JOURNAL OF THE MALAYSIAN INSTITUTE OF PLANNERS

PLANNING MALAYSIA





MALAYSIAN INSTITUTE OF PLANNERS
PLANNING MALAYSIA VOLUME 24 ISSUE 1 (2026)
[ISSN 1675-6215] e-ISSN 0128-0945]
www.planningmalaysia.org

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Published By
Malaysian Institute of Planners

ISSN Number
1675-6215
e-ISSN
0128-0945



Date Published: 13th February 2026

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 1 – 15

TRADITION & MODERNITY: LAND USE CHANGE AND LAND TENURE PATTERN IN CANGGU VILLAGE, BALI, INDONESIA

Suhirman[1], Tubagus Furqon Sofhani[2], Tri Rahayu Wulansari[3], Hafsah Restu Nurul Annafi[4], Titania Athaya Putri[5]

[1,2,3,4,5]*School of Architecture, Planning and Policy Development,*
BANDUNG INSTITUTE OF TECHNOLOGY (ITB) – INDONESIA

Abstract

Tourism development has become a major driving force behind land use change in Canggu Village, Bali, particularly through the rapid conversion of agricultural land into tourism-oriented spaces. This study examines how these changes have reshaped land use patterns and land ownership structures, while also exploring their environmental, economic, and socio-cultural implications for the local community. Special attention is given to the role of traditional village institutions (desa adat) in regulating land use amid increasing pressure from private and foreign investors. This research adopts a mixed-methods approach, combining qualitative and quantitative techniques. Primary data were collected through in-depth interviews with key stakeholders, questionnaire surveys involving 108 respondents in Canggu Village, and direct field observations. Secondary data were obtained from land use maps, satellite imagery, and regional spatial planning documents. The findings reveal a significant decline in agricultural land, accompanied by traffic congestion and the reduction of green open spaces. Although tourism development has generated new employment and business opportunities, the economic benefits received by local residents remain disproportionately lower than those gained by foreign investors. Beyond economic impacts, tourism-driven land conversion has also influenced the socio-cultural landscape of Canggu Village. The study identifies a gradual decline in community participation in traditional and ritual activities, alongside the potential erosion of local cultural values. These findings suggest that the current tourism development model has yet to deliver equitable and sustainable outcomes for the indigenous community. The study therefore emphasizes the need for concrete policy measures, including strengthening the authority of desa adat in spatial and land use planning, implementing fair and transparent land ownership regulations, and enhancing community empowerment within tourism management practices.

Keywords: Tourism, Land Use Change, Indigenous Village

[1] Corresponding author. Email: suhirman@itb.ac.id

INTRODUCTION

Since the 1960s, tourism development in Bali, Indonesia, has experienced a notable spatial shift. Initially concentrated in planned southern enclaves such as Sanur and Nusa Dua (Mantra & Kutanegara, 1990), tourism expansion has gradually moved northward, positioning Canggu Village as the island's most dynamic growth center (Suamba & Dwijendra, 2016). Once predominantly agrarian, Canggu has undergone an exceptionally rapid transformation, marked by a sharp decline in agricultural land from 281 hectares in 2010 to 211.5 hectares in 2022 (Wahyundaria & Sunarta, 2021; BPS Badung, 2022). This accelerated change is closely linked to the rise of digital nomadism and the formation of distinct international enclaves, including the so-called "New Moscow," shaped by global geopolitical dynamics and increasing digital connectivity (Hamel & Murti, 2023; Tanjungsari, 2018).

Previous studies have widely examined tourism-driven land-use change across Bali's tourism destinations (Dipayana & Sunarta, 2015; Ediastini, 2018; Sumantra et al., 2020). Canggu Village is selected as a critical case because it represents the most aggressive frontier of organic tourism expansion, where land-use change progresses faster than formal spatial planning mechanisms. This condition turns Canggu into a "living laboratory" for observing the direct encounter between market-oriented development and the traditional anthropocosmic principles upheld by the *Desa Adat* (Windia & Vidayanthi, 2020). While earlier research has largely emphasized physical or socio-economic impacts (Kristabela, 2023), the role of customary regulations *(awig-awig and pararem)* in managing complex land tenure arrangements under intense global pressure remains insufficiently explored. Accordingly, this study seeks to examine these dynamics by analyzing how customary institutions negotiate their continuity amid the most intensive tourism-driven land conversion in Bali.

LITERATURE REVIEW

The Impact of Tourism on Land Use Change

Land use change is commonly understood as a dynamic process shaped by human intervention in response to socio-economic needs (Arsyad, 1989). In tourism-oriented regions, this process often accelerates as land is increasingly reallocated to support accommodation, infrastructure, and leisure facilities. In Bali, tourism has been consistently identified as a major driver of land conversion, particularly through the expansion of built-up areas at the expense of agricultural landscapes.

Empirical studies have already documented a substantial transformation of land use patterns across the island. As-Syakur (2011) and Rimba (2020) demonstrate a steady increase in constructed areas accompanied by the rapid conversion of productive paddy fields into tourism-related land uses. This trend is particularly evident in emerging tourism zones, where spatial development tends to occur faster than formal planning controls. In Canggu

Village, for instance, the proliferation of villas, homestays, hotels, and entertainment facilities illustrates how tourism demand directly reshapes rural land use (Kartika et al., 2020).

Economic considerations play a central role in this transformation. Tourism offers higher and more immediate financial returns compared to agriculture, motivating local landowners to lease or repurpose their land for tourism activities (Dipayana & Sunarta, 2015). While this shift provides short-term income opportunities and contributes to local livelihoods, it also alters long-established land-use practices and weakens the agrarian foundation of rural communities.

However, the literature also highlights growing concerns regarding the sustainability of such land conversions. The loss of agricultural land not only threatens local food systems but also increases environmental vulnerability through reduced green open spaces and ecosystem services. These findings underline the importance of balancing tourism-driven development with environmental protection and long-term land-use sustainability. Without effective planning and governance, tourism expansion risks undermining the ecological, social and cultural foundations that originally make destinations like Bali attractive.

TOURISM IMPACT ON LOCAL COMMUNITIES RELATED TO LAND USE CHANGE AND LAND TENURE PATTERN

A review of literature on the impact of tourism on local communities, specifically concerning land use change and land tenure patterns, was drawn from various previous studies and is presented in the following table.

