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EXPLORING PEDESTRIAN NETWORK CONNECTIVITY THROUGH SPACE SYNTAX

**Quraishia Abd Rashid¹, Marina Mohd Nor^{2*},
Na'asah Nasrudin³, Nur Aulia Rosni⁴**

¹ *Postgraduate Studies, College of Built Environment,
UNIVERSITI TEKNOLOGI MARA SHAH ALAM*

^{*2,3} *Studies of Town and Regional Planning, College of Built Environment,
UNIVERSITI TEKNOLOGI MARA PUNCAK ALAM*

⁴ *Department of Urban and Regional Planning, Faculty of Built Environment,
UNIVERSITI MALAYA*

Abstract

The quality of the pedestrian environment is influenced by factors such as safety, comfort, attractiveness, and accessibility, collectively referred to as walkability. Walkability encompasses both the physical infrastructure and the social and cultural dimensions of walking. This study evaluates pedestrian network connectivity along three primary routes, namely Persiaran Bestari, Jalan Plumbum, and Persiaran Permai, using the space syntax approach with an axial map. The axial map, derived from Open Street Map (OSM) and supplemented with site inventory data, represents spatial connectivity through axial lines that illustrate relationships between spaces within the network. Integrating primary and secondary data facilitated a comprehensive assessment of pedestrian volume and spatial configuration. The findings indicate that Persiaran Bestari records the highest pedestrian volume, attributed to its proximity to schools and residential areas that sustain continuous foot traffic. Axial analysis further demonstrates that Persiaran Bestari and Persiaran Permai possess the highest levels of connectivity, particularly in zones characterised by dense residential and commercial land use. This study highlights the correlation between infrastructure, facilities, and land-use zoning, offering valuable insights for urban planners and policymakers seeking to design walkable cities that prioritise connectivity, accessibility, and social interaction.

Keywords: pedestrian, space syntax, axial analysis, connectivity, pedestrian movement

² Corresponding author. Email: marinamn@uitm.edu.my

INTRODUCTION

Pedestrian network connectivity is a critical element of urban planning, presenting considerable challenges for planners and designers (Lerman et al., 2014; Monokrousou & Giannopoulou, 2016; Jabbari et al., 2018; Nag et al., 2022). Improving pedestrian infrastructure, particularly in urban areas, is essential to mitigate the substantial environmental costs of motorised transport, which remains the primary mode of urban and regional mobility. Accordingly, pedestrian pathways should be designed with spatial continuity, while network properties must determine accessibility and permeability in relation to specific locations and surrounding land use activities (Özbek et al., 2022). These spatial characteristics influence pedestrian movement patterns and behaviour (Monokrousou & Giannopoulou, 2016). Well-designed pedestrian networks not only improve accessibility but also promote healthier lifestyles, reduce carbon emissions, and foster social interaction within residential communities (Litman, 2024; Gehl, 2013).

Building upon this notion, the present study evaluates pedestrian network connectivity using the space syntax approach, which provides a robust framework for interpreting and predicting pedestrian movement through spatial configuration (Nag et al., 2022; Lee et al., 2020). Specifically, this research examines how space syntax, as a spatial analysis tool, can deepen understanding of pedestrian network performance. This section establishes the significance of pedestrian connectivity and the relevance of the space syntax methodology in advancing walkable and sustainable urban planning. The following section details the research methodology, succeeded by an analysis of findings from the designated study area and their wider implications. The final section discusses potential applications and suggests avenues for future research.

This study makes a distinct contribution to the growing body of literature on pedestrian network connectivity by situating the space syntax approach within the Malaysian urban planning framework (Fan et al., 2024). Unlike most international studies centred on dense urban environments in developed contexts, this research offers empirical insights into how local urban morphology, mixed land use, and pedestrian infrastructure influence connectivity and movement patterns in a medium-density Malaysian city such as Shah Alam. These findings advance the understanding of walkability and connectivity within Malaysia's urban design and planning discourse.

Pedestrian behaviour, perceptions, and attitudes

Walking plays a vital role in promoting health, improving societal well-being, and reducing greenhouse gas emissions. The concept of walkability is therefore central to achieving sustainable urban environments (Karwand et al., 2024). Walkability extends beyond the physical act of walking and its health benefits; it also encompasses the “social environment”, “perceptions of place”, and

“pedestrians’ comfort” (Lo, 2009). The notion of walking in cities highlights the importance of providing safe, comfortable, and engaging settings. Pedestrians value attributes such as usefulness, a sense of belonging, and enjoyment – distinct needs that must be addressed to enhance the overall walking experience.

