on natural resources for livelihood, agriculture, and cultural practices. Despite their close relationship with the environment, these communities often have limited access to formal education, scientific information, and policy frameworks related to climate change. This gap in awareness and knowledge can hinder their ability to adapt effectively and participate in sustainable environmental management efforts. Understanding the level of climate change awareness and knowledge within these communities is crucial for designing effective adaptation strategies, community-based education programs, and policy interventions. Such an assessment provides valuable insights into how local perceptions, traditional knowledge, and socio-economic factors influence their understanding of environmental changes. It also helps identify barriers that prevent the dissemination of accurate climate information to rural populations.

Studies examining climate change have been conducted in the context of rural forests. According to Deni et al. (2024), locals were able to identify drought-tolerant native trees and recognise shifts in species distribution. In Turkiye, Sevim & Güven (2025) discovered that although participants had a comparatively high level of general awareness of climate change, this awareness frequently lacked depth with regard to its local ecological effects and practical solutions. In Malawi, Chisale et al. (2022) found that 60% of the respondents in Mchinji and 35% in Mangochim were aware of climate change; they also reported

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that they saw more unpredictable rainfall, high temperatures, strong winds, and seasonal changes. In India, Roy et al. (2024) found a decreasing trend in the availability of water for domestic purposes, crop failure, and low agricultural production, reduction in human health, poor livestock health, and a range of other problems due to climate change, which subsequently impacted their livelihood.

Research on climate change in Malaysia has been proliferating, with local studies addressing issues such as rising sea levels (Hamid et al., 2019; Hamid et al., 2018), global warming (Lim et al., 2009; Meng et al., 2005), and air pollution (Aghamohammadi & Isahak, 2018; Mohd Shafie & Mahmud, 2020). Additionally, technological approaches to climate change analysis, including Big Data (Abdullah et al., 2018; Knüsel et al., 2019) and Remote Sensing (Deafalla et al., 2014; Yang et al., 2013), have been explored. However, the focus of these studies remains on the science and numerical analysis of climate statistical analysis; however, the social sciences studies of climate changes, including climate change adaptation of fishermen (Mohamed Shaffril et al., 2015; Shaffril et al., 2020), farmers, palm oil (Abubakar et al., 2021; Paterson & Lima, 2017), and urban communities (Egerer et al., 2021; Mees & Driessen, 2011). Within the local context, there appears to be a lack of studies focusing on rural forest areas, with only one study focusing on the urban regions, which examines perceptions of climate change across different states (Yaacob et al. 2022).

To address the above gap, the current study aims to investigate whether Malaysia's rural forest community has been adequately informed about climate change and their efforts to adapt to it. Understanding community awareness levels and the factors influencing adaptation is essential to achieving the study's objectives. Toward this end, this study seeks to examine the awareness level of those who live in rural forest areas and the effects of selected demographic factors on farmers' adaptation towards climate change impacts.

METHODOLOGY

Design and Setting

The population of Hulu Selangor, Kuala Selangor, and Gombak is approximately 1,068,338; however, the study area is focused on those respondents who live near forest areas. The data collection process was conducted from 1st March 2021 to 31st March 2021. The main method of data collection was a questionnaire survey. Data were collected by trained enumerators. This study employed a non-probability sampling technique, as the respondents were selected based on accessibility and willingness to participate. Although the sample may not fully represent the population, it provides valuable insights into the perspectives and experiences of the target group relevant to the study objectives. A sampling approach was used to randomly and evenly sample 96 respondents throughout the study area. Individuals aged 30 years and above who have lived in their

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community for more than ten years as respondents are aware of how climate affects their lifestyle.

The framework of this study focuses on the awareness of the community towards climate change. An inferential multivariate statistical model was run on the survey data to visualise autocorrelations between climate change awareness and knowledge, and other variables (gender, age, job, and start learning religion) for the surveyed households. This study also explored how knowledge about bounded climatic events in the community (awareness) related to data from the literature is critically analysed. The instrument, prepared based on the literature review, comprised five sections: demographics (four questions), perception of the communities on the causes of climate change (eight questions), types of climate changes that have occurred during the past ten (10) years (nine questions), and influence of climate change on their life (seven questions). A basic question regarding climate change was designed because the questionnaire will be distributed to the villagers, which also includes aboriginal people. Table 1 shows the structure of the instrument and response formats.

Table 1: Structure of questionnaire and response formats

Section	Number of items	Option of answer for respondents
Demographic data	8	Open and closed-ended
Awareness	3	Open and closed-ended
	5	5-point Likert scales

Respondents were given open-ended and closed-ended alternatives for the demographic component, and *yes* and *no* responses for the perception of the communities on the causes of climate change, and a five-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) for the remaining sections. A panel of specialists and a series of instrument development sessions verified the questionnaire. This study also assessed the validity and reliability of the instrument using a reliability test. A Cronbach's alpha is 0.9 was derived, which is above the commonly accepted alpha cut-off value of 0.7, reflecting the instrument's strength and reliability. This study used descriptive statistics, such as frequency, percentage, and mean analysis. However, for inferential analysis, ANOVA was performed to identify any significant differences in the respondents' awareness of climate change among the different groups.

RESULTS AND DISCUSSION

Descriptive analysis of respondents'

This study aims to understand the perception and understanding of rural communities towards climate change. The 43 participants were male (44.8 per cent) and 53 were female (55.2 per cent). The mean score for respondent age is

28.4 years. The focus of the study is on respondents who settled in rural forest regions. Detailed profiles of the participants are presented in Table 2.

Table 2: Detailed frequencies for participants' profiles

Factors	Frequency	Percentages
Male	43	44.8
Female	53	55.2
Total	96	100.0

District	Frequency	Percentage
Gombak	31	32.3
Hulu Selangor	32	33.3
Kuala Selangor	33	34.4
	96	100.0

Started learning religious	Frequency	Percentages
At home	19	19.8
Religious School KAFA	56	58.3
Religious Islamic School	7	7.3
Not related	14	14.6
Total	96	100.0

Job description	Frequency	Percentages
Daily works	45	46.9
Entrepreneur/business	25	26.0
Housewife	2	2.1
Not working	16	16.7
NGO	2	2.1
Government servant	6	6.3
Total	96	100.0

The participants started learning religion at KAFA religious school (58.3%), home (19.8%), none (14.6%), and *pondok* religious school (7.3%). A total of 96 respondents were surveyed; most of them are from Kuala Selangor (34.4 per cent), followed by Hulu Selangor (33.3 per cent), and Gombak (32.3 per cent). More than half of the participants (45 participants) perform daily works (46.9%), and 26 % run businesses (25 participants); and 16.7% are not working. The least number of respondents is constituted by government servants (6.3%) the NGOs (2.1 %).

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Communities' awareness of climate change

The first question (Table 3) examined the respondents' awareness of climate change. A total of 95 respondents (97.9 percent) indicated that their understanding of climate change was based on personal experiences. This item formed part of the set of questions assessing community awareness of climate change.

Table 3: Responses on the basis of understanding climate change

I know climate change based on my personal experience	**Participants**	**Percentage**
YES	95	(99)
NO	1	(1)

Further questions sought responses on a Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The findings (Table 4) indicate that the mean ranged from 1.19 to 3.51. Only social media received a "moderately agree" response (mean = 3.51), indicating that respondents most frequently hear about climate change through platforms such as Facebook, Twitter, or Instagram. Other sources, such as health workers (mean = 1.77) and teachers (mean = 1.57) were reported less often, and traditional media such as newspapers, radio, and television received the lowest mean scores.

Table 4: Types of platforms through which respondents hear about climate change

Platform	Mean	Standard Deviation	Variance
Newspaper	1.19	.392	.154
Social Media	**3.51**	.466	.217
Radio	1.39	.489	.239
Television	1.22	.416	.173
Health worker	1.77	.423	.179
Teacher	1.57	.497	.247
Imam	1.90	.307	.094
Family	1.53	.502	.252
NGO	1.80	.401	.160

Further analysis recorded a moderate mean score (3.30 – 3.58) in terms of respondents' awareness of the types of climate change (Table 5). Although events such as flooding and heat waves are experienced in these areas, respondents did not appear to associate these events with climate change, which may explain the moderate awareness levels.

Table 5: Awareness of different types of climate change

Climate Change	Mean
Heat waves	3.54
Temperature changes	3.43
Rainfall monsoonal changes	3.42
Frequent flooding	3.58
Deforestation	3.53
Natural disaster	3.30

This finding (Table 5) suggests a necessity to expose the community to more knowledge of climate change. Respondents were most aware of immediate, visible climate impacts such as flooding and heat waves, while broader concepts such as general natural disasters showed slightly lower (but still positive) awareness levels. All scores indicate that the audience has at least basic recognition of these climate change types. Awareness-raising programs are needed to increase community knowledge of climate-resilient development (Asian Development Bank, 2014).

The analysis below (Table 6) shows differences in climate change awareness across respondent profiles. For this analysis, four climate-related phenomena— heat waves, temperature changes, monsoonal rainfall changes, and frequent flooding—were chosen because they are commonly experienced in tropical countries such as Malaysia.

Table 6: Differences in climate change awareness across respondent profiles

Climate changes	F	Significance (<.05)
Heat waves		
-Job	1.925	.113
-Gender	.663	.619
-Religion	9.282	.000*
-Race	.634	.639
-District	2.608	.041*
-Religious education	1.013	.405
-Civic education	1.165	.331
Temperature changes		
-Job	.715	.584
-Gender	2.781	.031*
-Religion	9.347	.000*
-Race	.341	.850
-District	5.469	.001*
-Religious education	2.530	.046
Civic education	1.156	.336
Rainfall monsoonal changes		

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Climate changes	F	Significance (<.05)
-Job	.852	.469
-Gender	.538	.657
-Religion	.486	.693
-Race	.233	.873
-District	.709	.549
-Religious education	1.445	.235
Civic education	.618	.605
Frequent flooding		
-Job	1.166	.331
-Gender	.869	.486
-Religion	.177	.950
-Race	.147	.964
-District	6.4	.000*
-Religious education	1.47	.218
Civic education	.163	.957

Findings in Table 6 indicate that the factors influencing awareness vary across the four climate change dimensions: heat waves, temperature changes, rainfall monsoonal changes, and frequent flooding.

For heat waves, significant differences were found by religion ($p = .000$) and district ($p = .041$). This may suggest that religious background and geographical context play a crucial role in shaping perceptions of heat-related climate impacts, either through value system or differences in local climate conditions or exposure to awareness campaigns.

For temperature changes, significant differences were found by gender ($p = .031$), religion ($p = .000$), district ($p = .031$), and religious education ($p = .046$). These patterns may indicate that men and women may perceive or experience temperature-related changes differently and that cultural or religious framing could influence how such changes are perceived, possibly due to differences in daily activities or exposure to outdoor environments. Variation across districts also points to the importance of local climate conditions and accessibility to information.

For rainfall monsoonal changes and frequent flooding, no significant differences were found across the profile variables. This suggests that awareness of these events is relatively uniform among rural forest communities, likely because such climatic events are frequently experienced and directly affect livelihoods, infrastructure, and local economies. Flooding and monsoon changes are tangible and recurrent events, making them universally recognised regardless of gender, religion, or education level.