Table 1: State of the Art about Tourism Impact on Local Communities

Aspect	State of the Art	Source
Environment	Agricultural land is often converted into tourism areas, which can reduce the land available for food production and disrupt local ecosystems.	Kunto, 2018
	Land conversion is often not accompanied by proper spatial planning, leading to environmental problems such as flooding and damage to local ecosystems	Sari et al (2016)
	Uncontrolled land-use activities for development create impermeable surfaces that disrupt hydrological balance and increase runoff.	Ata et al. (2023)
	Human exploitation of land for socioeconomic gain is a continuous process that often leads to a loss of biological diversity.	Latip et al. (2022)
	Tourism can be an effective tool for regional development, increasing income and creating local jo	Mitchell, J. & Ashley, C. (2010)

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Aspect	State of the Art	Source
Economy	Land conversion in Bali leads to changes in the local socio-economic structure, from farmers to workers in the tourism sector, which can sometimes be detrimental to their long-term welfare	Nurhadi (2010)
	Land conversion in developing countries often benefits large investors but disadvantages small farmers and local communities	Bakker, M. & Messerli, P. (2017)
	Large companies and travel agencies often reap greater benefits than the local population	Scheyvens, (2011).
Social and Culture	Land use for tourism in rural areas brought about complex socio-economic changes, including changes in land ownership and community structure	Torre, A. & Scarborough, H. (2017)
	Tourism development can result in the displacement of local communities and changes in settlement patterns, affecting social cohesion.	Hall, C. M. (2009
	The conversion of land for tourism often leads to significant changes in land ownership structures and livelihoods, with many locals transitioning from agriculture to tourism jobs, which in turn impacts their cultural identity and traditions.	Movono, Dahles, & Becken (2017)
	Rapid spatial transformation and road expansion can surround and obstruct the facades of sacred/heritage buildings.	Agustina et al. (2023)

Source: Various Source

RESEARCH METHODOLOGY

This study adopts a mixed-methods approach that integrates quantitative data from structured survey questionnaires with qualitative insights obtained through in-depth interviews, Focus Group Discussions (FGDs), and direct field observations. Canggu Village, Bali, Indonesia, is selected as the study area due to its position as a critical case of rapid and ongoing land-use transformation driven by tourism development.

Primary data were collected using a structured questionnaire administered to 108 respondents residing in Canggu Village. The sample size was calculated using the Slovin formula based on a total population of 7,027 residents, applying a 10% margin of error, which indicated a minimum requirement of 99 respondents. All 108 valid responses (100%) were included in the analysis and form the basis of the findings presented in this paper. To support the validity of the analysis, the socio-demographic characteristics of the respondents are summarized in the following table.

Table 2: Residency Status of the respondents

Residency Status	Frequency	Percentage
Indigenous residents of Canggu Village	46	42,6%
Balinese Hindu residents	36	33,3%
Balinese (non-Hindu) residents	10	9,3%
Non Balinese and non Hindu residents	2	1,9%
Foreign nationals	14	12,9%
Total	108	100%

Table 3: Main occupation of the respondents

Main Occupation	Frequency	Percentage
Business owner/entrepreneur	44	40,7%
Managerial/administrative staff	35	32,4%
Others	29	26,9%
Total	108	100%

To strengthen the qualitative analysis of land tenure policies, in-depth interviews were conducted with 18 key stakeholders who possess direct experience and decision-making authority in the governance of Canggu Village. The selection of these respondents was based on their institutional roles, knowledge of local land governance, and involvement in tourism-related development processes. A summary of the interviewees' profiles and institutional affiliations is presented in Table 4.

Table 4: List of Interviewed Stakeholders (Qualitative Data)

Stakeholder Category	Position / Expertise
Local Government	*Perbekel* (Village Head) and Secretary of Canggu
Traditional Authority	*Bandesa Adat* (Head of Customary Village)
Traditional Authority	*Kelian Adat* (Hamlet Chiefs) from 7 Banjars
Security Authority	*Ketua Pecalang* (Head of Customary Security)
Agriculture Authority	*Pekaseh* (Head of Subak Umalas)
Planning Authority	*Bappeda* Badung Staff (Regional Infrastructure)
Private Sector	Property Managers and Agents in North Kuta

In addition to individual interviews, a Focus Group Discussion (FGD) was conducted with 30 participants to further triangulate findings related to land conversion and its socio-cultural impacts. The FGD involved representatives from BUPDA (Customary Village-Owned Enterprise), Pakis (Women's Customary Group), and local community leaders, ensuring that multiple perspectives within Canggu Village were adequately represented.

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Secondary data were compiled from time-series land-use maps covering the period 2000–2022, historical satellite imagery obtained from Google Earth, and official regional and local development planning documents. To support clarity for international readers, the Indonesian planning instruments referenced in this study are briefly defined in the following section.

- RPJPD: Rencana Pembangunan Jangka Panjang Daerah (Long-Term Regional Development Plan).
- RPJMD: Rencana Pembangunan Jangka Menengah Daerah (Medium-Term Regional Development Plan).
- RTRW: Rencana Tata Ruang Wilayah (Regional Spatial Plan/Zoning Law).
- RDTR: Rencana Detail Tata Ruang (Detailed Spatial Plan).
- RIPPDA: Rencana Induk Pembangunan Kepariwisataan Daerah (Regional Tourism Development Master Plan).
- RPJMDes: Rencana Pembangunan Jangka Menengah Desa (Village-level Medium-Term Development Plan).

The analysis employed three main methods. Firstly, descriptive-qualitative analysis was used to interpret the survey results and interview transcripts. Secondly, land-use change analysis was performed through map overlay techniques using satellite imagery to identify spatial shifts. Lastly, content analysis was applied to the customary regulations (*awig-awig and pararem*) to evaluate how traditional rules respond to modern land tenure pressures.

ANALYSIS AND DISCUSSION

Land Use Change in Canggu Village

Canggu Village is located in the North Kuta District, Badung Regency, Bali, Indonesia (Figure 1).

