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ADAPTING MALAY TRADITIONAL HOUSE THROUGH GREEN BUILDING INDEX (GBI) FRAMEWORK: A CASE STUDY OF RUMAH DATO' RAJA DIWANGSA

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Abstract

Despite a growing emphasis on sustainability in construction, few studies have explored how traditional Malay houses align with contemporary green building standards, creating a significant research gap. Consequently, this study examines the adaptation of traditional Malay houses to modern green building standards, utilising the Green Building Index (GBI) as a benchmark. Here, Rumah Dato' Raja Diwangsa, a traditional house from Negeri Sembilan, was chosen as a case study to assess how well it satisfies GBI standards for indoor Environmental Quality (EQ), Water Efficiency (WE) and Energy Efficiency (EE), sustainable site planning, materials, and innovation. Using a qualitative case study approach, the research combines site observations and literature reviews to identify alignments and gaps between traditional design and contemporary sustainability standards. The findings reveal that traditional Malay houses incorporate sustainable features like passive cooling, natural ventilation, and locally sourced materials, aligning with several GBI criteria, particularly indoor EQ and innovation. However, the reliance on newer design requirements limits its performance in areas like advanced energy systems and recycled materials. This study highlights the potential for adapting traditional architectural elements to improve modern green building practices and suggests revising GBI guidelines to accommodate traditional houses. By bridging the gap between heritage preservation and sustainable construction, this research contributes insights for future developments in tropical climates. Future studies should expand this analysis to other traditional houses and incorporate quantitative performance metrics for a more comprehensive evaluation.

Keywords: Green Building Index (GBI); Malay Traditional House; Rumah Dato' Raja Diwangsa, Sustainable Architecture, Vernacular Design

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INTRODUCTION

Malaysia has various ethnicities and traditions, including traditional dwellings and architectural works. These diverse architectural styles reflect each community's values, beliefs, and environmental adaptations. Drawing from centuries-old wisdom, traditional Malay architecture reflects a profound understanding of sustainable living within its natural surroundings. Malay architectural traditions developed centuries before modern construction techniques, deeply rooted in local climate, culture, and environment. Their design principles provided a sustainable and comfortable living environment suited to Malaysia's hot and humid conditions. (Mohd Nawayai et al., 2020).

The design of Malay traditional houses varies according to society's beliefs, ideologies, and morality, which form its unique architectural work. Previous studies found that almost all Malay traditional houses shared common criteria, reflecting their design's consistent principles (Husen et al., 2020). These principles include structural features suited to the tropical climate, such as elevated floors for ventilation and flood prevention, open layouts to encourage natural airflow and using locally sourced materials like wood and bamboo, which are sustainable and readily available (Bahardin et al., 2022). The architectural styles also incorporate cultural motifs and craftsmanship, preserving symbolic elements significant to Malay heritage (Johari & Said, 2021). Authorities have undertaken several efforts to preserve Malaysia's traditional houses, including relocation to museums, restoration of existing structures, and reconstruction for educational or tourism purposes. Mini Malaysia and ASEAN Cultural Park (MMAC) in Melaka and Malay Heritage Museum of Universiti Putra Malaysia (UPM) are some of the efforts made to protect and preserve the architectural work of Malaysian traditional houses.

Many researchers have established that the architecture of Malay traditional houses contains many aspects of green architecture that can be emulated by its modern equivalent, especially criteria related to the Green Building Index (GBI) (Cheong et al., 2020). However, no previous studies have evaluated traditional Malaysian houses based on the GBI framework in detail. Therefore, there is a need to demonstrate and compare that traditional Malay architectural designs embody several principles of green architecture. In this case, it is crucial to assess its green architecture using the criteria listed in the GBI, which can determine the level of greenness of the traditional Malay house. Here, further improvement in incorporating green building features could help the traditional Malay house in future applications. Therefore, this study evaluates traditional Malay house features according to green building principles based on GBI characteristics.

LITERATURE REVIEW

Malay Traditional House

The characteristics of the Malay landscape are influenced by the orientation of the external environment of a Malay house in the traditional view, as indicated in an ancient manuscript of Adat Resam Melayu (Hussain et al., 2020). Based on the ancient manuscript, it is explained that in ancient times, the traditional Malay house had an architectural vision closely linked to the life of the Malays. At that time, the house's entrance was placed in a position facing the rising sun. Abdul Rahman Al-Ahmadi explains the reason for these ingrained practices in *Petua Membina Rumah Melayu: Dari Sudut Etnis Antropologi*, which the reason is to avoid harm to the homeowner because the afternoon sun is much warmer than the sunrise from the East. The afternoon sun can likely harm the homeowner in terms of health or loss of wealth. Such superstitions hold some truth, such as the location of the house protecting the house from being completely exposed to sunlight during the day (Hussain et al., 2020).