Street walkability reflects how well the built environment accommodates walking. A walkable street prioritises pedestrian safety and comfort, fosters an inviting atmosphere, and reduces the dominance of fast or heavy vehicular traffic.

The proper design and construction of pedestrian environments are therefore crucial to enhancing walkability. By accommodating diverse preferences and behaviours, well-designed streets become more attractive, convenient, healthy, and efficient (Quednau, 2018; Ewing et al., 2016)). Like other forms of human behaviour, walking is influenced by cultural factors, individual circumstances, preferences, and environmental conditions.

Environmental determinants of walking in urban areas include compact urban form, residential density, and land-use mix. Design features such as shading, aesthetic quality, scenic value, and proximity to retail or leisure amenities significantly affect street walkability (Navastara et al., 2018; Mehta, 2008). Behaviour related to street activities reflects individuals’ perceptions of the street environment and shapes their engagement with public spaces (Cambra, & Moura, 2020). The concept of street image links the physical identity of a place to how it is perceived through emotions and impressions. These perceptions are formed through a blend of cognition (comprehension or understanding), and cultural interpretation, generating a collective sense of place or spatial personality (Lynch, 1960; Montgomery, 1998).

Attitudes towards walking are similarly shaped by cultural, personal, and environmental factors. Such attitudes, informed by both physical and emotional responses, influence perceptions of pedestrian movement and behaviour. Perceptions of city streets, particularly regarding pleasantness, attractiveness, safety, liveliness, and cleanliness, offer valuable insights into how people experience urban spaces (Papadimitriou et al., 2009). The integration of street characteristics, including morphology and performance, contributes to a distinctive street environment. These attitudes are critical in shaping inclusivity, safety, and attractiveness in public spaces (Fonseca et al., 2022; Tibbalds, 2012).

Integrating Pedestrian Movement and Space Syntax

As cities adopt low-carbon initiatives, non-motorised transport planning has gained prominence, with an increasing emphasis on walkability. Walking has become a central concept and priority among urban planners (Rashid et al., 2024; Sharmin & Kamruzzaman, 2017; Monokrousou & Giannopoulou, 2016). Such efforts not only revitalise urban centres but also help alleviate automobile congestion and reduce dependence on fossil fuels (Lerman et al., 2013).

Consequently, contemporary transport planning prioritises the development of pedestrian-friendly cities. Establishing a high-quality pedestrian environment is vital for optimising pedestrian flow, while identifying the spatial characteristics and distribution of neighbourhood pedestrian networks is key to encouraging greater walking activity. Furthermore, predicting pedestrian movement within urban areas can significantly influence transformations in the urban fabric and spatial configuration (Iliyasu, Abdullah, & Marzbali, 2023).

Space syntax, introduced by Hillier (1996), offers a robust analytical framework for understanding how spatial configuration shapes pedestrian movement. Using axial maps, it is possible to evaluate connectivity and movement patterns in relation to human activity, pedestrian flow, and land use (Özbek et al., 2022; Lee et al., 2020; Khalid, Othman, & Marzukhi, 2020). This method supports the analysis of pedestrian behaviour and guides investment in enhancing the quality of walking environments. For instance, Özbek et al. (2022) used space syntax analysis to examine how urban grid configurations affect pedestrian movement, while Yıldırım and Çelik (2023) employed behavioural mapping to correlate pedestrian density with space syntax simulation outcomes (Rashid et al., 2024).

Integrating pedestrian perceptions, behaviour, and environmental factors strengthens both the physical and functional connectivity of urban spaces. Such integration enhances walkability and enables planners to leverage the potential of space syntax to bridge the gap between spatial design and pedestrian experience, ultimately contributing to more walkable and sustainable cities (Fan et al., 2024; Mona et al., 2017).