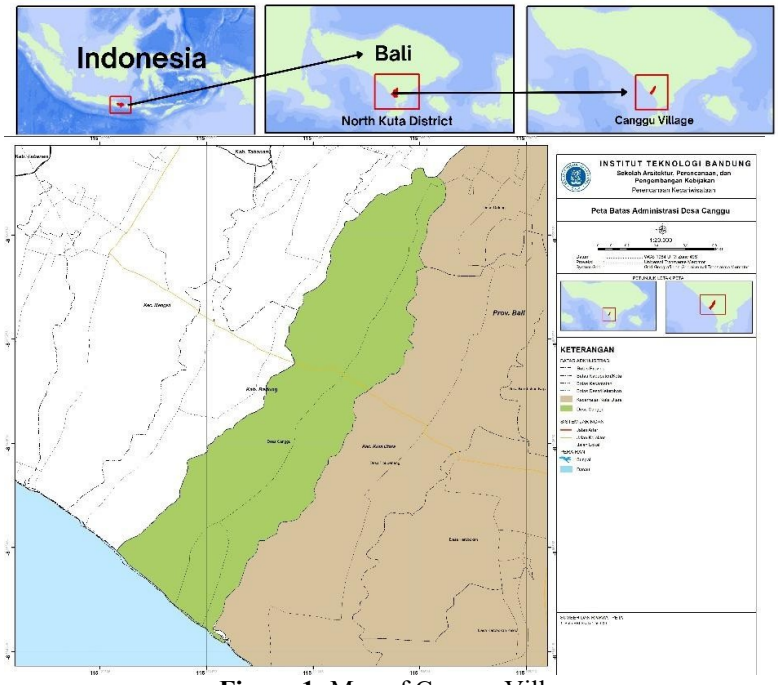


Figure 1: Map of Canggu Village
Source: Rupa Bumi Indonesia

The total area of Canggu Village is 524 hectares, with 211.5 hectares allocated for rice fields, 312.38 hectares for dry land, and 0.13 hectares for public facilities. Canggu Village is known as an agrarian area. However, over time, agricultural land in Canggu Village has been converted into built-up areas. Data on the reduction of agricultural land in Canggu Village is shown in the following figure.

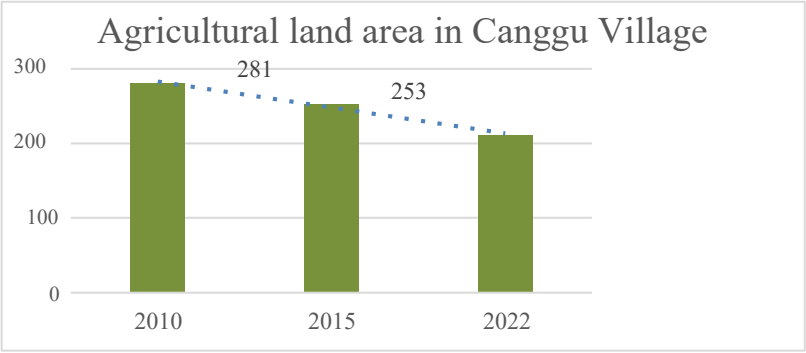


Figure 2: Agricultural land area in Canggu Village
Source: BPS-Statistics Indonesia, 2024

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Google Earth satellite imagery shows a clear transformation of agricultural land in Canggu Village from 2012 to 2022. In 2012, Canggu Village was still largely dominated by agricultural land, with rice fields forming the main landscape and only limited residential development. Starting around 2015, residential expansion along Jalan Subak Canggu began to reduce agricultural areas, a trend that intensified between 2018 and 2019 with the emergence of tourism-related developments such as hotels, restaurants, coffee shops and villas. By 2020 and 2021, agricultural land had become increasingly constrained as residential and tourism uses expanded further. By 2022, most agricultural land had been converted, resulting in a dense concentration of residential settlements and tourism facilities across the village.

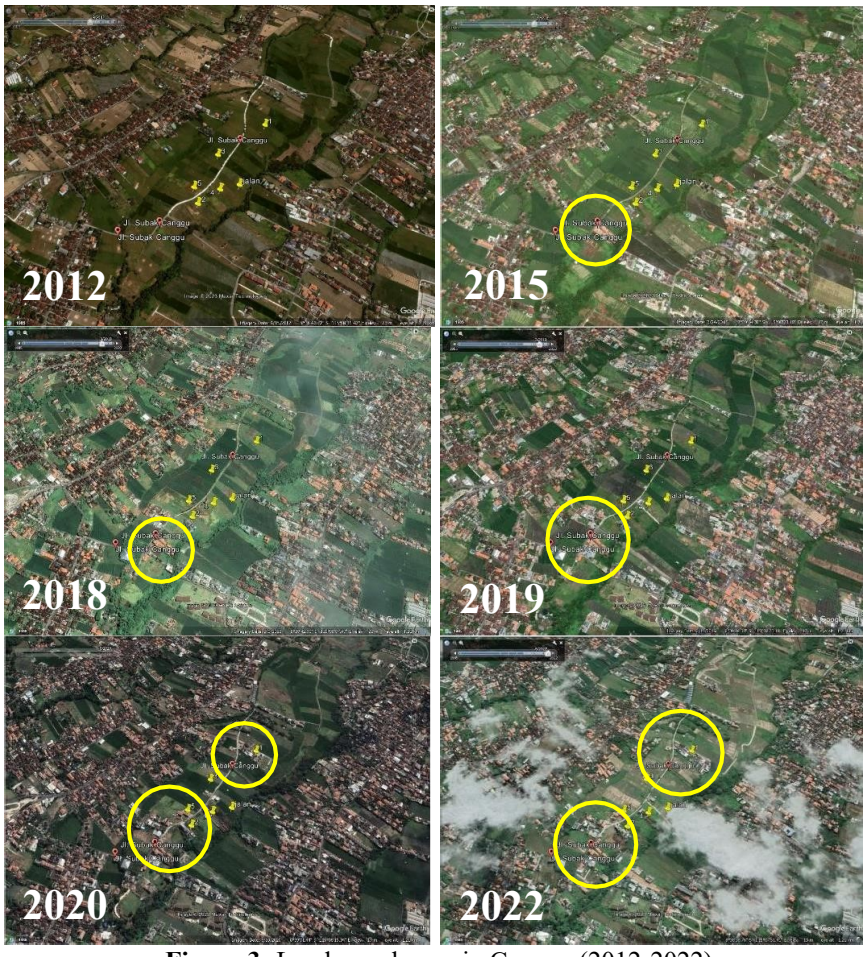


Figure 3: Land use change in Canggu (2012-2022)
Source: Google Eart

Land and Building Ownership Patterns

The survey of 108 business operators—ranging from large-scale villa developers to small traditional shopkeepers—shows that land ownership in Canggu Village largely remains with local residents, while operational control has increasingly shifted to investors. Both domestic and foreign investors are widely involved in developing villas and guesthouses on rented land, primarily through long-term lease arrangements of 25–30 years. Under this arrangement, an anthropocentric market logic dominates: local landowners benefit from immediate rental income but relinquish functional control over their ancestral land for extended periods.