Currently, such practices are not widely known and are not practised by Malaysians, which may be due to modernisation and different views taking place in society. Nevertheless, current studies show that the Malaysian cultural landscape and sustainability are closely related, such as the orientation of the house in relation to the position of the sun, ventilation of the air inside the house and surrounding area, the arrangement of planting trees and hedges, planting of edible plants, planting of flowers and open spaces of barns (Essig & Davis, 2021). The elements, designs, and arrangements of traditional Malay architecture depict and indicate the Malays' sustainable lifestyle and culture incorporated into their traditional house design, which is not only a traditional system of belief but also involves practical and sustainable design.

Green Building Index (GBI)

By 2050, the human population is expected to increase from 7 to 9 billion. This population growth raises questions about low water, energy, and natural resource supply due to high demand, and our ecosystems will be overwhelmed. This problem can be faced with the concept of sustainable development introduced by the United Nations to achieve several strategic goals related to long-term environmental issues (Hsu & Ou, 2022). The concept of sustainability adopted by the construction industry has given rise to a green construction movement, which shows that green construction outperforms conventional construction in several areas of activity, thereby meeting the strategic goals set by the United Nations (Prameswari, Rachamawati, Wiguna, & Rohman, 2021; Makmor, Ismail & Hashim, 2015).

According to Marchi et al. (2021), GBI offers four (4) ratings: Certified, Silver, Gold and the highest rating, Platinum. Here, six factors must be assessed

and scored to determine a building's GBI rating, ranging from 50 to 100 points for a building to be certified as green. The Malaysian construction industry, as highlighted by Raouf & Al-Ghamdi (2021), anticipates that GBI will be able to create a common language and measurement standard, encourage integrated and inclusive building design, identify and celebrate environmental leadership, reduce the environmental impact of the built environment and ensure that new and old buildings are fit for today and in the future.

A building's GBI certification is determined by considering several factors. The six criteria are Water Efficiency (WE), sustainable Site planning and Management (SM), Materials and Resources (MR), indoor Environmental Quality (EQ), Energy Efficiency (EE), and Innovation (IN). In addition, achieving and implementing environmentally friendly aspects beyond typical industry practices will earn points under the GBI rating system. The point ranges for GBI ratings (Platinum, Gold, Silver, or certified) are shown in the table below.

Table 1: Point System of GBI Ratings.

Points	GBI Ratings
86 to 100 points	Platinum
76 to 85 points	Gold
50 to 65 points	Certified

Source: *Green Building Index (GBI)*. (n.d.). *GBI Rating System*. Retrieved from <https://www.greenbuildingindex.org/how-gbi-works/gbi-rating-system/>.

In Malaysia, green architecture may still be relatively new and not widespread, especially since many recent studies have focused on assessing the green characteristics of new or existing buildings rather than traditional ones (Cheong et al., 2020). This is not aligned with the policy to preserve traditional house designs that can be used for future generations. In this case, researchers may have overlooked the socio-environmental value of traditional buildings, which creates a significant research knowledge gap. Cheong et al. (2020) also suggested that vernacular architecture can have a higher content of sustainable architectural designs because it draws from time-tested principles of resource efficiency, environmental harmony, and cultural relevance. In this case, vernacular architecture often utilises locally available materials and techniques, aligns with the local climate, and reflects the socio-cultural practices of the community. This makes vernacular architecture naturally sustainable and adaptable. Consequently, it can serve as a valuable reference for modern architectural practices that aim to minimise environmental impact and promote

sustainability. Therefore, valuing the past can be a great opportunity to understand the lasting characteristics of vernacular architecture associated with traditional Malay houses.

Significance of Green Building

The GBI is increasingly relevant to modern housing design due to growing environmental awareness among homeowners and developers. Nevertheless, its adoption remains limited, as many still prioritise cost-effective conventional practices over sustainable certification. Muchlis et al. (2021) also stated that adopting the GBI has been slow, with many homeowners and developers still prioritising cost-effective and conventional building practices over the more stringent requirements of green building certification. Nevertheless, the GBI can provide valuable guidance for the design and construction of modern houses, as it encourages using energy-efficient technologies, water-saving features, and environmentally-friendly materials. Modern houses designed and constructed per the GBI principles can significantly reduce energy usage, water usage, and waste generation, thereby contributing to a more sustainable built environment.