RESEARCH METHODOLOGY

Study area

This study focuses on three primary routes – Persiaran Bestari, Jalan Plumbum, and Persiaran Permai – located in Seksyen 7, Shah Alam, under the jurisdiction of the Shah Alam City Council. These routes were selected for their diverse land uses, encompassing residential, commercial, institutional, and recreational zones that generate varied pedestrian needs and movement patterns. The area experiences moderate pedestrian activity but is constrained by limited functional walking infrastructure. This context provides an ideal setting for assessing pedestrian network connectivity and examining how infrastructure design influences pedestrian volume and spatial connectivity within mixed-use urban environments.

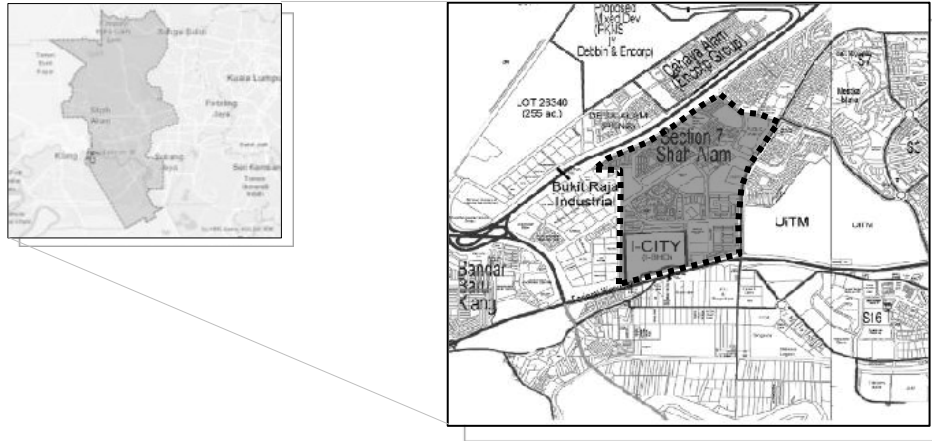


Figure 1: Location of study area

Materials and Method

This study employed a site inventory and GIS-based spatial databases to assess pedestrian connectivity. These tools facilitated the identification of existing conditions in the study area and provided insights into how pedestrians navigate within the neighbourhood context.

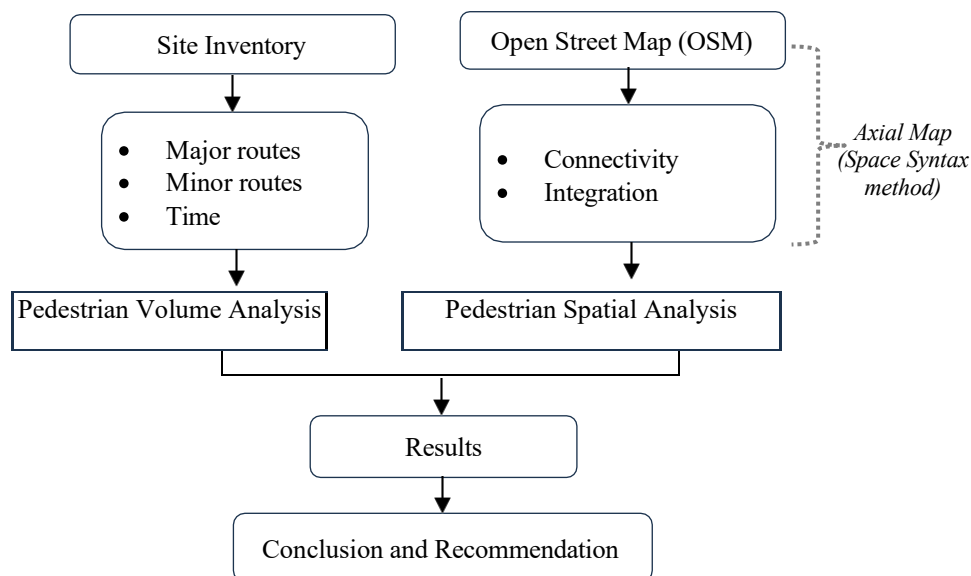


Figure 2: Flowchart of methodology for this study

a. Site Inventory

The site inventory guided the selection of pedestrian routes and the assessment of pedestrian infrastructure performance. Manual pedestrian counts were conducted to evaluate how effectively the infrastructure accommodates varying pedestrian volumes. Observers were strategically positioned along selected routes and recorded counts during predefined time intervals. Data collection took place during peak morning and afternoon hours on both weekdays and weekends to capture temporal variations in pedestrian activity. The pedestrian counts were based on a set of parameters designed to reflect the spatial and behavioural diversity of movement patterns.