Awareness of Customary Land Laws and the Knowledge Gap

The findings also reveal a notable knowledge gap regarding customary land governance. Nearly half of the respondents (48.8%) were unaware or uncertain about customary regulations (*Awig-Awig* and *Pararem*) related to building construction, while 50% expressed uncertainty regarding rules governing land buying or renting. Cross-tabulation analysis indicates that this lack of awareness is strongly associated with recent demographic changes, as non-indigenous actors—comprising non-local Balinese residents and foreign nationals—account for 57.4% of the respondents in this group. In contrast, indigenous residents generally demonstrate a stronger understanding of customary spatial principles, whereas non-indigenous stakeholders tend to approach land primarily as an economic asset, often overlooking traditional spatial orientations and sacred temple zones.

Networking Tourism Demand and Multidimensional Impacts

The transformation of Canggu Village is shaped by a complex network of causal relationships in which global tourism demand increasingly exerts pressure on local ecological and social systems, as summarized in Figure 2.

A) Environmental Impact: Challenges to *Palemahan*

Within the Balinese cosmological framework, Palemahan represents the principle of harmony between humans and the natural environment. In Canggu Village, however, the rapid shift toward an anthropocentric tourism economy has generated a form of spatial pressure that disrupts this balance. As illustrated in Figure 4, global tourism demand triggers a chain of development needs—such as luxury villas, lifestyle facilities, and improved accessibility—that directly compete with agricultural land.

This systemic pressure is strongly reflected in local perceptions, as 65.7% (71 out of 108) of business operators reported a significant reduction in green open spaces due to tourism expansion. A clear example of this interconnected demand is the construction of the “Canggu Shortcut,” which was

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developed as an emergency response to increasing traffic congestion caused by tourist mobility. Paradoxically, this infrastructure project required the conversion of productive rice fields, reinforcing a vicious cycle in which tourism-supporting infrastructure further accelerates environmental degradation.

The cumulative effect of this process is the fragmentation of the Subak irrigation system. As commercial developments interrupt traditional water channels, the remaining 211.5 hectares of agricultural land—down from 281 hectares in 2010—become increasingly isolated and difficult to sustain. Consequently, environmental challenges in Canggu extend beyond the mere loss of land area, reflecting the gradual dismantling of the socio-ecological system that underpins the Tri Hita Karana philosophy.

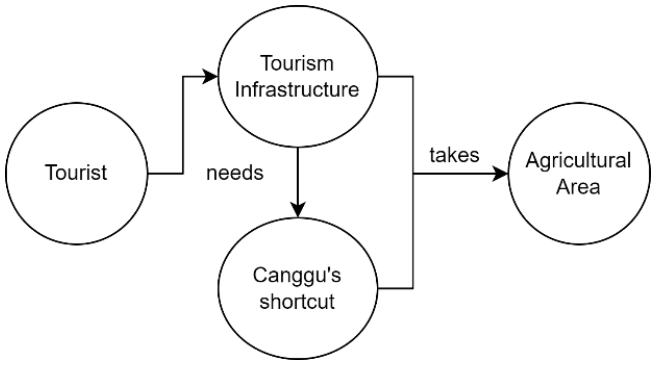


Figure 4: Networking tourism demand and needs of agricultural area
Source: Author's analysis (2024)



Figure 5: Canggu Shortcut at *Subak* Umadesa
Source: Author's documentation (2023)

B) Economic Impact: Structural Shifts in *Pawongan*

Pawongan focuses on harmony among humans, including economic relations. The networking of tourism demand has shifted the local labor structure. Out of the total 108 respondents, 88 stated that tourism has led community members to work in the tourism area of Canggu Village, and 72 respondents indicated that

local communities have started businesses or are selling goods around that area. The community's jobs have shifted from farming and fishing to working in the tourism sector; they have opened guest houses, food stalls, shops, spas, and motorbike rentals. This situation has improved their local economy.

However, on a larger scale, investors gain much more profit than the local community. Investors lease land from residents and construct buildings on it; they also manage the business and employ local labor. So, although the community also receives economic benefits from tourism, they actually get only a small portion of those benefits. If this continues in the long term, foreign investors will dominate the land in Canggu Village and further limit opportunities for the community to advance their local economy.

C) Social and Cultural Impact: Erosion of Tradition and *Parahyangan*

Within the *Tri Hita Karana* framework, Parahyangan governs the relationship between humans and the divine, including ritual practices and sacred spatial orders such as *Sanga Mandala* and Radius of Pura Holiness *(Jarak Kesucian Pura)*. The findings indicate that Canggu's rapid tourism-driven transformation has increasingly disrupted this spiritual balance. The transition from agriculture to tourism-based livelihoods has reduced active gotong royong, as residents tend to substitute physical participation in rituals with monetary contributions, weakening communal bonds *(Pawongan).* At the same time, rapid land conversion has encouraged the desacralization of customary arts, with sacred performances such as *Barong* Dance and *Kecak* Dance frequently detached from their ritual context and repurposed for commercial entertainment. This erosion is further intensified by the dominance of non-local stakeholders (57.4%), whose limited awareness of customary spatial principles has contributed to modern developments encroaching upon sacred zones. Without effective intervention, Canggu risks losing not only its environmental character but also the sacred atmosphere that forms the core of its cultural identity.

Comparative experiences from other Balinese tourism destinations demonstrate that such impacts are not inevitable. In Ubud, several customary villages *(desa adat)* have enforced stricter customary regulations to establish customary green belts *(jalur hijau adat),* which are respected by both local communities and investors to preserve the area's "back-to-nature" identity (Sutantri & Wijaya, 2021). A more robust example is found in Desa Adat Panglipuran, where a strict customary zoning system based on the *Tri Mandala* concept grants the customary villages full authority over land use, successfully preventing commercial intrusion into sacred and conservation areas, including protected bamboo forests (Ariani et al., 2022; Sudarmi et al., 2023). These cases highlight the role of strong and unified customary leadership as an effective gatekeeper against the negative externalities of global tourism.

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In contrast, Canggu's current development trajectory is marked by fragmented and organic growth, lacking a comparable gatekeeping mechanism. Moving forward, Canggu must shift beyond passive land leasing toward a negotiated development model, similar to Jatiluwih, where tourism activities remain secondary to Subak preservation through profit-sharing arrangements that incentivize farmers to retain their land (Pickel-Chevalier, 2021). Recent spatial studies further emphasize that safeguarding Canggu's anthropocosmic identity requires the formal integration of customary spatial regulations into the government's RDTR (Detailed Spatial Plan) through digital mapping, ensuring that global influences—such as the "New Moscow" phenomenon—are effectively aligned with local spiritual and ecological principles (Pradana et al., 2023; Suryawan et al., 2022).