The GBI can be applied to both modern and traditional houses. However, the specific strategies and approaches may vary in their use. Yu et al. (2020) mentioned that modern green homes often incorporate advanced technologies to achieve EE and reduce environmental impact. These may include solar photovoltaic systems to generate renewable electricity, high-efficiency Heating, Ventilation, and Air Conditioning (HVAC) systems that minimise energy consumption, and smart home automation systems that optimise the home's energy usage. By integrating these cutting-edge sustainable technologies, modern green homes can significantly reduce their environmental footprint and operational costs while providing occupants with a comfortable and healthy living environment (Yu et al., 2020).

On the other hand, traditional green homes often emphasise passive design strategies, using locally sourced and renewable materials and integrating natural ventilation and daylighting to achieve sustainability (Abood et al., 2020). These approaches leverage the inherent qualities of traditional building techniques and local resources to create energy-efficient and environmentally friendly homes well adapted to their regional contexts. By incorporating these traditional green building practices, homeowners and builders can preserve cultural heritage while improving the residential sector's overall sustainability (Sokienah, 2020). Furthermore, integrating passive cooling and heating strategies into contemporary adaptations of traditional houses can enhance EE.

This study extends the existing body of knowledge by drawing parallels between Malay vernacular architecture and similar sustainable

adaptations found globally. For example, the integration of passive cooling and natural materials in traditional architecture parallels practices in Indonesian, Thai, and Japanese vernacular systems that have been adapted into green rating frameworks. This comparative lens positions the Malay traditional house within a broader discourse of culturally rooted sustainable architecture.

RESEARCH METHODOLOGY

This study applied a qualitative interpretive approach using site observation and document analysis to evaluate the alignment of traditional architectural elements with GBI criteria. This may be the opposite of the typical GBI-based research where quantitative scoring systems are used. This approach is appropriate to this study as Rumah Dato' Raja Diwangsa was not originally designed for green certification but incorporates many potential sustainability features, which align with GBI criteria. Sampling from research conducted by Martinovic et al. (2023), this method is suitable for analysing specific aspects of traditional Malaysian architecture from the standpoint of the current sustainability standards, such as the GBI framework. This study does not aim to calculate the GBI scores or percentages but rather to explore the compatibility and adaptability of traditional design principles with modern green standards. However, this qualitative approach does not incorporate numerical GBI scoring or comparative benchmarking with other buildings, which may limit the generalisability of the findings. Future studies integrating quantitative performance metrics would strengthen the comparative rigor of such assessments.

SELECTION OF CASE STUDY

Rumah Dato' Raja Diwangsa was chosen as the case study due to its historical significance and representation of Malay architectural principles, especially Negeri Sembilan Malay Traditional House (NSTMH). The case study was selected due to its easy access for site observation as the house has been relocated and preserved at the Malay Heritage Museum in Universiti Putra Malaysia. As a well-preserved traditional house, it offers a unique opportunity to explore the intersection of NSTMH and the modern sustainability framework. Rumah Dato' Raja Diwangsa has authentic architectural elements such as timber stilt construction, serambi layout and passive ventilation design, making it an ideal case study for analysing how vernacular features align with the GBI framework. This house represents various traditional houses across Malaysia, reflecting cultural and sustainable design principles relevant to this study. This case study will focus on key aspects of the GBI framework, such as EE, WE, indoor EQ, sustainable SM, MR, and IN.

Data Collection Method

Data collection for this study will have two sources of evidence to ensure a comprehensive understanding of the case study. This includes a literature review and site or field observation. Literature studies, such as historical records, architectural plans, conservation reports, and previous studies on Rumah Dato' Raja Diwangsa, were analysed. This provides contextual information and helps identify building features that correspond to GBI standards.

Site observation

Direct observation of Rumah Dato' Raja Diwangsa was conducted to document its architectural features, material usage, and environmental performance. The observations were guided by the GBI framework, focusing on relevant criteria. This included photographing the house and taking notes on elements relevant to GBI criteria, such as EE, natural ventilation, and material sustainability.

Framework for Analysis

The GBI framework evaluated the house's sustainable features. The six categories of GBI—EE, indoor EQ, sustainable SM, MR, WE, and IN—were used as benchmarks for assessment. Each category was systematically compared with the architectural features of Rumah Dato' Raja Diwangsa to identify alignments, gaps, and potential adaptations. The analysis emphasised the house's vernacular features, including its stilt construction, open layout, use of natural materials, and passive cooling strategies. These elements were critically examined to assess their contributions to GBI criteria, especially in indoor EQ and IN. Areas where traditional practices could be adapted to meet modern sustainability standards were highlighted.