Overall, the results indicate that religion and district are the most recurrent differentiating factors, with gender and religious education appearing in specific cases. These findings emphasise the need for localised and culturally

sensitive climate awareness programs that integrate community beliefs and regional experiences. Policy makers and planners should therefore collaborate with religious institutions and local district authorities to enhance community-level engagement and adaptive capacity toward climate change.

Table 7 presents the respondents' views on the causes of climate change. Deforestation was most frequently identified as the major cause of climate change 85.4 per cent 'yes'), followed by black smoke from vehicles (82.3 per cent). Industrial activities were the third cited cause (77.1 per cent). Population growth (52.1%) and urbanisation and lifestyle changes (53.1%) were less frequently selected, with a comparatively higher proportion of "Not sure" responses for these items.

Table 7: Respondents' views on the causes of climate change

What are the causes of climate change?	Yes (%)	No (%)	Not sure (%)
Deforestation	82 (85.4)	3 (3.1)	11 (11.5)
Industrial	74 (77.1)	9 (9.4)	13 (13.5)
Population growth	50 (52.1)	11 (11.5)	35 (36.5)
Black smoke from vehicle	79 (82.3)	6 (6.2)	11 (11.5)
Release of excessive carbon dioxide by developed countries	65 (67.7)	10 (10.4)	21 (21.9)
Urbanization and changes in lifestyle	51 (53.1)	16 (16.7)	29 (30.2)

Flooding (70.8%) and drought (67.7%) were the most frequently reported events, indicating that such hydrological events are commonly experienced by the respondents. Other major changes reported were forest fires (67.7%), reduction in agricultural yield (58.3%), and increased health costs after extreme weather (57.3%). These responses are consistent with the socioeconomic and environmental consequences of climate variability, particularly for communities dependent on agriculture and natural resources. Moderately reported changes included rainfall trends (54.2%), heavy rains (56.2%), and rivers becoming shallower (56.2%), suggesting that gradual shifts in precipitation patterns and river conditions are being noticed at the local level. Natural disasters (52.1%) received the lowest "Yes" responses, with a relatively higher "No" (24%) and "Not Sure" (24%) responses, which may indicate that respondents interpreted "natural disasters" differently or associated them only with severe, large-scale events. Details are provided in Table 8.

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Table 8: Respondents' reported experiences of climate-related events in the past 10 years

Events past 10 years	YES (%)	NO (%)	NOT SURE (%)
Drought	65 (67.7)	13 (13.5)	18 (18.8)
Flooding	68 (70.8)	14 (14.6)	14 (14.6)
Changes in rainfall trend	52 (54.2)	11 (11.5)	33 (32.4)
Reduction of yield of agriculture	56 (58.3)	13 (13.5)	27 (28.1)
Occurrence of forest fires	65 (67.7)	15 (15.6)	16 (16.7)
Increased health costs after extreme weather event	55 (57.3)	15 (15.6)	26 (27.1)
Heavy rains occur	54 (56.2)	15 (15.6)	27 (28.1)
The river becomes shallower	54 (56.2)	13 (13.5)	29 (30.2)
Natural disaster	50 (52.1)	23 (24%)	23 (24)

Overall, the findings suggest that rural forest communities have a high awareness of extreme weather events such as flooding, drought, and forest fires, which are likely to have direct and visible impacts on their livelihoods, agriculture, and health. The increased health expenditure (57.3%) highlights the indirect social and economic burden of climate change, where extreme events contribute to illnesses, stress, and medical costs.

Table 9 presents the respondents' reports of human activities occurring around their settlements. Air and water pollution reported the highest mean score (3.91), followed by open burning (3.56). Other activities reported were illegal waste disposal (3.44), mining (3.28), illegal logging (3.22), and land clearing (3.16). These findings indicate that environmentally impactful activities are present within the vicinity of the respondents' communities. As noted by Shaffril et al. (2013), possessing environmental knowledge is important because it enables communities to understand climate change, its causes and impacts on them, their families, and their communities.

Table 9: Human activities reported around the settlements

If happens around settlements	Mean	Standard Deviation	Variance
Logging	3.06	1.238	1.533
Illegal logging	3.22	1.275	1.625
Land clearing	3.16	1.208	1.460
Hill cutting	3.00	1.223	1.495
Mining	3.28	1.194	1.425
Air and water pollution	3.91	1.164	1.355
Open burning	3.56	1.280	1.638
Illegal waste disposal	3.44	1.221	1.491

Table 10 presents findings on whether climate change has influenced the lifestyle of the rural forest community. Overall, the mean values are above 3.00, indicating that the respondents perceived climate change as having a moderate influence on their lifestyle. However, they did not agree that climate change has led to destruction and loss of property, and loss of life. This may suggest that they feel that they have adapted to certain conditions, such as heat, without recognising these changes as part of the climate change effect. This pattern is aligned with Shaffril et al. (2013), who reported that community awareness and level of knowledge on climate change are only general.

Table 10: Perceived influence of climate change on respondents' lifestyle

What is the influence of climate change on your lifestyle	Mean	Standard Deviation	Variance
Reduction of outdoor activities	3.12	1.078	1.163
Reduction of sources of income	3.49	1.142	1.305
Destruction and loss of property	2.99	1.342	1.800
The disease is transmitted to people around	3.00	1.214	1.474
Loss of life	2.82	1.205	1.453
Changes in lifestyle	3.42	1.158	1.340

Overall, this study reveals limited climate change awareness, likely because respondents have not yet experienced clear, direct impacts on their daily lives. Enhancing awareness requires direct community engagement and stronger collaboration between communities and relevant agencies. Information dissemination strategies should utilize existing local governance structures, such as village chiefs and community leaders, to ensure effective communication.

The National Forestry Policy and Malaysia's National Climate Policy (2024) are two examples of national and regional climate policies that place a strong emphasis on public education, sustainable forest management, and community involvement. However, policy implementation may become top-down and ineffectual without adequate local knowledge. Assessing awareness levels enables policymakers to identify areas where local knowledge and national strategies diverge, enabling focused education campaigns, participatory planning, and capacity-building projects.

CONCLUSION

This study presents several distinctive findings regarding rural communities' level of awareness of climate change. The communities were found to have a moderate level of awareness; however, this awareness remains conceptual (common knowledge) and has not translated into behavioural change. From the perspective of lifestyle, respondents reported that climate change has not altered

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their daily practices. The findings indicate that community lifestyles remain similar even during climate-related events.

The rural forest communities were quite conscious of climate change, particularly in relation to obvious and frequent occurrences such as flooding, drought, and forest fires. From these incidents, the effects of climate change were felt directly on the environment and livelihoods, in addition to being understood theoretically. Both cultural and geographic contexts affected how they viewed and reacted to climate issues, as the awareness levels differ significantly by religion, district, gender, and religious education.

Notwithstanding this awareness, the results imply that local knowledge was largely experiential rather than scientific, which could limit adaptive responses. Targeted educational and communication initiatives that integrate climate science into regional knowledge systems should be prioritised. To ensure that local perspectives and experiences inform climate resilience efforts, policies should incorporate rural community-based approaches into national frameworks, such as the National Adaptation Plan and the National Climate Policy (2024). Encouraging inclusive climate education and developing adaptive capacity requires closer collaboration between government agencies, local governments, and religious institutions. Ultimately, attaining sustainable and equitable climate resilience in Malaysia's forested areas depends on empowering rural forest communities via awareness-raising, education, and participatory planning.

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EMPOWERING COMMUNITIES FOR HERITAGE CONSERVATION THROUGH COMMUNITY-BASED TOURISM: INSIGHTS FROM UNESCO SITE BENCHMARKING AND LOCAL PERCEPTIONS

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Abstract

Community-based Tourism (CBT) has gained increasing attention as a sustainable approach that empowers local communities while conserving cultural heritage. This study examines the potential of Pasir Salak, Perak, as a heritage-driven CBT destination by benchmarking it against Kampung Morten, Melaka, a recognised living heritage village. Using a mixed-methods approach, the research combines a benchmarking visit, pre- and post-surveys of community members (N = 38), focus group discussions, and field observations to evaluate community perceptions, participation, and empowerment. Findings indicate that while Pasir Salak community demonstrates strong cultural pride and in CBT, challenges remain in governance support, infrastructure and policy framework. The benchmarking exercise highlighted transferable lessons from Kampung Morten, especially in governance structures, cultural branding, and enterprise development, as challenges of empowerment and policy alignment persist. This study contributes to planning discourse by positioning benchmarking as both an evaluative and capacity-building tool in heritage tourism and by linking CBT practices to sustainable development and cultural resilience. Policy implications suggest that strengthening co-governance mechanisms, aligning initiatives with the United Nations Sustainable Development Goals (SDGs) and fostering inclusive community participation are essential for revitalising Pasir Salak and similar heritage sites.

Keywords: Community-based Tourism, Benchmarking, Heritage Conservation, Community Empowerment, Pasir Salak, Kampung Morten.

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INTRODUCTION

Heritage conservation and community-based tourism (CBT) are intrinsically interconnected as both emphasise the safeguarding of cultural identity while fostering sustainable socio-economic development. Heritage conservation refers to a systematic process of protecting, maintaining and managing both tangible and intangible cultural heritage for future generations without compromising its authenticity and integrity (Ahmad, 2006; Jokilehto, 2017). The practice encompasses the preservation of built heritage, cultural landscapes, artefacts and traditional knowledge systems that together embody a community's history, values and identity. Community-based tourism (CBT), on the other hand, provides a participatory framework that allows local communities to play an active role in conserving and interpreting their heritage, ensuring that cultural assets such as traditional architecture, crafts and historic narratives are not only preserved but also valorised as tourism resources (Wijayanti et al., 2023).

In Malaysia, heritage conservation is guided by the National Heritage Act 2005 (Act 645) and international frameworks such as the Burra Charter and the Venice Charter. The framework aims to strike a balance between protecting and sustainably using the unique character and meaning that heritage holds for a community, while also adapting to contemporary needs. Although there are acts for local heritage conservation, the initiatives are somehow not rigorous, selective and not widely known. For example, while urban heritage sites such as George Town and Melaka have benefited from the UNESCO World Heritage status, small rural heritage sites like Pasir Salak face different challenges, like limited funding, underdeveloped tourism infrastructure and inadequate conservation expertise as found in Harun (2018) and Hashim et al. (2025).

Although Pasir Salak was once a significant heritage and tourism asset to Perak, developed with proper infrastructure and governance in its local authority planning (Isa et al., 2022), over the years, Pasir Salak has been facing a decline in its tourism charms due to promotion challenges and stakeholder coordination issues, as found in Mohamed et al. (2023). Numerous studies have highlighted declining issues in Pasir Salak and proposed various strategies. Yet, only one study by Hashim et al. (2025) has emphasised the local community's role as a significant tourism agent for Pasir Salak's regenerative tourism. Community-led tourism, also known as community-based tourism (CBT), according to Rocca & Zielinski (2022), is a tourism model that involves local active participation, along with government initiatives, in equitable decision-making regarding its development and management, thereby sustaining local benefits from its economic, social, and cultural impacts. The model emphasises the community as the foundation for transforming mainstream tourism into sustainable, identity-preserving, and economically beneficial activities (Prasad, K. (2024).