Table 1: List of parameters

Parameter	Description
Routes	Consist of three major and minor routes namely; • Persiaran Bestari • Jalan Plumbum • Persiaran Permai
Pedestrian volume	• High volume • Low volume
Time intervals	• Weekdays (0700-0800; 1600-1830) • Weekends (0700-1800)

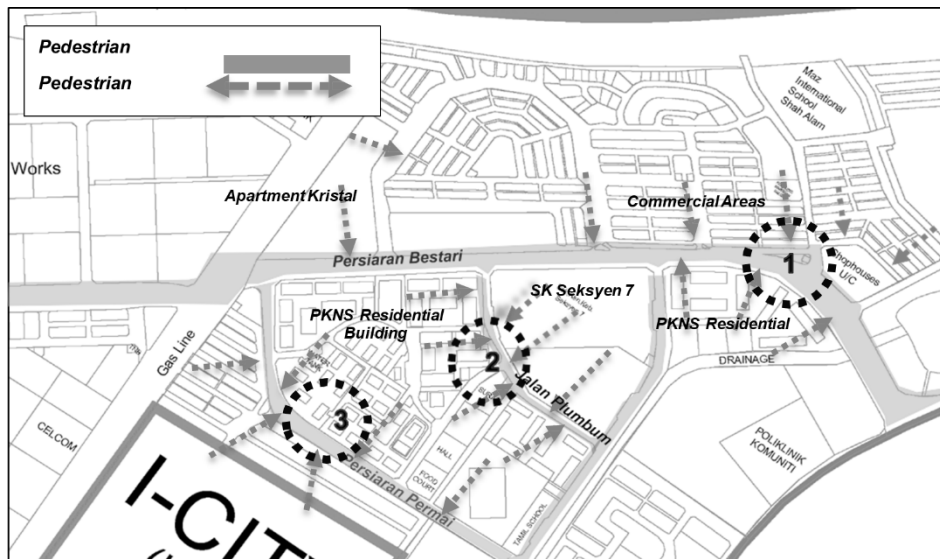


Figure 3: Pedestrian or route that are used in this study area; (1) Persiaran Bestari, (2) Jalan Plumbum dan (3) Persiaran Permai.

Source: Author's work

b. Open Street Map (OSM) and Axial Map

Open-source spatial data from Open Street Map (OSM) were used to analyse pedestrian spatial dynamics within the study area. The data were digitised and analysed using the space syntax approach via the axial map technique, which represents urban spaces as the longest straight lines that can be drawn through open space without interruption (Sharmin & Kamruzzaman, 2017). This method enables the evaluation of spatial connectivity by examining how these axial lines intersect and relate to one another within the network.

The analysis was performed using DepthMapX version 0.7 to assess pedestrian network accessibility and connectivity. The software generates two key indicators: connectivity, which measures the degree to which each axial line links to other lines, and integration, which indicates the level of localised accessibility between an axial line and its adjacent connections (Lee et al., 2020). These outputs were interpreted to assess spatial accessibility, correlating areas of high connectivity and integration with observed pedestrian behaviours such as increased foot traffic and greater walkability.

A 400-metre radius – approximately a 10-minute walk – was adopted as the standard walkable distance, consistent with common pedestrian mobility patterns. This radius, while indicative, also considers variations in pedestrians' physical capabilities. Major and minor pedestrian routes were identified as analytical parameters: major routes refer to wider streets or pathways with higher pedestrian volumes and stronger network connections, whereas minor routes are narrower, serving more localised areas within the neighbourhood.

ANALYSIS AND DISCUSSION

Pedestrian Volume Analysis

Persiaran Bestari recorded the highest pedestrian volume during the morning peak hour, largely influenced by daily routines and the proximity of the nearby school and PKNS residential complex. Morning activity, particularly between 7.00 a.m. and 8.00 a.m., significantly increased usage of the pedestrian network (Figure 4).

In contrast, pedestrian numbers along Jalan Plumbum rose gradually from Point A to Point B, indicating a more stable flow throughout the day. During the morning period (7:00 a.m. to 8:00 a.m.), 24 pedestrians were recorded – lower than Persiaran Bestari but indicative of consistent utilisation. The flow remained steady during the day, with a minor peak in the evening (4:30 p.m. to 5:30 p.m.), when 18 pedestrians were observed.