ANALYSIS AND DISCUSSION

Negeri Sembilan Malay Traditional House (NSMTH)

The traditional matrilineal system of Adat Perpatih is often associated with the NSTMH. The matrilineal women are the heads of the household, and the owner's position in the neighbourhood affects the size of the house (Azman et al., 2022). The development of two cultures, the Biduanda village (Jakun) and the Minangkabau people, has significantly impacted the NSTMH's architecture. A unique design was created when the Minangkabau matrilineal system and the local Negeri Sembilan matrilineal system could coexist. The local community's culture greatly influences the architectural and design values of the NSMTH.

The architectural design of NSMTH is a mixture of two evolving cultures: the Minangkabau and Biduanda (Jakun) communities. These two communities influenced the architectural design of NSMTH. NSMTH can be identified easily based on its unique features in its physical form. The house's

features can be categorised into two classes: physical attributes and external influences (Azman et al., 2022).

Physical attributes:

1. Layout typologies such as *serambi* (verandah), which consists of *serambi pangkal*, *serambi tengah*, *serambi hujung*, mother house with *loteng* (attic) and kitchen house.
2. The curved roof at both ends is Negeri Sembilan's regional identity.
3. Traditional *tanggam* application as a construction method.
4. Specific shapes of the column, such as *tiang pecah lapan* (octagon shape column) or *tiang pecah empat* (square shape column), in which the specific shape represents the status of the owner.

External influences:

1. High-quality chengal wood and other materials, such as palm leaves.
2. The traditional expertise of *tukang* (master builder).
3. The social system (*Adat Perpatih*), religious system and specific environmental constraints.
4. The time capsule (coin) is concealed under the *tiang seri* as evidence of the birth date of the house.

Rumah Dato' Raja Diwangsa is located at Malay Heritage Museum of UPM. The house's owner is Datuk Raja Diwangsa Muhammad Yunus bin Jabar, one of the Orang Empat Istana Seri Menanti. Originally, the 82-year-old house was located in Kampung Merual, Seri Menanti, and the house was preserved and relocated to the museum for the museum's exhibition.

A traditional house has its own uniqueness, especially in terms of design and functionality. The base structure was implemented using the timber base column as its stilts to elevate the house and protect the owner from any harm or natural disaster below. The house's elevation on the stilts demonstrates an adaptation to the tropical climate and the local topography, particularly in areas prone to flooding. This design ensures that the house remains cool and dry and guarantees safety from floods. The disturbance of poisonous insects or creeping animals can allow sunlight to shine on the lower part of the house, which is *kolong* to reduce humidity, with air circulation underneath helping regulate temperature.

In this traditional house of Datuk Raja Diwangsa Muhammad Yunus bin Jabar, the *serambi* area is situated at the front of the house (Figure 1) and was shaped in the shape of three corners, which are *serambi tengah*, *serambi pangkal* and *serambi hujung*. This space serves as a transitional area between the outside and inside. It is often used to welcome guests and for socialising. The openness of the *serambi* allows for ventilation and cooling, making it an ideal space for

relaxation with the addition of many windows and openings. The stairs are needed to access this area from the outside due to the stilt's elevation by the timber base column. Next, rumah Ibu is the largest section of the house in the centre, used for family gatherings, sleeping, and daily activities. It is the most spacious part of the house, often in the shape of a square or big rectangular, reflecting its role as the central living area. It is separated from serambi using an internal wall partition. In this rumah ibu area, there is a space for giving birth that is called kolek anak, whereas the flooring space has gaps that allow for cleaning, giving birth, draining, and more. Due to its spacious area, the attic can be constructed and located under the steeply pitched roof. The attic can be accessed using a small staircase from the rumah ibu, with small windows and vents to allow light and air circulation.