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This study seeks to address the gap by evaluating the potential of Pasir Salak as a heritage-driven CBT destination through community perceptions and benchmarking against Kampung Morten. Specifically, the study aims to:

1. Examine community awareness, perceptions and interest in CBT for heritage conservation in Pasir Salak.
2. Analyse lessons from Kampung Morten as a benchmarking model for heritage-driven CBT, and
3. Identify policy and governance implications for revitalising Pasir Salak

By linking benchmarking with CBT models and community empowerment frameworks, this study contributes to the discourse on heritage conservation within Malaysian planning scholarship, offering insights into how rural heritage tourism can align with cultural sustainability and the SDGs.

LITERATURE REVIEW

Heritage Conservation in Malaysia: Urban and Rural Contrasts

Pasir Salak is a vital and rich in tourism potential site for Perak Tengah that could contribute to its economic revitalisation. The place boasts a vast cultural heritage, comprising unique culture and art, traditional knowledge, natural beauty, and more (Harun, 2018). Although Malaysia's heritage conservation framework is shaped by the National Heritage Act 2005 and influenced by international charters, yet, conservation outcomes vary between urban and rural contexts. Urban heritage sites such as George Town and Melaka benefit from UNESCO designation, which brings investment, policy attention and global visibility (Harun, 2018). In contrast, rural heritage destinations like Pasir Salak face persistent challenges, including limited promotion, declining visitor numbers, fragmented stakeholder coordination, and insufficient conservation expertise (Isa et al., 2022; Mohamed et al., 2023; Hashim et al., 2025). Despite these constraints, Pasir Salak retains strong cultural assets and symbolic values as a site of national history, making it a candidate for CBT revitalisation.

Models of CBT: Participation, Sustainability and Governance

Several CBT models offer evaluative lenses for analysing tourism development (Table 1). Tosun (2000; 2006) conceptualised community participation along a continuum of coercive, induced and spontaneous, highlighting the barriers to empowerment in developing context. He et al. (2021) advanced a sustainability evaluation framework that integrates economic, socio-cultural, environmental and institutional dimensions. Pasanchay and Schott (2021) demonstrated how homestay enterprises can preserve cultural heritage while advancing livelihoods.

Rocca and Zielinski (2022) underscored governance and social capital, emphasising networks, trust and institutional support as prerequisites for CBT success. More recently, Abreu et al. (2024) aligned CBT directly with the United Nations Sustainable Development Goals (SDGs), showing how heritage-based tourism can contribute to inclusive development. Collectively, these models provide a multi-dimensional framework to assess CBT practices in Pasir Salak.

Table 1: Summary of CBT models for Pasir Salak Benchmarking Literature Review

CBT Model	***Key Dimensions***	***Variables***
Tosun (2000; 2006) – Normative Model of Community Participation	Level of participation: Coercive, Induced, Spontaneous	Movement of Pasir Salak community from induced to spontaneous participation
He et al. (2021) – Sustainability Evaluation Framework	Economic; Socio–cultural; Environmental; Institutional	Changes in institutional support, community awareness of sustainability principles, and initial tourism product/service improvement
Pasanchay & Schott (2021) – Homestay Enterprise – Outcomes Model	Local enterprise practice; Cultural heritage preservation; Economic	Lessons from Kampung Morten homestay model, Potential for Pasir Salak to develop enterprises
Rocca & Zielinski (2022) – Governance & Social Capital Model	Governance structure; Social networks; Trust building; Institutional	Roles of MOTEC, Bahagian. Promosi Pelancongan, and Perak agency in supporting CBT
Abreu et al. (2024) – SDG Aligned Assessment Framework	Alignment with SDGs; Policy integration; Inclusive	Mapping benchmarking visit outcomes to SDGs

Lessons from Kampung Morten as a Benchmark

Kampung Morten is a Malay settlement located just outside Melaka's UNESCO World Heritage buffer zone. The Melaka State Government has declared it a heritage village under the state's conservation enactment, preserving its vernacular architecture and cultural identity amid rising urban development (Sukri, 2017). Kampung Morten is a living heritage village actively engaged in tourism activities, including homestays, cultural performances, tours, traditional products, and delicacies, among others. Study in Radzuan and Ahmad (2020) highlights that although many residents are highly interested in the tourism initiative, fewer feel empowered to contribute their opinions to tourism planning and decision-making, which is the gap between involvement and empowerment.

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Additionally, they highlighted the issues with relying on limited incentive programs for heritage conservation, illustrating the challenges of maintaining cultural authenticity and sustaining community interest in tourism. In essence, the village exemplifies how CBT is adapted to preserve heritage, culture, architecture and livelihood. It demonstrates both the strength in community involvement and cultural authenticity, while also highlighting challenges such as limited agency and a lack of alignment between policy and community. This makes Kampung Morten an excellent benchmarking reference for Pasir Salak's CBT initiative.

RESEARCH METHODOLOGY

Research Design

The study adopts a mixed method approach combining field benchmarking visits as an experiential learning tool, community survey analysis, participant observation, focus group discussions (FDGs) and field notes. This design ensured both quantitative insight through surveys and qualitative depth through FDGs and observations, aligning with recommendations for participatory tourism research (Tosun, 2006; Rocca & Zielinski, 2022).

Benchmarking Approach, Sampling and Participants

A benchmarking visit was organised to Melaka, including a visit to Kampung Morten for discussions and exchange ideas between the communities, visits to the state and local authorities, Ministry of Tourism (MOTAC) Melaka and Bahagian Promosi Pelancongan Melaka (BPP). The benchmarking exercise aimed to expose the Pasir Salak community to established heritage tourism models and facilitate mutual learning through observation and dialogue. Participants comprised the Ketua Kampung (village head), local villagers, small entrepreneurs, and representatives from the Perak state government, reflecting a diverse and inclusive group of community stakeholders.

Participants were selected using a purposive sampling approach focusing on individuals actively involved or interested in heritage and tourism development. The selection process was coordinated by the Ketua Kampung and PAMIS chairman, who identified community members who were available and eager to participate after the program was publicly announced. In total, 38 participants joined the program, among whom 18 respondents completed the pre-survey and 16 respondents completed the post-survey (n = 18 pre-visit, n = 16 post-visit). The survey measured awareness, perceptions, motivation, and perceived roles of the community in tourism development. The data were analysed descriptively, supported by thematic insights from discussions during benchmarking activities.

Although the sample size was modest, it reflects the active engagement from key community actors, consistent with CBT research norms that emphasise depth of participation over breadth of representation. Purposive sampling is considered appropriate in such contexts, as it captures the perspectives of directly involved stakeholders and those capable of influencing local tourism initiatives (Pasanchay & Schott, 2021; Tosun, 2006). This approach ensures that the analysis reflects the authentic voice of the Pasir Salak community, aligning with participatory and empowerment-oriented principles central to community-based tourism studies.

Data Analysis and Methodological Framework

Survey data were analysed descriptively using frequency distributions and percentage comparisons to identify changes in awareness, perceptions, and interest in CBT. Qualitative data (FDGs and field notes), on the other hand, were analysed thematically, guided by CBT models (Tosun, 2006; He et al., 2021; Rocca & Zielinski, 2022; Abreu et al., 2024). To ensure systematic extraction of lessons from Kampung Morten, the benchmarking framework employed a structured comparative approach guided by three analytical lenses derived from established CBT models: (i) community participation and empowerment, (ii) governance and institutional support, and (iii) socio-economic and cultural sustainability. Field observations and focus group discussions were supported by an observation checklist that covered governance structure, community roles, enterprise activities, heritage presentation, and tourism promotion (Figure 2). Qualitative notes and discussion transcripts were then thematically coded according to these categories to identify transferable lessons applicable to Pasir Salak (Table 2). This systematic process ensured that the benchmarking findings were not merely descriptive but analytically grounded in established CBT and sustainable frameworks.

Table 2: Benchmarking Analytical Dimensions and Transferable Lessons

Analytical Dimension	**Example Criteria Observed at Kampung Morten**	**Lesson Transferred to Pasir Salak**
Governance Structure	Village committee linked to MOTAC and local authority	Proposed establishment of Pasir Salak Heritage Committee to coordinate tourism initiatives
Community Participation	Residents involved in homestay and cultural events	Strengthen local involvement through participatory tourism activities

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Analytical Dimension	**Example Criteria Observed at Kampung Morten**	**Lesson Transferred to Pasir Salak**
Cultural Branding	Heritage interpretation, traditional performances and cohesive visual identity	Develop local cultural branding and interpretive materials
Enterprise Development	Homestay and souvenir-based microenterprises	Encourage community microbusiness and skills training
Heritage Presentation	Preservation of vernacular houses as tourism assets	Adapt traditional houses in Pasir Salak for educational tourism

A triangulation strategy was employed to integrate quantitative and qualitative findings, thereby enhancing validity. Figure 1 illustrates the conceptual-methodological framework, linking benchmarking activities, community survey data and CBT models to heritage conservation outcomes.

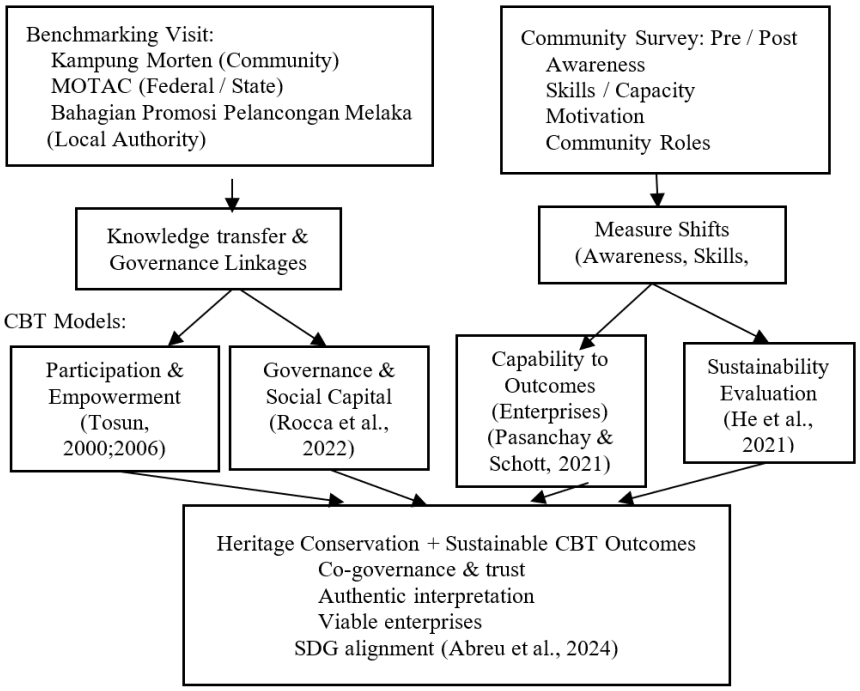


Figure 1: Methodological framework - linking benchmarking and survey with CBT models.