CONCLUSION

This study demonstrates that tourism-driven land conversion in Canggu Village has generated multidimensional impacts on the local community, encompassing environmental, economic, and socio-cultural dimensions. The reduction of agricultural land, increasing traffic congestion, and the loss of green open spaces reflect the environmental pressures accompanying rapid tourism growth. At the same time, tourism development has created new employment and business opportunities, offering alternative livelihood options for indiginous residents.

Despite these benefits, the economic gains experienced by the local community remain considerably lower than those captured by investors. This imbalance indicates that the prevailing tourism development model in Canggu has yet to deliver equitable and sustainable outcomes. Beyond economic concerns, the study also identifies significant socio-cultural shifts, including declining community participation in traditional practices and ceremonies, which pose a long-term threat to the preservation of local values and cultural identity.

To address these challenges, several policy directions are essential. First, the role of Desa Adat must be strengthened by granting greater authority in spatial planning and land-use regulation, enabling a more balanced negotiation between tourism development, environmental protection, and cultural preservation. Second, land ownership and land-use regulations should more affirmative and more transparent to safeguard indiginous rights and limit the excessive dominance of foreign investors. Third, community empowerment programs need to be expanded to encourage more active local involvement in tourism management, particularly in areas such as business operations, marketing, and cultural conservation. Finally, tourism development in Canggu Village should be redirected toward a sustainable tourism framework that minimizes environmental and cultural degradation while ensuring more equitable benefit distribution.

Through the implementation of these measures, tourism development in Canggu Village can be better aligned with local cultural values and environmental sustainability, allowing tourism to function not only as an economic driver but also as a mechanism for long-term community well-being.

ACKNOWLEDGEMENT

The authors gratefully acknowledge Institut Teknologi Bandung (ITB) for the financial support provided through research grant No. 659a/IT1.C08/TA/2023. We also extend our sincere appreciation to the Canggu Village Administrative Office and the Canggu Customary Authorities (Desa Adat) for granting official permission and facilitating access to essential primary data, including land-use information, historical records, and customary regulation documents (*Awig-Awig* and *Pararem*).

We are further thankful to the 108 local entrepreneurs and business operators in Canggu Village who generously contributed their time and perspectives by participating in the survey, without which this study would not have been possible.

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Received: 2nd April 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 16 – 31

ADAPTIVE REUSE OF HISTORIC HERITAGE BUILDINGS IN GUANGZHOU, CHINA: RETHINKING SUSTAINABLE DEVELOPMENT THROUGH CASE STUDIES

Ma Yuancheng[1], Ruhizal Roosli[2*]

[1,2] *School of Housing, Building and Planning,*
UNIVERSITI SAINS MALAYSIA, PENANG 11800, MALAYSIA

Abstract

With the rapid advancement of urbanisation, the digital age's demands on historic heritage buildings have put pressure on and created challenges for Guangzhou (China)'s historic heritage buildings. This study investigates the adaptive reuse of three key Guangzhou heritage sites, Chen's Lineage Hall, Sai Kwan Mansion, and Sun Yat-sen Memorial Hall, to understand their contribution to urban sustainable development and future trends. We evaluate their new uses in modern cities and their comprehensive environmental, economic, and social impacts. Findings indicate that while Guangzhou has progressed in heritage protection and reuse, adaptive adjustments are necessary to meet contemporary demands. The current reuse process, though diverse, lacks international perspectives. This paper recommends policy improvements, drawing lessons from successful international cases like the Tate Modern Museum, and addressing digital age requirements to foster sustainable development of historic heritage buildings. Through strategic planning, Guangzhou's historic heritage buildings can preserve their historical value, enhance their role in urban development and socio-cultural activities, and boost their social status. Protecting and innovating cultural values will further economically benefit, aiding Guangzhou and other cities in revitalising cultural heritage within a global context, promoting harmonious economic, social, and cultural growth.

Keywords: Adaptive reuse, Historic heritage buildings, Sustainable development

[2] Corresponding author. Email: ruhizal@usm.my

INTRODUCTION

The global preservation and reuse of built heritage is a growing trend, guided by international conventions such as the 1972 Convention Concerning the Protection of the World Cultural and Natural Heritage (Kahvecioğlu & Arslan Selçuk, 2023). These frameworks ensure the preservation of physical structures, history, and cultural narratives, exemplified by projects like St. Vincent de Paul Church in Brooklyn and London's Tate Modern. In Guangzhou, *the 2015 Regulations for the Protection of Famous Historical and Cultural Cities* provide legal and policy support for heritage conservation, promoting sustainable use and overall cultural protection. These regulations emphasise the importance of conservation and provide specific management measures and conservation methods to promote the sustainable use of historic heritage buildings and the overall protection of the city's cultural heritage.

Guangzhou, situated in southern China, is an ancient city with a history spanning over 2,200 years. It was also the main terminus of the ancient Silk Road and has been an important commercial centre in China since ancient times (Lin et al., 2022). These structures not only symbolise the city's cultural identity but also drive sustainable urban development by retaining historical value and boosting economic vitality and community engagement. For instance, Chen's Lineage Hall attracts numerous tourists and locals through cultural events, fostering cultural and economic growth.

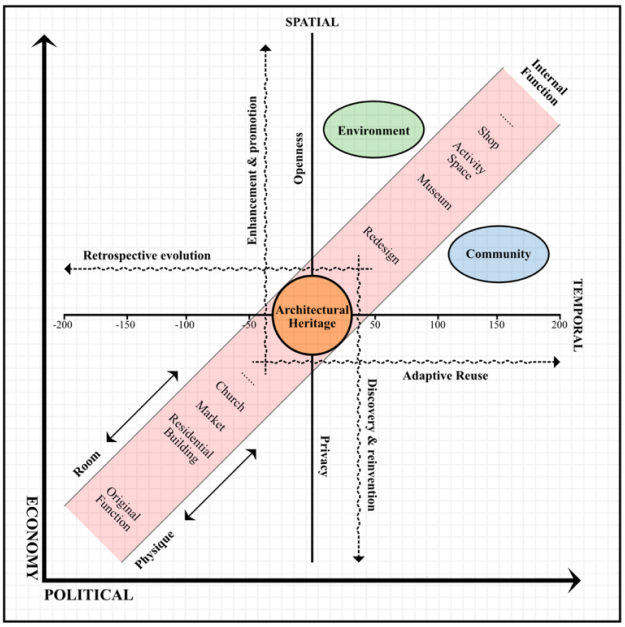


Figure 1: Conceptual model of sustainable development research in Adaptive Reuse
Source: Author's Designed and Self-made

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Despite these efforts, rapid urbanisation poses challenges to Guangzhou's historic heritage buildings, particularly due to the high demand for land resources (Zhuang & Meng, 2021). The digital age further necessitates a re-evaluation of sustainable development strategies for these buildings (Ma et al., 2025). Chen's Lineage Hall, Sai Kwan Mansion, and Sun Yat-sen Memorial Hall serve as crucial case studies, demonstrating the balance between preservation and commercial pressures and their contribution to sustainable urban development through policy support and public awareness. This study employs a four-dimensional framework, Political, Economic, Temporal, and Spatial, to analyse sustainability issues in the adaptive reuse of Guangzhou's historic heritage buildings (Figure 1), aiming to address challenges in Guangzhou and similar cities.