Table 1 summarises the pedestrian volume across the three study routes –Persiaran Bestari, Jalan Plumbum, and Persiaran Permai – at various times of the day. The data highlight distinct movement patterns, with Persiaran Bestari consistently experiencing higher pedestrian numbers, particularly during peak hours, compared with the other two routes. For example, during the afternoon

interval (1:00 p.m. to 2:00 p.m.), Persiaran Bestari recorded 55 pedestrians, whereas Jalan Plumbum and Persiaran Permai recorded only 13 and 20, respectively.

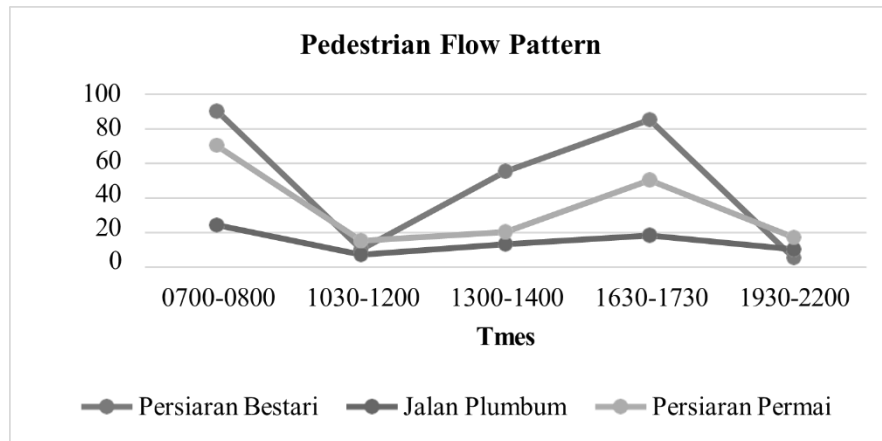


Figure 4: Pedestrian flow pattern in the study area.
Source: Author's work

Table 2: Pedestrian Volume Data for Persiaran Bestari, Jalan Plumbum, and Persiaran Permai

Time Range	Persiaran Bestari	Jalan Plumbum	Persiaran Permai
0700-0800	90	24	70
1030-1200	10	7	15
1300-1400	55	13	20
1630-1730	85	18	50
1930-2200	5	10	17

Source: Author's work

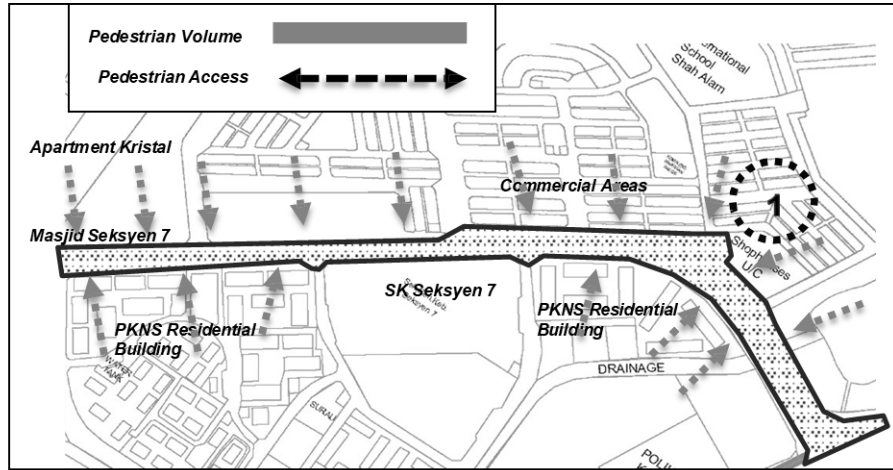


Figure 5: Pedestrian flow pattern at Persiaran Bestari (route 1).
Source: Author's work

The high pedestrian flow along Persiaran Bestari (Route 1) can be attributed to its surrounding land-use composition. The mixed-used development, which integrates residential and commercial activities, strongly influences walking behaviour. Proximity to institutional facilities such as SK Seksyen 7 Primary School further encourages pedestrian movement. The diversity of land uses within the area reduces reliance on private vehicles, promoting walking and cycling for daily activities, including trips to grocery stores, eateries, parks, schools, and other public spaces.