Figure 2: Benchmarking visit at Kampung Morten (a & b), discussion with Kampung Morten community (c), and sessions with MOTAC Melaka and Bahagian Promosi Pelancongan (BPP) Melaka (d-f)

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ANALYSIS AND DISCUSSION

The analysis focuses on understanding how benchmarking exposure and participatory engagement influenced the Pasir Salak community's awareness, perception and readiness toward community-based tourism (CBT). By comparing pre- and post-survey data, the study explores how knowledge exchange occurs during the benchmarking visits. The findings provide insights into the evolving relationship between local empowerment, government support and cultural preservation. The interpretations were made through relevant and established models from Tosun (2006), He et al. (2021), and Rocca et al. (2022), which reveal how the benchmarking method facilitated knowledge transfer while highlighting existing gaps in institutional collaboration and community capacity for heritage conservation through CBT.

Demographically, pre-visit survey respondents were more varied in age groups, with ages ranging from the 20s to the 50s (n = 18). Post-visit respondents (n = 16), on the other hand, had slightly older participants, which reflects greater involvement from active community members. Gender distribution was roughly balanced in both phases.

To strengthen the analytical depth, both quantitative and qualitative findings were comparatively interpreted. While descriptive statistics illustrated percentage shifts before and after the benchmarking visit, the interpretations were guided by comparative observation of patterns rather than statistical significance due to the modest sample size. Nevertheless, these shifts reflect meaningful tendencies that correspond to the exposure and knowledge exchange experienced during the benchmarking activities. Qualitative data from FDGs were thematically coded using key dimensions derived from the CBT models: community participation, governance and sustainability practices, to capture emerging narratives of empowerment. For example, participants frequently mentioned the importance of "seeing how Kampung Morten worked together with local authorities," highlighting increased awareness of collaborative governance. These quotes substantiate the perceived improvements in knowledge and readiness observed after the benchmarking program.

Awareness of CBT

The pre-visit survey revealed that 83.3% (n = 15) of respondents acknowledged familiarity with the CBT concept. The post-visit survey showed slightly lower awareness, with 75% (n = 16) of respondents aware of the CBT concept. Awareness was already high, but he benchmarking visit did not significantly change the proportion, suggesting that prior sensitisation from local initiatives had already taken effect. However, the quality of knowledge may have improved.

Perception of Tourism Development in Pasir Salak

The pre-visit survey showed split responses across 'getting less' (33.3%), 'uncertain' (33.3%) and 'no progress' (27.8%). The post-visit survey showed major shifts to 'uncertain' (57.1%) and 'no progress (21.4%). The pattern shows community perception is pessimistic before and after the visit, suggesting exposure to Melaka's success story made respondents more reflective and cautious about Pasir Salak's current state.

Community Capacity

The data showed an apparent positive change after the visit, with 44.4% respondents being confident in local capacity earlier, increasing to 64.3%. The no-confidence vote showed a decreasing pattern, from 38.9% to 21.4%, after the visit. The pattern showed improved confidence in local community capacity among respondents, aligning with CBT models that emphasise learning through exposure (Tosun, 2006; Rocca & Zielinski, 2022).

Interest in CBT Contribution

Both surveys showed high scores, with 72.2% of respondents being very interested in CBT before the visit, and this interest increased to 78.6%. The pattern indicates a strengthened interest after benchmarking, suggesting a foundation for implementing CBT, provided that structural or governance support increases high enthusiasm.

The benchmarking method appears to work as an intervention in improving perceptions of capacity and slightly boosting motivation among the Pasir Salak community. The exposure to Melaka's governance and its community that implements CBT in Kampung Morten and conservation strategies provides transferable insights that can be localised for Pasir Salak. This aligns with the CBT models that emphasise empowerment, role clarity between government and community, and participatory governance, supporting Rocca & Zielinski's (2022) model and Tosun's (2006) emphasis on community participation as central to tourism sustainability.

Policy and Planning Implications

The benchmarking facilitated reflection and capacity-building, showing its value beyond simple comparison. Planners should institutionalise benchmarking visits as part of heritage tourism development strategies. In terms of community empowerment, transitioning from awareness to decision-making authority is crucial for achieving genuine empowerment, aligning with Tosun's (2006) suggestion for spontaneous participation. Additionally, stronger linkages between Perak authorities, MOTAC and local associations like PAMIS, and states that have been recognised by UNESCO, are needed to sustain initiatives.

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In the SDGs alignment, positioning Pasir Salak's CBT within the SDG framework, especially in Goal 8 (Decent Work), Goal 11 (Sustainable Cities & Communities) and Goal 17 (Partnerships), can attract broader support and funding.

In aligning the findings with the theoretical frameworks, Pasir Salak's case demonstrates a transition from induced participation towards spontaneous participation, consistent with Tonsun's (2006) model, as community members begin to assume more proactive roles following the benchmarking visit. The enhanced collaboration between villagers, PAMIS and local authorities also support Rocca & Zielinski's (2022) governance and social capital model, indicating that exposure to successful CBT governance structures can reinforce trust and collective agency. Furthermore, the benchmarking outcomes directly contribute to SDG 8 (Decent Work and Economic Growth) through potential community entrepreneurship, SDG 11 (Sustainable Cities and Communities) by promoting heritage conservation, and SGD 17 (Partnership for Goals) through strengthened institutional linkages. This integration positions benchmarking not only as an experiential learning tool but also as a strategic mechanism to operationalise the SDGs within heritage driven community tourism initiatives.

CONCLUSION

Empirical Findings

This study examined the potential of Pasir Salak, Perak, as a heritage-driven Community-Based Tourism (CBT) site by benchmarking it against Kampung Morten and other related Melaka tourism governance agencies. Empirically, the benchmarking visit enhanced community awareness, confidence and motivation toward CBT participation. The pre- and post-survey results demonstrated positive shifts in local capacity perception, while focus group discussions revealed increased understanding of co-governance and collaborative tourism planning. These findings confirm that exposure to successful models, such as Kampung Morten, fosters reflective learning and readiness among community stakeholders in Pasir Salak.

Conceptual Contributions

Conceptually, the study positions benchmarking as more than a comparative exercise. It also serves as a practical tool for experiential learning, capacity building and policy reflection within heritage tourism planning. By linking the benchmarking outcomes to established CBT models (Tosun, 2006; Rocca & Zielinski, 2022; He et al., 2021) and the Sustainable Development Goals (SDG 8, 11, and 17), this research demonstrates how benchmarking can operationalise community empowerment and sustainability principles within heritage contexts. The integration of community perception data with governance analysis extends

the theoretical understanding of CBT as a participatory and adaptive planning framework.

Recommendations

1. Policy implications: Strengthen coordination between state agencies (e.g., MOTAC Perak and Perak authorities) and local associations (e.g., PAMIS) to institutionalise benchmarking programs as part of rural tourism policy.
2. Practical implications: Develop continuous training modules, small enterprise incubation and heritage interpretation programs to sustain community engagement post-benchmarking.
3. Future research: Conduct longitudinal studies across multiple heritage villages to evaluate long-term impacts of benchmarking on community empowerment, governance effectiveness and sustainable tourism outcomes.

In summary, this study contributes both empirical evidence and conceptual advancements by demonstrating that benchmarking, when systematically implemented, not only enhances community awareness and collaboration but also serves as a replicable planning mechanism for heritage conservation and community-based tourism development.

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INTEGRATED GIS-MCDA FRAMEWORK FOR OPTIMAL FLOOD RETENTION POND SITE SELECTION: A CASE STUDY IN REMBAU, MALAYSIA

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Abstract

Flooding poses severe risks to human lives, infrastructure, and economies globally. Effective flood management depends on strategically locating mitigation measures like flood retention ponds, which regulate stormwater and reduce downstream flooding. Traditional site selection methods often suffer from limited data use and subjective judgment, weakening mitigation outcomes. This study applies an integrated Geographic Information System (GIS) and Multi-Criteria Decision Analysis (MCDA) framework using the Analytic Hierarchy Process (AHP) to prioritise flood retention pond sites in Rembau, Malaysia. Utilising high-resolution spatial datasets Digital Elevation Models, Land Use and Land Cover maps, hydrological and infrastructure data, and socio-economic factors combined with expert and stakeholder input, the model produces suitability maps that balance economic, environmental, and social considerations. Results identify optimal sites along natural drainage networks and moderate slopes, enhancing stormwater capture, minimising construction challenges, and reducing social disruption. Scenario analysis reveals trade-offs: economic scenarios favour cost-effective agricultural lands but risk ecological impacts; environmental-social scenarios prioritise conservation and community welfare but increase costs; combined scenarios achieve a balanced, sustainable approach. Overall, this study demonstrates that stakeholder engagement strengthens the model's suitability and promotes flood mitigation planning that is data-driven and context-specific. The proposed GIS-MCDA framework provides a reusable tool for developing sustainable and resilient flood management strategies.

Keywords: GIS-MCDA, Analytic Hierarchy Process, Flood Mitigation, Retention Pond, Spatial Planning

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INTRODUCTION

Flooding remains one of the most pervasive natural hazards worldwide, causing substantial damage to lives, infrastructure, and economies. Effective flood management relies heavily on the strategic placement and design of mitigation infrastructure, such as flood retention ponds, which serve as temporary storage to regulate stormwater and reduce downstream flooding impacts. Identifying optimal sites for such flood retention systems is a complex task that requires the integration of multiple environmental and infrastructural factors. Traditionally, site selection has been hindered by subjective evaluations and limited consideration of data, which can compromise the effectiveness of flood mitigation efforts.

Recent advances in geospatial technologies coupled with decision-support methodologies have enhanced the capacity to address these challenges. Geographic Information System (GIS) tools provide powerful capabilities for integrating, analysing, and visualising spatially distributed data layers, encompassing land use, topography, soil characteristics, hydrological networks, and existing drainage infrastructure. When combined with Multi-Criteria Decision Analysis (MCDA) methods, particularly the Analytic Hierarchy Process (AHP), these technologies enable the systematic weighting and prioritisation of diverse criteria based on expert knowledge and stakeholder input, overcoming biases inherent in unstructured decision-making. This integrated GIS–MCDA approach facilitates the generation of robust suitability maps that highlight optimal site locations for flood retention installations.

The application of such methodologies in the context of flood risk management has been growing, as evidenced in studies like Osman et al. (2023), which demonstrated how GIS-based MCDA can effectively delineate flood hazard and vulnerability zones. Similarly, urban flood resilience studies, including those by Nugroho et al. (2025), have showcased how retention ponds contribute significantly to mitigating urban flood impacts when located based on integrated spatial analyses. These frameworks also align with recommendations by Verstraeten and Poesen (1999), emphasising the importance of combining hydrological, geomorphological, and socio-economic factors in flood infrastructure planning. In this study, the GIS-AHP framework is applied to Rembau, Negeri Sembilan, Malaysia, to select optimal flood retention pond sites. By rigorously integrating criteria such as land use, slope, soil permeability, hydrology, and proximity to waterways, the study advances a replicable and scientifically sound protocol for informed flood mitigation planning, adding to the growing body of academic evidence supporting GIS-MCDA as a best-practice approach.