The research model provides a multidimensional analytical framework for adaptive reuse, focusing on political, economic, spatial, and temporal axes. Historic heritage buildings are central, with their evolution and transformation explored along a timeline. The model illustrates how political and economic factors influence original functions and physical structures, including changes in economic value and political status. The temporal axis tracks evolution from original state to adaptive reuse, integrating heritage into modern urban contexts. The spatial axis highlights the building's openness, environmental relationship, and community impact. Adaptive reuse involves not only physical redesign but also functional contributions to the community. This model demonstrates how historic heritage buildings can adapt to modern needs while retaining original value, merging history with modernity to support urban sustainable development.

LITERATURE REVIEW

Adaptive Reuse of Historic Heritage Buildings

Adaptive reuse involves transforming existing buildings to meet new societal needs while preserving their historical and cultural values (Bullen & Love, 2011). This concept addresses sustainability in architecture and urban planning, aiming to preserve cultural values by redefining building use (Nik Hashim et al., 2024). Originally developed for resource sustainability in cultural heritage preservation, it revitalises old buildings. Adaptive reuse extends a building's lifespan and enhances its social, cultural, and economic value (Foster & Kreinin, 2020). Heritage preservation emphasises retaining original materials and structures while allowing modernisation for new uses.

The concept of adaptive reuse evolved through four stages (Figure 2). The early to mid-20th century was the embryonic stage, with foundational concepts developing as industrialisation led to abandoned urban facilities in Europe. These sites became redevelopment resources, laying the groundwork for adaptive reuse theory (Bullen & Love, 2011; Tam & Hao, 2019). The term

"adaptive reuse" was coined in 1937 but gained international attention three decades later.

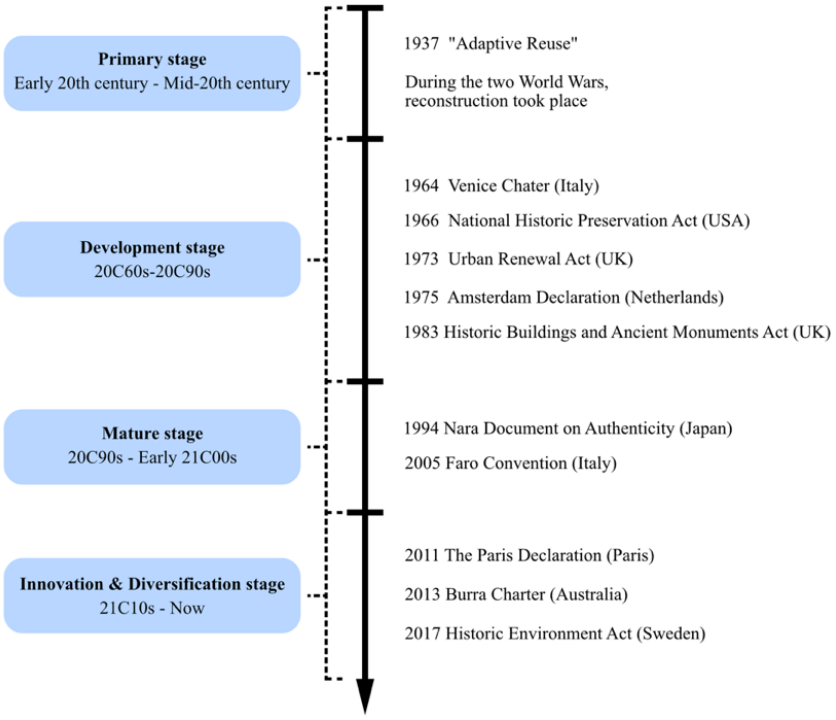


Figure 2: The development of the concept of "Adaptive Reuse"
Source: Author's Self-made

The second stage, from the 1960s to the 1990s, saw the concept's development and popularisation (Yarza Pérez, 2022). The 1970s environmental movement highlighted sustainable development, with adaptive reuse recognised for resource conservation and waste minimisation. *The 1964 Venice Charter* standardised cultural heritage protection methods. Subsequent acts and declarations, such as *the US National Historic Preservation Act (1966)*, *the UK Urban Renewal Act (1973)*, and *the 1975 Amsterdam Declaration*, provided legal frameworks and emphasised the social and use value of historic buildings (Vardopoulos, 2023).

Between the 1990s and early 2000s, adaptive reuse matured, driven by professionalised laws and regulations. Documents like *the Nara Charter (1994)* and *Faro Declaration (2005)* underscore its importance for urban development and cultural heritage preservation, emphasising reintegration into modern urban life while maintaining historical values (Baharuddin et al., 2022). In the 21st century, technological advancements have led to innovative and diversified

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adaptive reuse practices. Recent research highlights the multidimensional benefits of this approach, particularly in terms of environmental sustainability, by reducing construction waste and increasing energy efficiency (Bullen & Love, 2011; Hassan, 2023). Adaptive reuse also promotes social and economic development and contributes to environmental sustainability by creating shared cultural heritage communities, aligning with circular economy principles (Figure 2).

Urban regeneration, in the context of sustainable development, aims for a balance between economic, social, and environmental factors. Cultural heritage is increasingly recognised as a catalyst for urban regeneration, enhancing city identity and attractiveness (Ma & Roosli, 2025). Adaptive reuse of historic buildings is a key strategy, transforming underutilised structures into valuable community assets, thus promoting sustainable urban development.

Historic heritage buildings are structures of significant historical, architectural, cultural, or social value. They represent a tangible link to the past and are crucial for cultural identity and collective memory (De Gregorio et al., 2020). The scope of heritage has expanded from monumental structures to include vernacular architecture and industrial sites, reflecting diverse historical narratives.

Preservation and adaptive reuse of these buildings are essential for maintaining cultural continuity and promoting sustainable development. International charters like *the Venice Charter (1964)* and *the Burra Charter (1999)* provide principles for conservation, emphasising minimal intervention and authenticity. Adaptive reuse allows these buildings to meet contemporary needs while retaining their heritage significance, ensuring their continued relevance and contribution to urban life (Bullen & Love, 2011).