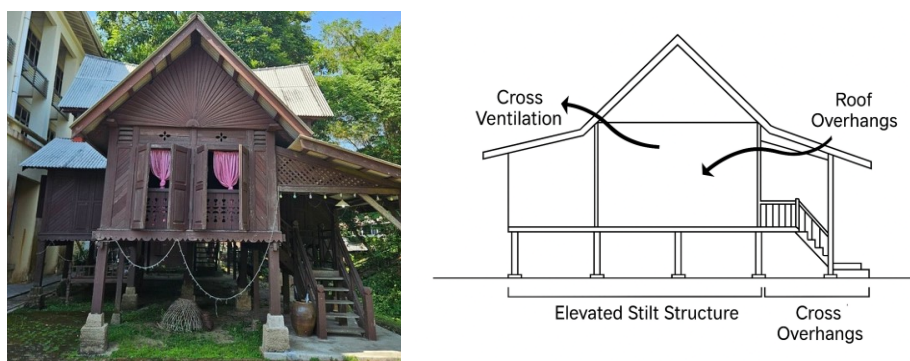


Figure 1. Rumah Dato' Raja Diwangsa, verandah front view – *serambi* (left), and the house's passive design features, including cross ventilation, an elevated stilt structure, and roof overhangs (right)

Source: Authors

Looking at the curved roof of the house, often likened to the shape of buffalo horns, is symbolic of the Minangkabau heritage. Beyond its symbolic meaning, the curved roof serves practical purposes. The design helps to shed rainwater efficiently, which is particularly important in the tropical climate of Malaysia, which has heavy rainfall. The roof's curvature also assists in ventilation, allowing hot air to rise and exit the building, keeping the interior cooler. Besides the roof design, the structural concept is built using *pasak dan tanggam* using high-quality wood such as chengal and teak, thus allowing the house to be opened and reassembled without damaging the structure and architecture.

Previous research highlights the universal application of traditional architectural practices in promoting sustainability. For example, Flores et al. (2022) examined colonial houses in Santiago, Chile, identifying passive climate

conditioning strategies inherent in these structures. Their study revealed that features such as thick adobe walls and internal courtyards effectively regulate indoor temperatures, minimising reliance on artificial cooling and heating systems. These findings parallel the sustainable design elements observed in Rumah Dato' Raja Diwangsa, such as natural ventilation and the use of local materials. Similarly, a study by Sari et al. (2024) investigated traditional mosques in the Gayo Highland of Indonesia, uncovering sustainable approaches like elevated structures for air circulation and expansive roof overhangs for shading. These architectural strategies, tailored to the local climate, resonate with the design principles of traditional Malay houses. By integrating insights from these international studies, it becomes evident that vernacular architecture worldwide embodies sustainable solutions adaptable to contemporary green building frameworks, reinforcing the relevance of traditional designs in modern architectural discourse.

Table 2 summarises the GBI-required criteria, and the house's architectural criteria are evaluated based on the detailed guidelines listed in the GBI Assessment Criteria for Residential New Construction Version 3.0.

Utilizing the GBI Assessment Criteria for Residential New Construction Version 3.0, Rumah Dato' Raja Diwangsa demonstrates potential alignment with 10 key sub-criteria, which are indoor EQ, IN, sustainable SM, MR and WE. The house incorporates multiple passive design elements that support sustainability and do not involve applying advanced modern energy systems. The evaluation of the house may suggest that the house could score within the 50-65 point range, which qualifies the house for a 'Certified' rating under GBI. Nonetheless, the technological expectation of a few criteria from GBI may not be attainable. Criteria such as EE2, EE3 and MR2 are geared towards contemporary construction methods, which are not present in a traditional house. Thus, this study supports the need for a revised GBI guideline that accommodates the heritage and passive sustainability of traditional architecture. This is essential to ensure the construction of traditional houses can be encouraged and widely enforced to prevent the extinction of traditional houses in Malaysia. This step may help preserve the architecture of traditional Malay houses across the nation for future generations.

Table 2: Adaptation of Green Characteristics of Rumah Dato' Raja Diwangsa with GBI Requirement.