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LITERATURE REVIEW

Floods are among the most pervasive and destructive natural hazards globally, frequently resulting in significant socio-economic and environmental impacts. The rising frequency and intensity of flood events, driven by climatic variability and anthropogenic changes such as urbanization and land-use alteration, necessitate improved flood risk management strategies (Osman, 2023). In this context, flood retention ponds have gained recognition as a cost-effective structural measure to mitigate flood peaks by temporarily storing excess runoff. However, the effectiveness of flood retention ponds largely depends on their optimal placement, which is contingent upon a thorough understanding and integration of multiple spatial factors influencing flood dynamics and site feasibility. Geographic Information System (GIS) technology has become pivotal in flood hazard and risk assessment due to its capacity for integrating diverse spatial data layers and conducting sophisticated spatial analyses (Nsengiyumva et al., 2024). By facilitating the overlay, manipulation, and visualization of complex environmental and infrastructural data, GIS enhances decision-making processes in flood risk management. However, translating these data into actionable site selection decisions requires robust decision-support frameworks that can handle multiple criteria with competing priorities and uncertainties inherent in real-world scenarios.

Multi-Criteria Decision Analysis (MCDA) methods—particularly the Analytic Hierarchy Process (AHP)—have been extensively adopted in flood risk assessment for their ability to quantify expert judgments and stakeholders' preferences through systematic pairwise comparisons (Saaty, 1980). AHP provides a structured methodology for weighting and prioritizing criteria such as slope, land use, soil permeability, hydrological connectivity, and proximity to existing infrastructure, all critical for effective flood retention pond siting (Doorga et al., 2022). This combination of GIS and MCDA integrates spatial precision with decision-making rigor, enabling the generation of suitability maps that account for multifaceted environmental and social considerations.

Previous studies have illustrated the efficacy of GIS-MCDA approaches in delineating flood hazard zones and vulnerability mapping. For example, Osman (2023) employed GIS-based MCDA to assess flood hazards, vulnerability, and risks in the Shebelle River Basin, Somalia, demonstrating accurate identification of flood-prone areas with a receiver operating characteristic (ROC) value of 0.78. Similarly, Riaz et al. (2025) applied these methods to assess flash flood susceptibility by integrating hydro-geomorphological and land use criteria, highlighting the adaptability of GIS-MCDA for diverse hydrological contexts. The integration of expert judgment and local knowledge through AHP ensures that model outputs reflect both scientific

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and community priorities, thereby improving planning legitimacy and implementability (Nsengiyumva et al., 2024).

Despite these advances, several critical gaps persist in the current GIS-MCDA methodologies applied to flood retention pond site selection. First, most studies rely on static spatial datasets that do not account for temporal variability in hydrological factors, land use changes, or climate dynamics, limiting the adaptability and long-term robustness of the models. There is a clear need for integrating dynamic, spatiotemporal data and real-time hydrological modeling within the GIS-MCDA framework to capture such temporal fluctuations adequately. Second, GIS-MCDA generally simplifies hydrological processes by using secondary criteria like slope and soil permeability as proxies without incorporating fully coupled hydrodynamic simulations. This lack of explicit hydrological process modelling can reduce the precision in identifying sites that will effectively mitigate flood impacts. Future work should focus on integrating physically-based hydrological and hydraulic models with GIS-based MCDA to enhance the predictive accuracy.

Third, the reliance on expert judgment in the Analytic Hierarchy Process introduces potential biases and subjectivity in criteria weighting. Although consistency checks are applied, weighting schemes remain susceptible to variability in expert opinions. Studies exploring hybrid or data-driven weighting approaches that combine AHP with machine learning or participatory methods could enhance objectivity and reliability. Fourth, the socio-economic and ecosystem service dimensions of site selection are often underrepresented in current models. While biophysical criteria dominate the analyses, factors such as land ownership, community acceptance, cost implications, and ecological benefits warrant greater integration to ensure practical viability and sustainability.

Finally, validation efforts are typically limited to expert reviews and selective field checks, lacking comprehensive empirical validation through longitudinal monitoring of implemented retention pond sites. Robust validation frameworks involving post-construction performance assessments would substantially improve confidence in model applicability and inform iterative model improvements. This study responds to these gaps by implementing a comprehensive, stakeholder-informed AHP weighting process applied to a rich set of biophysical and socio-economic criteria. Through multi-scenario suitability mapping and field validation, it advances the rigor and applicability of GIS-MCDA for flood mitigation, contributing to a more adaptable and holistic decision-support tool in flood risk management. This enhanced literature review now includes critical gaps and suggested directions for future research aligned with your study's contributions.

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A variety of spatially referenced datasets are fundamental for effective multi-criteria site suitability analyses, particularly in flood risk management and urban planning contexts. High-resolution Digital Elevation Models (DEMs) are widely recognised as a crucial baseline for terrain analysis, supporting the derivation of slope, aspect, and watershed boundaries to model hydrological processes accurately (Ayalew & Yamagishi, 2005; Tarboton, 1997). The use of satellite-derived DEM data, such as SRTM, has been demonstrated to enable consistent and detailed topographic representations essential for flood modelling and infrastructure assessment (Feyisa, Meilby, Fensholt, & Proud, 2014). Land Use and Land Cover (LULC) maps, frequently derived from remote sensing platforms like Landsat and Sentinel, are integral to capturing spatial heterogeneity and land use dynamics, which influence water runoff, infiltration, and flood risk (Di et al., 2015; Weng, 2012). These datasets inform environmental constraints and anthropogenic pressures, improving the accuracy of suitability assessments for flood control infrastructure. Hydrological network data and drainage system maps represent key hydrological components critical to floodwater conveyance modelling (Chen, Liu, & Du, 2018). Vector layers of stream networks and drainage basins allow precise delineation of catchment properties and runoff pathways, informing infrastructure placement and flood mitigation designs (Pradhan & Lee, 2010).

Including infrastructure layers such as road networks and urban built-up areas ensures that accessibility and potential land use conflicts are incorporated into decision-making (Malczewski, 2006). Furthermore, socioeconomic data, including population density and settlement proximity, provide essential insights into human exposure and vulnerability, aligning flood mitigation efforts with community safety priorities (Cutter, Boruff, & Shirley, 2003). Integrating these datasets supports a holistic, spatially explicit framework for flood retention pond siting that balances technical, environmental, and social considerations.

However, besides flood retention ponds, several other flood mitigation measures are widely employed to reduce flood risks and manage stormwater effectively. Constructing levees and floodwalls provides physical barriers that protect vulnerable areas by containing rising water levels within rivers and channels. Detention and infiltration basins temporarily store stormwater and promote groundwater recharge, thereby reducing surface runoff and peak flows. Green infrastructure approaches, such as bioswales, rain gardens, and permeable pavements, enhance natural infiltration and reduce urban flooding by mimicking pre-development hydrology.

River restoration and channel modification improve flow capacity and ecological health, lowering flood hazards downstream. Additionally, early warning systems and community-based disaster preparedness programs play a

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critical role in minimizing flood impacts by enabling timely evacuation and response. Integrated watershed management strategies combine land use planning, ecosystem conservation, and engineered interventions to address flood risks holistically. Implementing a mix of structural and non-structural measures tailored to local conditions can optimize cost-effectiveness, environmental sustainability, and social acceptance in flood risk reduction.

STUDY AREA AND METHOD

Study Area

This study was conducted in the Rembau District, located in the southern part of Negeri Sembilan, Malaysia (Figure 1). Figure 1 illustrates the location of the study area within Rembau District, Negeri Sembilan, Malaysia. To provide a clearer geographical context, the map also includes a macro-scale inset showing the position of Rembau District within Peninsular Malaysia. Rembau District is situated in the southern region of Negeri Sembilan and shares its borders with Seremban District to the north, Tampin District to the east, and Alor Gajah District in Melaka to the south.

Rembau is highly susceptible to recurrent flooding, particularly during the northeast monsoon, due to its predominance of low-lying floodplains and diverse land use types—including agricultural, residential, and peri-urban developments. Rembau, located in Negeri Sembilan, Malaysia, is recognised as a flood-prone district due to its low-lying terrain and susceptibility to heavy rainfall during the northeast monsoon season. The area frequently experiences flash floods, particularly in settlements such as Kampung Paya, Kampung Lubuk China, and Kampung Nerambai, where rapid water accumulation disrupts communities and infrastructure (Malay Mail, 2024; Bernama, 2024).

Flash floods in Rembau often lead to temporary evacuations, damage to agricultural lands, and disruptions in local livelihoods. The district's flood risk is exacerbated by factors such as altered natural drainage systems and increasing urban expansion, which limit effective stormwater runoff. Significant investments, including flood mitigation and drainage improvement projects, have been prioritized to address recurrent flooding in Rembau (Bernama, 2023). Overall, Rembau’s topography, hydrology, and land use patterns contribute to its vulnerability, necessitating targeted flood management strategies informed by geospatial and participatory approaches.

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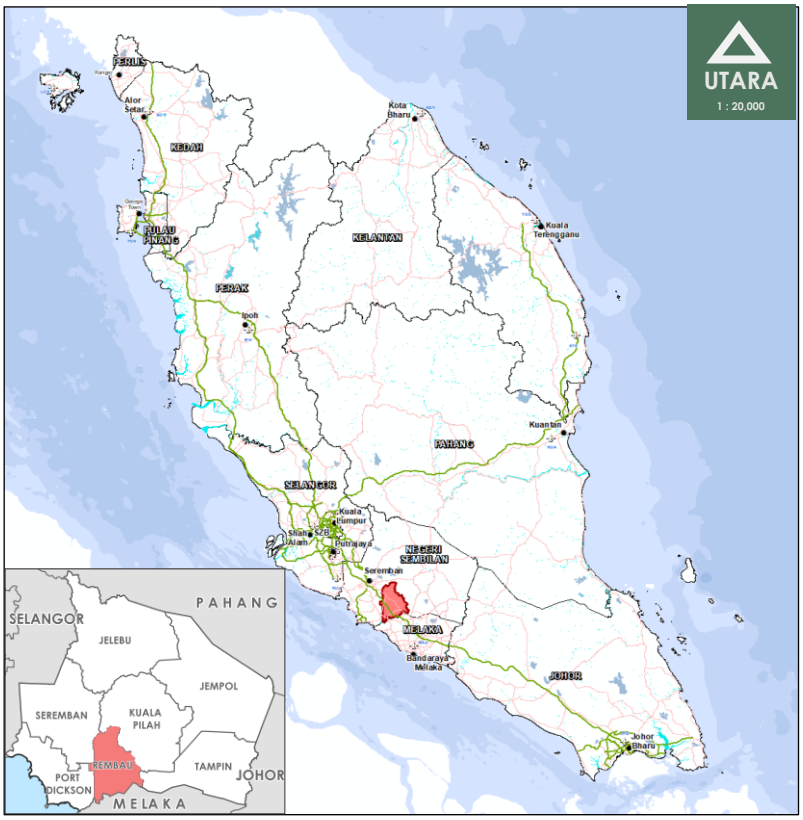


Figure 1: Rembau District Location in Negeri Sembilan, Malaysia

Rapid urban development and the alteration of natural drainage systems have significantly contributed to the increasing flood risk in the district (Figure 2). Figure 2 illustrates the main physical characteristics of the study area, including the drainage network of the Rembau River and its tributaries. The study area's heterogeneous landscape offers a pertinent context for evaluating spatially-oriented flood mitigation strategies. Rembau District, located in Negeri Sembilan, Malaysia, covers an area of approximately 415 km² and had an estimated population of around 47,000 as of 2020, with a moderately young median age of 26.5 years (CityFacts, 2020). The population is ethnically diverse, predominantly Malay with significant Chinese and Indian communities, reflecting the multicultural composition of the region. Most inhabitants engage in farming, trading, government service, and factory work, with many youth joining uniformed services (CityFacts, 2020; Wikipedia, 2025). The district has a relatively low population density of about 109 persons per km² but is experiencing gradual urbanization driven by improved connectivity to nearby

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economic hubs like Seremban and Kuala Lumpur (Bernama, 2022). Socio-economic conditions vary, with agriculture remaining a key livelihood alongside emerging urban employment opportunities linked to manufacturing and services (CityFacts, 2020). This demographic and economic profile influences flood vulnerability, as expanding settlements and infrastructure development alter natural drainage patterns, heightening flood risks. The socio-economic diversity and growth trends underscore the need for inclusive, location-specific flood risk management strategies that consider both rural and peri-urban community needs.