In Guangzhou, historic heritage buildings reflect its rich history as a major trading port and cultural hub. These include ancestral halls, traditional residences (like Sai Kwan Mansions), and colonial-era structures. Efforts to preserve and reuse these buildings are crucial for maintaining Guangzhou's unique urban character and promoting sustainable tourism and cultural development (Lau, 2020; H. M. Li & Lee, 2022). Challenges include balancing preservation with modernisation pressures and ensuring that reuse strategies are economically viable and socially inclusive.

RESEARCH METHODOLOGY

The objective of this research is to examine the adaptive reuse of historic heritage buildings in Guangzhou, China, emphasising their role in sustainable urban development. The study employs a qualitative methodology, conducting detailed case analyses of three significant sites: Chen's Lineage Hall, Sai Kwan Mansion, and Sun Yat-sen Memorial Hall. Each case highlights specific challenges and

successful practices, providing deep contextual insights into Guangzhou's adaptive reuse approaches.

This study employs a qualitative research approach, focusing on case studies to explore the adaptive reuse of historic heritage buildings in Guangzhou. The research framework, as introduced in the Introduction (Figure 1), guides the analysis through Political, Economic, Temporal, and Spatial dimensions. This multi-dimensional approach allows for a comprehensive understanding of the sustainability issues and contributions of adaptive reuse projects.

Data collection begins with a literature review establishing a theoretical basis on sustainable heritage preservation. Subsequently, the current status, functions, and community impacts of the selected buildings are examined, identifying commonalities and differences in their adaptive reuse processes. Additionally, a comparative analysis involving an internationally recognised example (Tate Modern) provides further insights, highlighting universal principles and localised strategies within adaptive reuse practices.

THE CLASSIC CASE OF ADAPTIVE REUSE IN GUANGZHOU, CHINA

Chen's Lineage Hall

Chen's Lineage Hall in Guangzhou, constructed from 1890 to 1894, covers 15,000 square meters, with buildings occupying 8,000 square meters. Funded by the Chen clan across 72 counties in Guangdong, it initially served as an ancestral shrine and educational academy, exemplifying traditional Lingnan architecture with nine halls, six courtyards, and promenades (Figure 3). The building is in the north-south direction, with a depth of 80 meters, and is a typical Lingnan courtyard pattern with nine halls, six courtyards, ten compartments, and promenade alleys. It is not only a masterpiece of architectural art but also carries rich cultural and historical connotations.

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Figure 3: Chen's Lineage Hall Plan
Source: Author's Self-made

The adaptive reuse of the hall spans five key stages. Initially repurposed from an exam hall to the Chen Industrial Academy in the late Qing to early Republican era, it continued serving educational roles through 1949 without major structural changes. From 1950 to 1980, it underwent partial restoration but suffered damage from industrial misuse, before full restoration in 1981 led to its reopening as a cultural site. Between 1980 and 2000, state support grew, earning it national relic status in 1988 and 4A tourist attraction recognition by 2008. Since 2000, the hall has embraced sustainable practices, digital innovation, and intelligent management, enhancing cultural engagement and global visibility.

Chen's Lineage Hall, now the Guangdong Folk Crafts Museum, has become a significant cultural and tourist attraction in Guangzhou through adaptive reuse, drawing substantial visitor numbers and economic revenue. Within a 0.5-km radius, it is surrounded by 63 neighbourhoods, 23 offices, 8 shopping malls, 6 hotels, 123 public facilities, and 91 educational institutions, supporting a dense residential population. In 2023, visitor numbers reached a record 1.88 million, up approximately 30% from 2019. Annual ticket revenue was 12.2 million yuan, with cultural product sales exceeding 10 million yuan. This tourism boom has stimulated local dining, accommodation, retail, and related creative industries.

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Table 1: Data Sheet on the Surrounding Situation of Chen's Lineage Hall.

Population			
Size (Thousand)	119.3	Density (People / km²)	151897
Community			
Number	63	Households	29372
Office Building			
Number	23	/	/
Commercial Facilities			
Commercial street	/	Shopping centre	8
Hotel Facilities			
Youth hostel	/	Star hotel	1
Chain hotel	3	Rest house	2
Public Facilities			
Traffic	80	Bank	23
Hospital	20	/	/
Educational Facilities			
Kindergarten	5	Primary school	2
Middle school	2	Education & Training	82

Source: Author's Calculation and Self-made

Culturally, adaptive reuse transformed Chen's Lineage Hall into a museum showcasing traditional Lingnan crafts, employing digital exhibitions to enhance educational impact. Economically, it boosted local businesses and community prosperity through increased tourism. Socially, it evolved from a purely cultural site to a multifunctional community hub, offering diverse activities and educational programs that significantly improved local cultural life and community cohesion.

Sai Kwan Mansion

Sai Kwan Mansion, a prominent Qing Dynasty residence in Guangzhou's Xiguan (now Liwan District), exemplifies traditional Lingnan residential architecture. Built over 200 years ago, it features a symmetrical layout combining halls, patios, and gardens, predominantly constructed of brick, wood, granite, and green bricks (Figure 4). Originally numbering over 800, fewer than 10 complete examples remain due to extensive urban redevelopment and modernisation during the early Republic of China period.

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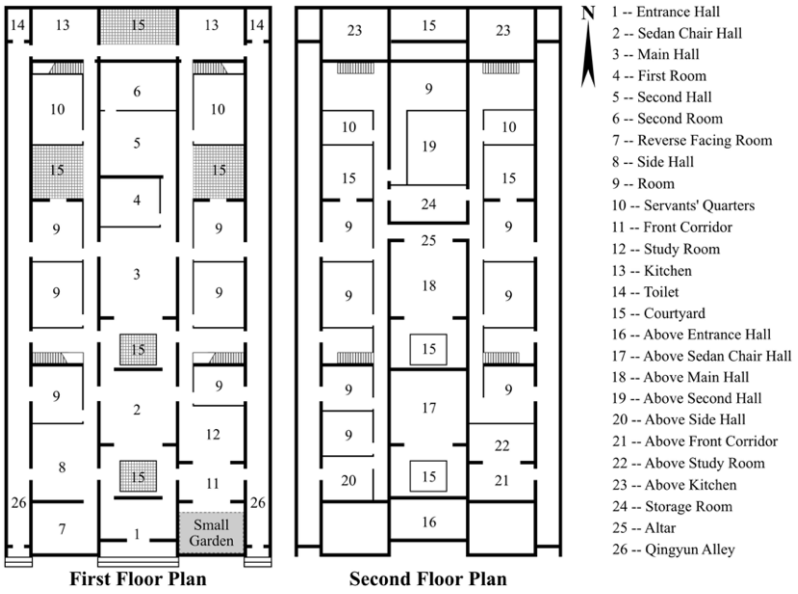


Figure 4: Plan of the main building of Sai Kwan Mansion in Guangzhou
Source: Author's Self-made

Sai Kwan Mansion's adaptive reuse unfolded in three phases. In the mid-20th century, early protection efforts amid urbanisation focused on structural repairs, preserving its architectural integrity. By the late 20th to early 21st century, comprehensive restoration and functional diversification, into museums, cultural parks, boutique hotels, and leisure zones like Enning Road, boosted cultural tourism and economic growth. In the 21st century, digital innovations such as intelligent inspection systems improved preservation and visitor experience, positioning the Mansion as a model for heritage conservation in the modern era.