Conversely, Jalan Plumbum (Route 2), as shown in Figure 6, exhibits a gradual increase in pedestrian volume from Point 1 to Point 2, reflecting a distinct movement pattern dominated by workers and residents. Average pedestrian counts ranged from 10 and 20 individuals. The forthcoming operation of the LRT 3 line, scheduled for completion in 2024, is expected to enhance connectivity and potentially increase pedestrian movement in this area.

Persiaran Permai (Route 3), however, shows moderate pedestrian activity, constrained by insufficient walking infrastructure and disruptions caused by ongoing LRT3 construction works. Inconsistent and discontinuous sidewalks compel pedestrians to navigate obstructed paths, while inadequate lighting and poor maintenance further deter walking. These deficiencies contribute to low pedestrian volume and limited accessibility during the construction phase.

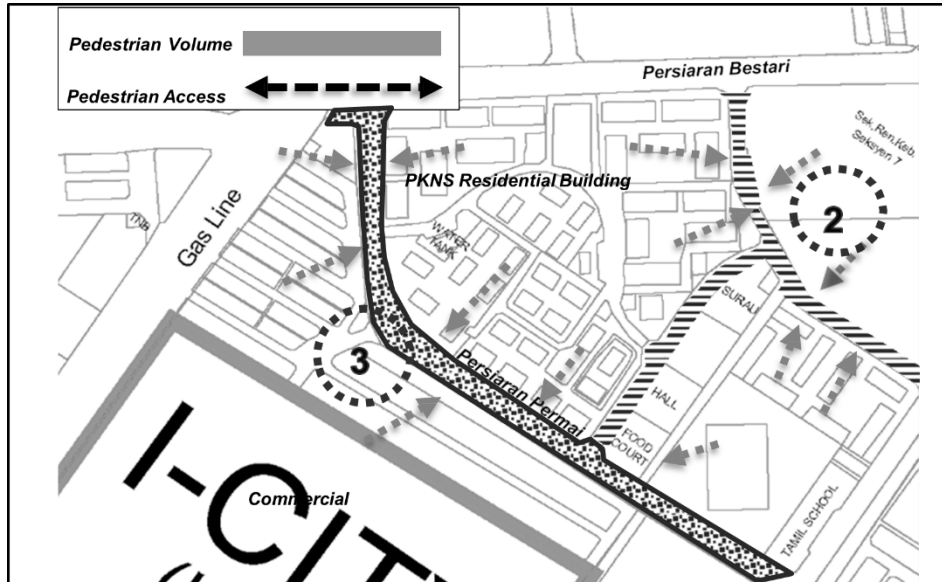


Figure 6: Pedestrian flow pattern at Jalan Plumbum (route 2) and Persiaran Permai 9 (route 3).

Source: Author's work

Pedestrian Spatial Analysis

A substantial network of medium local integration scores was identified within the study area, suggesting that Persiaran Bestari, Seksyen 7, has significant potential to improve pedestrian circulation. The primary and secondary road networks represent the most locally interconnected components. However, the surrounding residential and institutional arterials, although well-integrated in terms of walkability and their ability to support local movement, are often perceived as pedestrian "barriers" due to inadequate infrastructure and restricted accessibility.