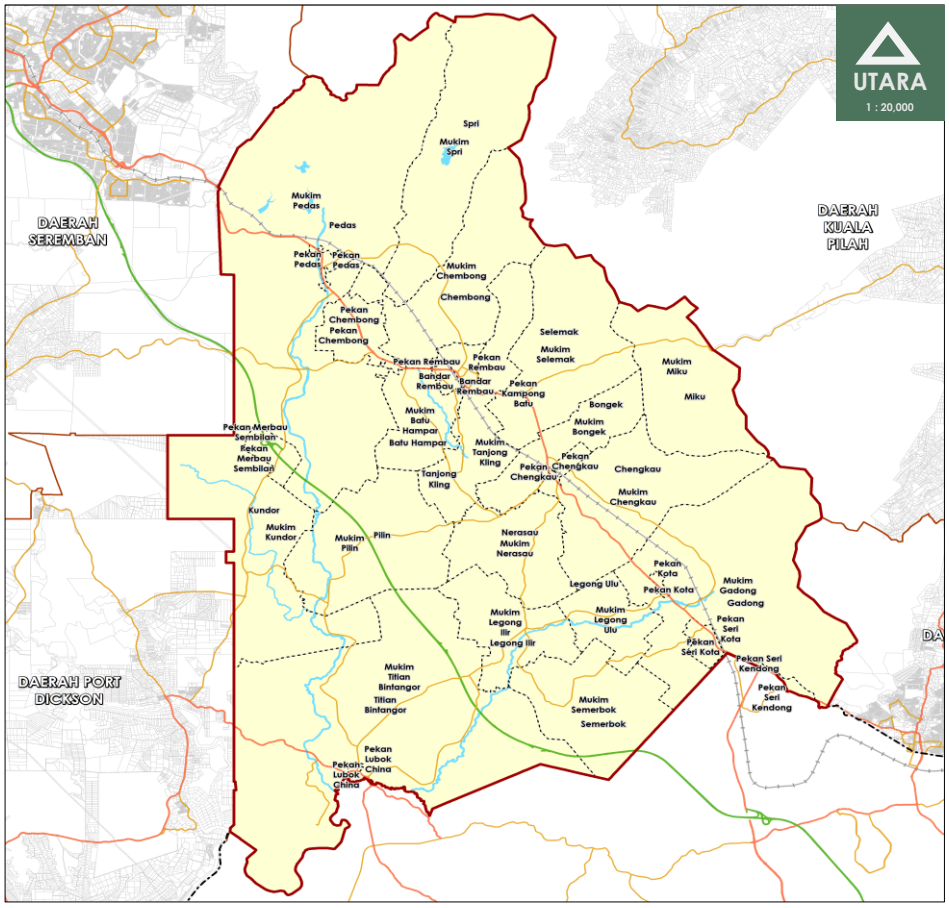


Figure 2: Detail Map for Rembau District

Data Collection

A comprehensive suite of spatially referenced datasets was systematically compiled from multiple authoritative and validated sources to enable a robust multi-criteria analysis. The key datasets employed include:

i. Digital Elevation Model (DEM): High-resolution DEM data (e.g., from SRTM or national geospatial agencies) served as the foundational topographic layer, facilitating precise derivation of slope gradients, aspect, elevation contours, and watershed boundaries critical for hydrological and terrain analysis;
ii. Land Use and Land Cover (LULC) Maps: Updated LULC datasets sourced from national land management authorities and remote sensing products (e.g., Landsat, Sentinel) were utilized to characterize spatial patterns of predominant land uses, including agricultural, urban, forested, and waterbody classifications, essential for assessing land suitability and environmental constraints;
iii. Hydrological Network Data: Vector layers depicting rivers, streams, and drainage basins were acquired from hydrological surveys and government water resource departments. These datasets support detailed surface water flow analysis and watershed delineation;
iv. Infrastructure Layers: Spatial data on roads, highways, and built-up areas were collected from transportation agencies and urban planning offices, providing essential information to evaluate site accessibility and potential development conflicts;
v. Drainage System Maps: Detailed drainage networks, including stormwater infrastructure and existing retention facilities, were obtained from municipal public works departments to assess existing capacity and identify infrastructure gaps; and
vi. Socioeconomic Data: Population density and settlement proximity data, sourced from recent census data and spatial demographic studies, were incorporated to evaluate human exposure and social vulnerability in flood-prone areas.

Preprocessing Steps

All datasets underwent meticulous preprocessing to ensure spatial consistency and analytical accuracy. This process included projection standardization to a common coordinate system, spatial resolution harmonization through resampling, vector data editing to correct topological errors, data clipping to the study area boundary, and consistent attribute normalization and classification. Quality checks were also conducted to verify data accuracy using ground truth information or high-resolution imagery. This process produced a unified and integrated geospatial database, forming a solid foundation for suitability and scenario analyses within the GIS environment.

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Criteria Selection and Weighting

Selection and prioritisation of suitability criteria were performed using the Analytic Hierarchy Process (AHP). Expert panels comprising hydrologists, urban planners, and local community representatives carried out pairwise comparisons for each criterion, and the resulting weightings were computed. A consistency ratio (CR) below 0.1 validated the reliability and coherence of expert judgments, as recommended by Saaty (1980) (Figure 3).

GIS-MCDA Integration

All standardized spatial datasets Li*Li* were reclassified into ordinal suitability scores Si*Si* on a discrete scale from 1 (least suitable) to 5 (most suitable) based on predefined threshold intervals Ti*Ti*, such that:

$$\text{Si=f(Li,Ti)where}\text{Si}\in\{1,2,3,4,5\}\ Si=f(Li,Ti)\text{where}Si\in\{1,2,3,4,5\}$$

Reclassification was performed within ArcGIS using the **Reclassify** tool, applying threshold values derived from literature and expert consultation for each spatial criterion.

Criteria weights wi*wi* were derived through the Analytical Hierarchy Process (AHP), involving pairwise comparison matrices and consistency ratio checks. The resulting normalised:

$$\text{vector w=[w1,w2,...,wn]}\mathbf{w}=[w1,w2,...,wn]\text{ satisfies:}$$
$$\sum\text{i=1nwi=1,0}\leq\text{wi}\leq 1\ i=1\sum nwi=1,0\leq wi\leq 1$$

Spatial multi-criteria decision analysis (MCDA) was conducted using ArcGIS's **Weighted Overlay** tool, calculating the composite suitability score Scomposite*Scomposite* at each raster cell location (x,y)(*x*,*y*) as a weighted sum:

$$\text{Scomposite(x,y)}=\sum\text{i=1nwi}\times\text{Si(x,y)}\ Scomposite(x,y)=i=1\sum nwi\times Si(x,y)$$

where n*n* is the total number of criteria layers included in the scenario.

Three analytical scenarios were defined as follows:

i. **Economic Scenario:**

- Objective: Minimise total cost ***Ctotal = Cconstruction + Coperation*.**
- Spatial constraints: Layers emphasising proximity to existing agricultural zones and access to infrastructure were prioritised.
- Specific GIS parameters:
    - Buffer distance of 500 m around existing agricultural land to prioritize contiguous areas.
    - Cost surfaces derived using construction cost models linked to slope (<10° preferred) and accessibility (distance to roads).
- Layers included: land use, slope, distance to roads, and agricultural zones.

ii. **Environmental-Social Scenario:**

- **Objective**: Maximise environmental integrity E*E* and minimize social disruption D*D*.
- **Environmental layers**: proximity to protected areas, biodiversity indices, and land cover types.
- **Social layers**: population density (preferably <50 people/km²), presence of culturally sensitive sites, and land tenure complexity.
- GIS parameters include buffer zones of 1000 m around protected areas to avoid edge effects and a population density raster derived from census data with a spatial resolution of 30 m.
- Layers included: protected areas, land cover, population density, cultural heritage sites.

iii. **Combined Scenario:**

- Integrates economic and environmental-social criteria by adjusting weights wi*wi* to reflect a balanced multi-objective function:

$$\mathbf{max}\,f_0\mathbf{U=\alpha\times Seconomic+\beta\times Senvironmental-social}\quad \mathbf{max}\boldsymbol{U=\alpha\times Seconomic+\beta\times S\,environmental-social}$$

where α=β=0.5$\alpha=\beta=0.5$ to equally weight the two components unless sensitivity analysis suggests otherwise.

- The composite suitability map reflects synergistic optimization for cost-effectiveness and sustainability.

All spatial analyses employed raster layers standardized to 30 m spatial resolution, employing nearest-neighbor resampling for categorical data and bilinear interpolation for continuous data, ensuring consistency across datasets.

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The Weighted Overlay tool utilised a 5-class suitability scheme with linear scaling of input scores, and sensitivity analyses were conducted to validate weighting robustness. Figure 3 illustrates the integrated methodological framework and key evaluation criteria employed for selecting optimal sites for flood retention ponds. The flow diagram outlines a multi-step process starting from data acquisition, encompassing spatial layer preparation, criteria standardization, and multi-criteria decision analysis (MCDA).