PART	CRITERIA	ASSESSMENT	DESCRIPTION
2	EQ1	Minimum Indoor Air Quality Performance	Large window opening (half/full opening), it has the ability to encourage natural ventilation.
			Opening the roof attic helps allow ventilation to happen naturally.
			High indoor spaces help ventilation happen naturally and efficiently.
	EQ4	Daylighting	Large window opening (half/full opening) allows daylight to enter the house.
			An area with open space allows good natural ventilation.
			Opening on the wall (i.e., wooden raft/timber louver) allows natural ventilation.
			An open floor plan helps encourage cross-ventilation.
	EQ5	External Views	House plan with a small width allows good natural ventilation.
3	SM1	Site Selection & Planning	Modular house plan allows easy construction and able to be extended in the future.
3	SM1	Site Selection & Planning	House oriented towards Qiblat, facing the west sunlight, scientifically helps in lowering the heat in the house in the late evening.
	SM13	Heat Island Effect - Roof	Wide roof overhang helps protect the house from direct sunlight. A roof made of leaves or clay (senggora) acts as a heat insulator, hence reducing heat transfer into the house and reducing heat absorption.
4	MR4	Sustainable Timber	Natural construction materials (i.e., timber/bamboo).
5	WE1	Rainwater Harvesting	Rain harvesting and use of water well are for domestic purposes such as shower, irrigation and cleaning.
5	WE2	Waste Water Recycling	Flooring with gaps allows for draining.
5	WE3	Water Efficient Irrigation and Landscaping	Rain harvesting and use of water well are for domestic purposes such as shower, irrigation and cleaning.
6	IN1	Innovation in Design and Environmental Design Initiatives	Built on stilt with concrete or stone base helps overcome flood, is easy to maintain, and gives more privacy to the occupants.
			Opening the roof attic helps allow ventilation to happen naturally and daylight to enter the house.
			An open floor plan allows natural cross ventilation and natural lighting.
			Construction using wood joints will allow for stronger construction and an easy assembly and disassembling process.

PART	CRITERIA	ASSESSMENT	DESCRIPTION
			The attic space below the roof provides additional floor area that can serve as a multipurpose room and storage.

Note: Only sustainable design elements observed in Rumah Dato' Raja Diwangsa are mentioned in Table 2.

CONCLUSION

This study evaluated the traditional Malay house, Rumah Dato' Raja Diwangsa, against the GBI framework to assess its sustainability features and compatibility with modern green building standards. The findings revealed that, while the house demonstrates strong compliance in specific GBI criteria, particularly in indoor EQ and IN, it falls short in areas that heavily rely on modern construction technologies, such as advanced EE systems and recycled material use. The analysis highlights the inherent sustainability of traditional Malay architectural practices, including passive cooling, natural ventilation, and the use of locally sourced materials. These findings bridge the gap between traditional design principles and contemporary sustainability demands.

This study contributes to the growing body of knowledge on sustainable architecture by reinforcing the relevance of vernacular architecture within modern sustainability frameworks. The research demonstrates that traditional designs can offer innovative, culturally significant approaches to green architecture in future applications by applying the GBI framework to a traditional house.

This research makes a novel contribution to the body of literature on sustainability and vernacular architecture in Malaysia by offering the first systematic alignment of a Malay traditional house with the GBI framework. By contextualising vernacular design principles within a formal green rating system, this study demonstrates how cultural heritage can actively inform and enhance sustainable building standards in tropical regions.

The findings emphasise the need to revise sustainability standards to better reflect traditional building practices. Traditional design strategies—such as elevation for flood mitigation, natural material use, and passive cooling—can inform modern tropical housing. Adapting the GBI framework to recognise these vernacular features would both preserve cultural heritage and promote sustainable construction. The study provides valuable insights, but several constraints must be acknowledged. The evaluation was limited to a single case study, potentially restricting the generalizability of the findings to other traditional houses. Furthermore, the study relied heavily on qualitative data, including observations and literature, which may lack the precision of quantitative performance metrics (e.g., energy consumption or material efficiency). However, Rumah Dato' Raja Diwangsa was selected due to its cultural architectural significance as a representative example of Negeri Sembilan

traditional houses. Future research should extend this analysis to other traditional houses from various regions and typologies. Future studies could also incorporate mixed methods, including qualitative assessment and quantitative GBI scoring. In conclusion, traditional Malay houses such as *Rumah Dato' Raja Diwangsa* exemplify sustainability principles that complement modern green building goals. Developing a tailored assessment framework for heritage structures would help integrate vernacular wisdom with contemporary environmental objectives, ensuring their continued relevance in the built environment.

ETHICAL STATEMENT

Site observations and photographic documentation were conducted in accordance with Universiti Putra Malaysia (UPM)'s research ethics guidelines. Permission for access and documentation of *Rumah Dato' Raja Diwangsa* was obtained from the Malay Heritage Museum, UPM.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests with the funders and concur that this study was carried out free from financial, commercial, or self-benefitting conflicts.

AUTHORS' CONTRIBUTIONS

Aqilah Adib carried out the research and wrote the article. Nasyairi Mat Nasir conceptualised the research framework and supervised the research progress. Mohd Azrai Azman, Maisarah Makmor, and Abdul Hadi Ahamad have provided critical reviews, edited, and approved the article for submission.

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