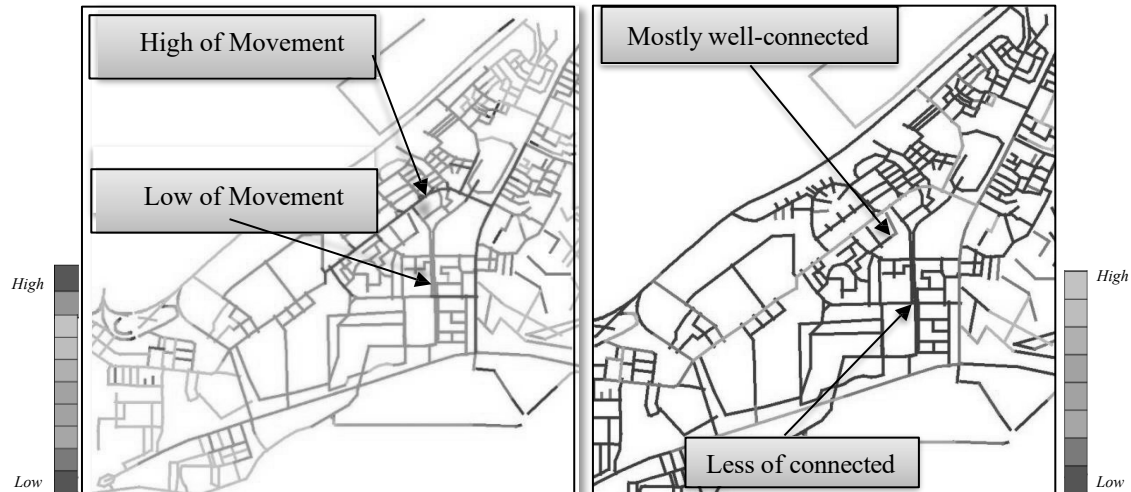


Figure 7: Total depth of connectivity (left) and choice of connectivity potential (right)
Source: Author's work

Node counts, connectivity, and integration values were classified according to thresholds derived from the study's specific dataset and context. Following Hacar et al. (2020), the Jenks Natural Breaks Classification method was used to categorise variations within the data into three classes – low, medium, and high – facilitating the analysis of space syntax measures that influence pedestrian density. For example, node counts were classified as low (<300), medium (300- 700) and high (>700); connectivity values as low (<500), medium (500-1000), and high (>1000); and integration values as poor (<0.3), moderate (0.3-0.7), and good (.0.7).

Using a metric segment map with a 400m radius, Total Depth and Choice values were computed. These values typically peaked near the city core, where numerous residential areas recorded a maximum integration value of 1402 (average 0.589; minimum 1) and a maximum choice value of 145,304 (average 58,823; minimum 0). Overall, the study area exhibited a total node count of 496.794 and total connectivity of 1,219.59.

Figure 7 illustrates the special distribution of Choice and Total Depth values for the street network of Seksyen 7, Shah Alam. The highest integration levels were observed along Persiaran Bestari, with notable concentrations along major routes linking schools and residential zones. The corresponding colour range on the map (Figure 7) highlights Persiaran Bestari and Persiaran Permai as the most integrated and active streets, reflecting dense residential populations and heightened social and commercial activity in these areas.

Future Statistical Validation

Although this study reveals clear spatial correlations between integration values and pedestrian volumes, future research could incorporate statistical techniques – such as correlation or regression analysis – to quantitatively validate the relationship between axial values and pedestrian movement. Such methods would strengthen the analytical rigour of space syntax applications and provide a more robust understanding of pedestrian dynamics within local urban contexts.

CONCLUSION

This study demonstrates that the integration and connectivity of pedestrian networks strongly influence walking patterns, shaped by both the spatial configuration of the built environment and individual behavioural factors. Building functions – such as institutional, residential, and commercial uses – exert a pronounced effect on pedestrian flow, while personal variables including lifestyle, preferences, and trip purpose further define movement dynamics.

This analysis establishes a clear relationship between pedestrian activity and spatial integration in Shah Alam, with Persiaran Bestari and Persiaran Permai emerging as key pedestrian nodes. Their centrality, coupled with proximity to schools, neighbourhoods, and commercial areas, contributes to vibrant social and economic activity.

The results also show that a higher number of intersections enhances route options and accessibility, underscoring the need to improve infrastructure in high-traffic and underperforming areas through continuous sidewalks, better lighting, and clearer wayfinding.

The application of space syntax provides a robust analytical framework for understanding urban connectivity and its influence on pedestrian movement and economic vitality.

However, future research should integrate user-based data, such as behavioural patterns, perceived safety, and route preferences, to deepen insights into pedestrian behaviour.

Certain methodological limitations are acknowledged. Manual pedestrian counts, although systematic, may be affected by temporal factors, weather, and observer bias, potentially limiting data accuracy. Future studies could employ automated or sensor-based data collection techniques to enhance precision and reliability.

Overall, the findings offer valuable evidence for urban planners and policymakers seeking to enhance walkability. By aligning pedestrian infrastructure improvements with sustainable mobility and community engagement objectives, this research contributes to the development of more inclusive, connected, and liveable urban environments.

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ETHICAL CONSIDERATION

This research involved non-intrusive pedestrian observations conducted in publicly accessible areas. No personal data or individual identification was recorded during fieldwork. All observations adhered to institutional ethical guidelines and ensured the privacy, anonymity, and safety of individuals observed.

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