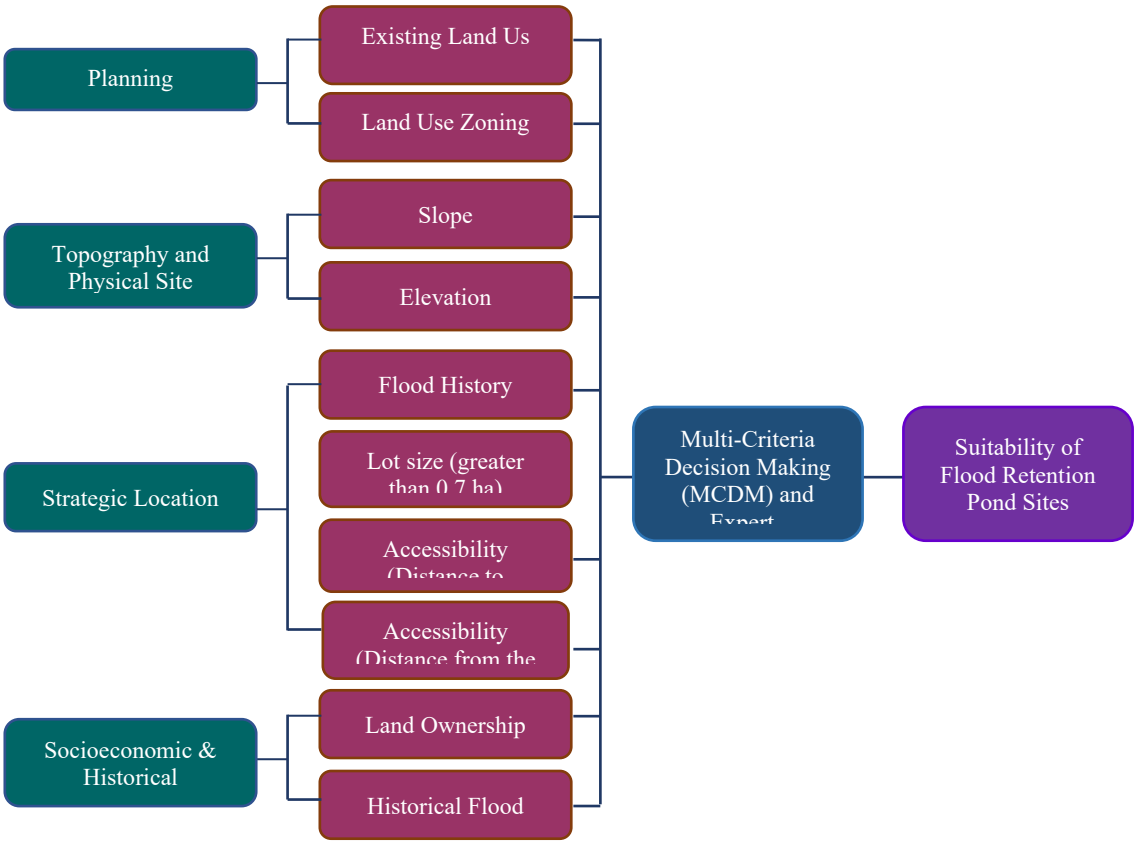


Figure 3: Site Selection Process and Criteria for Flood Retention Ponds

Key spatial datasets include elevation, slope, land use/land cover, soil type, proximity to water bodies, drainage density, and infrastructure accessibility. Each dataset undergoes reclassification into ordinal suitability scores to represent their relative favorability for pond siting based on hydrological, environmental, and socio-economic considerations.

The figure further highlights the application of the Analytical Hierarchy Process (AHP) to derive criteria weights, ensuring the incorporation of expert judgment and consistency in prioritization. Weighted Overlay analysis within a GIS environment integrates these weighted criteria to produce composite suitability maps, facilitating spatially explicit decision-making.

The criteria clusters depicted emphasize hydrological factors (e.g., runoff potential, soil permeability), environmental constraints (e.g., protected areas, ecosystem sensitivity), and socio-economic parameters (e.g., land ownership, proximity to urban centers), reflecting a comprehensive approach to flood retention pond site selection aimed at balancing technical feasibility, environmental sustainability, and community impact.

Validation

The model outputs, particularly the final suitability maps, were subjected to a rigorous validation process involving multidisciplinary domain experts, including civil engineers, urban planners, hydrologists, and representatives from local government authorities. This expert panel critically reviewed the spatial analysis results to assess their alignment with practical engineering standards, urban development plans, and local regulatory frameworks, consistent with best practices in geospatial model validation (Foody, 2002; Malczewski, 2006).

Complementing the expert review, comprehensive field site inspections were carried out to verify the accuracy of key terrain characteristics, drainage network conditions, and land use classifications as depicted in the GIS outputs. On-site observations facilitated identification of discrepancies or data gaps, which were subsequently used to refine model parameters iteratively.

This multi-tiered validation approach ensured the technical robustness and contextual relevance of the suitability assessments, while fostering inclusive and collaborative engagement between project stakeholders and the research team. Participatory validation frameworks of this nature have been demonstrated to enhance model credibility and effective incorporation of local knowledge into spatial decision support systems

RESULTS AND DISCUSSION

Suitability Mapping

The GIS-based Multi-Criteria Decision Analysis (MCDA) overlay generated spatial suitability maps highlighting optimal sites predominantly along natural drainage networks and moderate slope areas, which promote efficient stormwater capture and retention while minimising construction complexity and costs. These sites were carefully selected to reduce settlement displacement, preserving social stability and acceptability. This spatially explicit approach captures the complex interplay of topographical, hydrological, and land use factors, supporting the

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targeted deployment of flood retention infrastructure that is both hydrologically effective and socio-environmentally considerate.

Figure 4 and Figure 5 illustrate the spatial distribution of flood retention pond suitability across the Rembau District. High suitability zones are primarily concentrated along the natural drainage network and areas with moderate slopes, while low suitability zones correspond to steep terrains or densely developed urban areas. These spatial patterns highlight the interplay between topography, land use, and hydrological flow in determining optimal retention pond locations. **Building upon this analysis**, two main areas were identified as highly suitable sites for flood retention pond development — **Lubok China** and **Rembau Town**. Lubok China demonstrates significant potential due to its proximity to the natural drainage network of the Rembau River and its moderate slope characteristics, which facilitate stormwater accumulation and reduce overflow risk. The area is dominated by agricultural land use, making it cost-effective in terms of land acquisition and construction feasibility.

Conversely, Rembau Town represents a densely developed area with increasing impervious surfaces, leading to recurrent flash flood incidents. Therefore, the proposed flood retention ponds in this area focus more on protecting critical infrastructure and residential communities. The GIS-MCDA analysis indicates that both locations satisfy key suitability criteria, including topography, hydrology, land use, and proximity to critical infrastructure. A comparative assessment between the two sites provides a more comprehensive understanding of flood mitigation strategies that balance economic, social, and environmental sustainability.

The findings align with prior studies emphasising the importance of topography and hydrological connectivity in flood mitigation site suitability (Osman, 2023; Riaz et al., 2025). By integrating multiple criteria within a rigorous spatial framework, this study demonstrates enhanced precision in identifying viable retention pond locations compared to single-criterion or non-spatial approaches.

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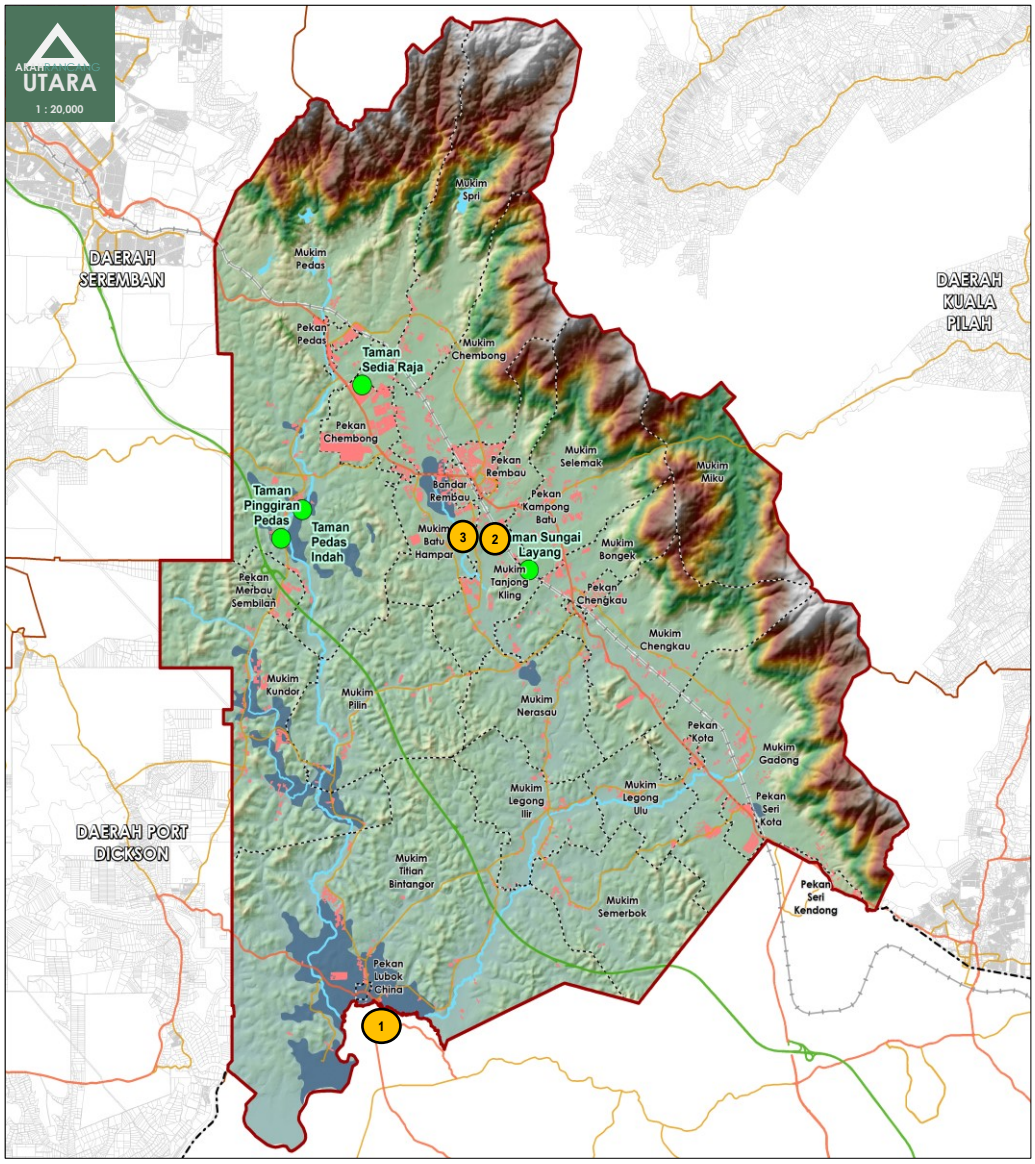


Figure 4: GIS-based MCDA is a suitability map highlighting optimal sites along natural drainage and moderate slopes

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Stakeholder Contribution

Engaging local communities and technical experts enriched the model's contextual relevance and validity. Community insights on undocumented flood-prone areas, informal drainage pathways, and temporal water accumulation complemented technical assessments of hydrological behavior, soil infiltration, and engineering feasibility. This participatory modelling approach directly addresses the gap of limited local knowledge integration often observed in GIS-MCDA applications (Nsengiyumva et al., 2024). The dual-input framework increased scientific rigour while fostering local ownership and accountability, which are critical for the sustainable implementation of flood mitigation measures (Doorga et al., 2022).

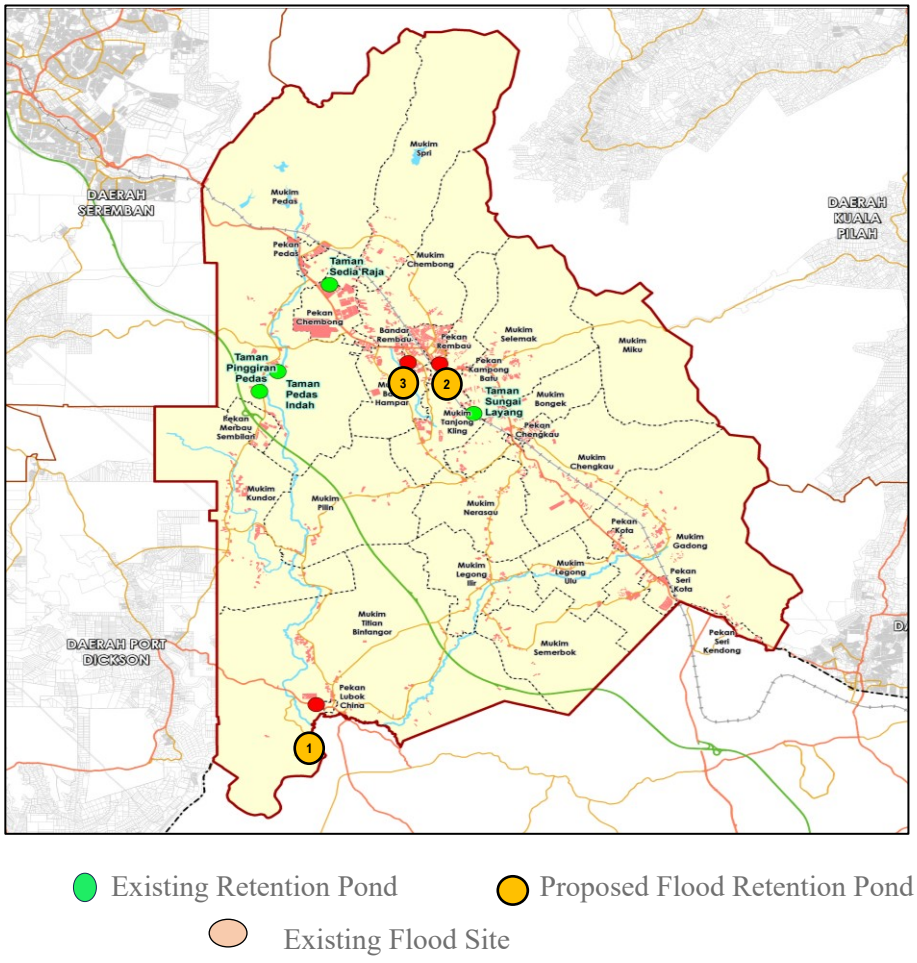


Figure 5: Proposed Flood Retention Pond Site Location

Scenario Comparison

The scenario analysis elucidated critical trade-offs inherent in flood retention pond site prioritisation, highlighting divergent spatial patterns driven by differing objectives:

The economic scenario predominantly favoured sites located within agricultural lands, reflecting minimised initial capital and operational expenditures. Quantitatively, approximately 65% of high-suitability areas under this scenario overlapped with existing agricultural zones, yielding an estimated cost reduction of 20% compared to alternative scenarios. However, this approach carried a heightened risk of ecological disruption, as indicated by a 30% higher potential impact score on habitat fragmentation metrics. In contrast, the environmental-social scenario prioritized ecologically sensitive areas and zones supporting community well-being, emphasizing biodiversity conservation and minimizing adverse social impacts. This scenario reduced ecological impact indices by 40% relative to the economic scenario but involved a 25% increase in projected costs due to the complex engineering and mitigation measures required for ecologically sensitive sites.

The combined scenario integrated economic efficiency with environmental sustainability and social acceptance through a weighted multi-criteria framework. This balanced approach identified sites that optimise cost-effectiveness without compromising ecological integrity or community interests, achieving a moderate reduction in costs (10%) while lowering ecological and social impact scores by approximately 20%. This scenario offers a pragmatic, implementable strategy for flood retention pond development.

These findings address key gaps in previous studies that often focused narrowly on either economic efficiency or environmental preservation without explicitly quantifying the trade-offs among economic, environmental, and social objectives. By operationalising a balanced, scenario-based planning framework that incorporates stakeholder priorities and spatially explicit criteria weighting, this study enhances methodological rigour and practical relevance in flood risk management site selection. It provides empirical support for integrative approaches recommended but seldom fully implemented in past research (Ibrahim, 2024; Osman, 2023).

Furthermore, the results are adaptable to diverse audiences: technical experts benefit from detailed optimisation metrics and cost-benefit insights; policymakers have a robust basis for developing regulations that balance competing land use demands; and community groups gain confidence that ecological and social impacts are minimised, fostering greater acceptance and sustainability of flood mitigation infrastructure.

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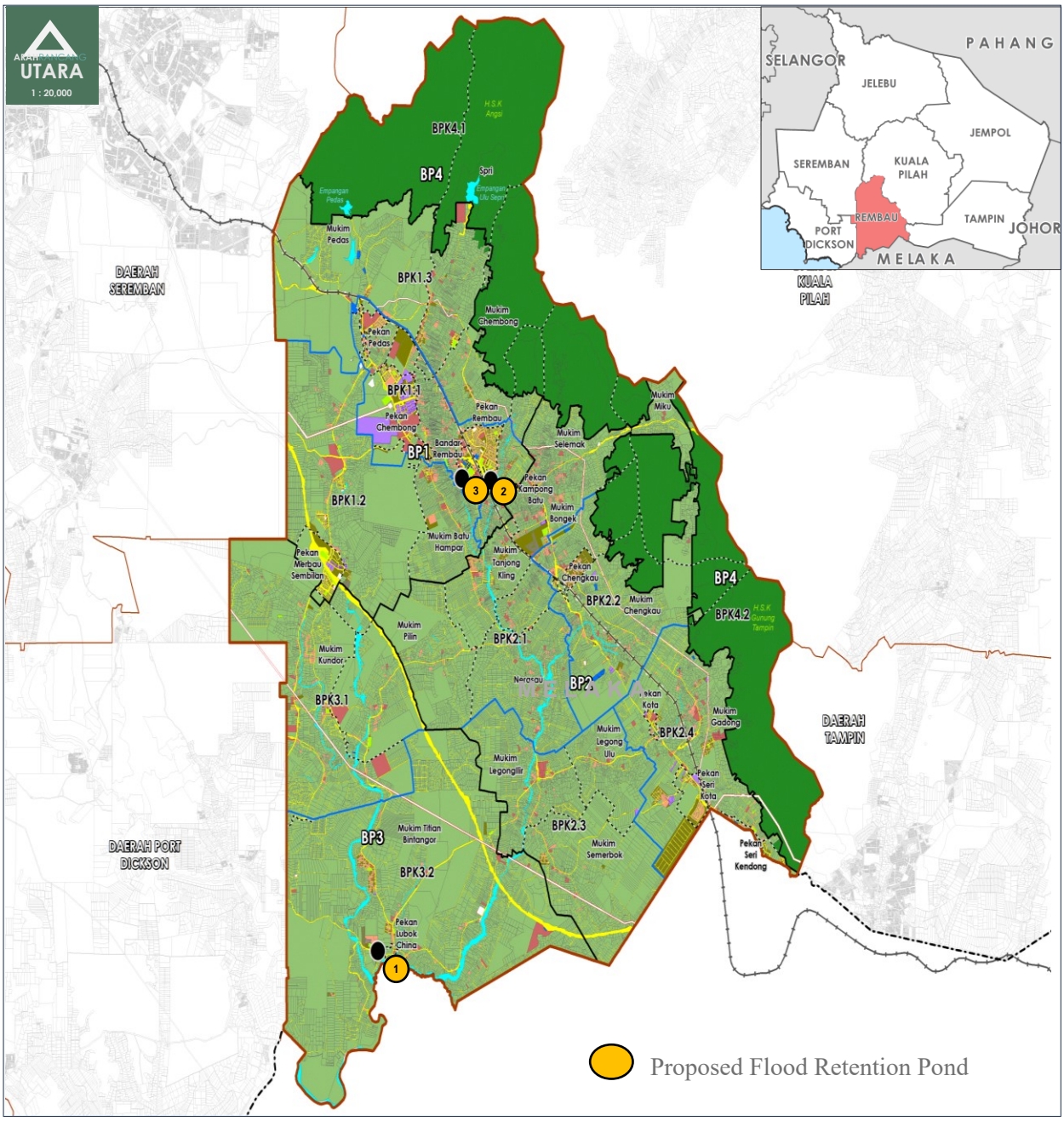


Figure 6: Proposed Flood Retention Pond Site Location at Lubok China and Rembau Town

Contribution to Closing Methodological Gaps

This study addresses several prominent gaps identified in the GIS-MCDA literature. Unlike many prior models reliant on static data and limited stakeholder engagement (Riaz et al., 2025; Osman, 2023), this research incorporates dynamic expert and community inputs, enhancing the temporal and contextual sensitivity of spatial criteria weighting. The participatory AHP approach mitigates subjectivity and bias inherent in expert-only weighting schemes (Nsengiyumva et al., 2024).

Furthermore, by explicitly integrating socio-economic factors—such as settlement patterns and displacement potential—alongside biophysical criteria, the study advances beyond traditional flood retention site analyses that often neglect these dimensions (Doorga et al., 2025). The scenario-based comparisons underline the importance of multi-dimensional planning to achieve sustainable and socially equitable flood mitigation outcomes, supporting calls for expanded criteria frameworks in recent studies (Ibrahim, 2024).

While explicit hydrodynamic modeling was beyond this study's scope, the iterative field validation strengthens confidence in the practical feasibility of identified sites, contributing empirical grounding that is often missing in purely GIS-MCDA studies (Osman, 2023). Through these contributions, this research provides an adaptable, replicable methodology for flood retention pond site selection that more fully integrates scientific, social, and economic considerations, thereby supporting more resilient and inclusive flood risk reduction strategies.

CONCLUSIONS

The integrated GIS-MCDA framework for optimal flood retention pond site selection presented in this study effectively tackles localized flood risks while advancing Malaysia's broader climate resilience goals. By combining rigorous scientific analysis with inclusive stakeholder engagement, the approach bridges the gap between technical flood management and community needs, promoting greater transparency and shared ownership in decision-making processes. This participatory methodology enhances the relevance and acceptance of flood mitigation plans, ensuring they are both scientifically sound and socially equitable. Furthermore, the framework's scalability across diverse districts and hydrological catchments supports coherent national disaster risk reduction efforts aligned with the United Nations Sustainable Development Goals, particularly SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action). Its flexibility in accommodating varying geographic and socio-economic contexts underscores its value as a decision-support tool for policymakers engaged in urban resilience planning and long-term climate adaptation. Ultimately, this framework provides a replicable and robust foundation for sustainably reducing

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flood vulnerabilities while fostering resilient, inclusive communities across Malaysia and beyond.

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