Sai Kwan Mansion has been transformed into a cultural and creative park, introducing commercial businesses and cultural activities that have revitalised the community. This adaptive reuse has generated employment, enhanced the local economy, and enriched cultural life through exhibitions, lectures, and workshops. The creative industries foster a vibrant cultural atmosphere and improve residents' quality of life with better leisure and living environments.

Unlike the educational focus of Chen's Lineage Hall, Sai Kwan Mansion reflects traditional residential life and emphasises community-centred development. Within a 0.5-km radius, the area includes 30 neighborhoods, 70 public facilities, and 33 educational institutions, supporting a population of 63,700 with a density of 81,105 people/km² (Table 2). The project highlights the

role of community participation in achieving sustainable urban renewal, blending economic growth with cultural preservation in a livable, humanistic environment.

Table 2: Data Sheet on the Vicinity of Sai Kwan Mansion.

Population			
Size (Thousand)	63.7	Density (People / km²)	81105
Community			
Number	30	Households	15578
Office Building			
Number	6	/	/
Commercial Facilities			
Commercial street	1	Shopping centre	3
Hotel Facilities			
Youth hostel	1	Star hotel	1
Chain hotel	1	Rest house	3
Public Facilities			
Traffic	44	Bank	15
Hospital	11	/	/
Educational Facilities			
Kindergarten	5	Primary school	3
Middle school	2	Education & Training	23

Source: Author's Calculation and Self-made

Sun Yat-sen Memorial Hall

The Sun Yat-sen Memorial Hall, originally Sun Yat-sen's presidential office, completed in 1921 and later rebuilt from 1929 to 1931, commemorates Sun Yat-sen with a distinctive blend of Chinese palace and Western architectural elements. Occupying 60,000 square meters, it serves as a key venue for cultural activities in Guangzhou (Figure 5).

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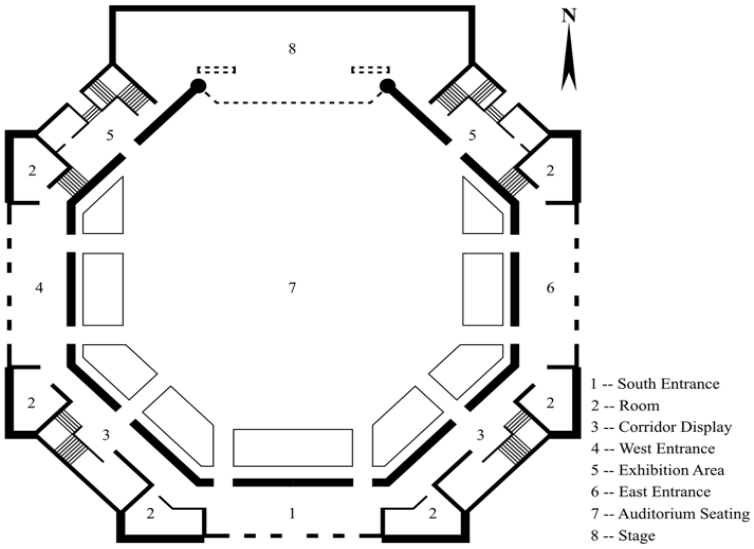


Figure 5: Plan of Sun Yat-sen Memorial Hall
Source: Author's Self-made

Sun Yat-sen Memorial Hall's adaptive reuse history includes three key phases. From the 1950s to 1990s, restoration efforts repaired structural damage, introduced historical displays, and modernised facilities, making it a prominent cultural and educational venue. Between 1998 and 2010, further upgrades enhanced infrastructure and exhibition spaces, expanding its role in cultural events and civic life. Since 2011, multimedia and interactive technologies have been added, enriching visitor experiences and reinforcing its status as both a tourist attraction and international cultural platform.

Compared to the other two cases, the Sun Yat-sen Memorial Hall distinctly maintains its original commemorative role while expanding into multifunctional public services, cultural exchanges, and tourism. It is surrounded by a resident population of 79,100 within a 0.5-km radius, with a density of 100,713 people/km² (Table 3). The area includes 20 office buildings, half of which are government-related, along with 94 public facilities such as hospitals and banks, and 12 educational institutions across all levels. Commercial facilities are limited, with only one shopping centre and three hotels. This relatively modest commercial scale reflects the Memorial Hall's solemn character and its avoidance of over-commercialisation. While it lacks strong entertainment or leisure functions, its adaptive reuse has maintained the building's cultural integrity and contributed to a stable, well-supported community environment.

Table 3: Data Sheet on the Vicinity of Sun Yat-sen Memorial Hall.

Population			
Size (Thousand)	79.1	Density (People / km^2)	100713
Community			
Number	37	Households	14633
Office Building			
Number	20	/	/
Commercial Facilities			
Commercial street	/	Shopping centre	1
Hotel Facilities			
Youth hostel	/	Star hotel	2
Chain hotel	1	Rest house	/
Public Facilities			
Traffic	68	Bank	17
Hospital	9	/	/
Educational Facilities			
Kindergarten	1	Primary school	1
Middle school	2	Education & Training	8

Source: Author's Calculation and Self-made

INTERNATIONAL SUCCESSFUL CASES AND EXPERIENCES

Tate Modern

The Tate Modern, a globally renowned museum of modern and contemporary art in London, exemplifies successful adaptive reuse. Originally the Bankside Power Station, it was transformed by Herzog & de Meuron in 1995, preserving its industrial exterior while modernising the interior (Logan, 2016). Today, it functions not only as an art museum but also as a hub for education, community engagement, and cultural tourism. Through a comprehensive digital strategy, Tate Modern has embedded digital capabilities across its operations, training staff, integrating digital tools into governance, and using metrics for content, engagement, and revenue. This digital transformation enhances both visitor experience and institutional efficiency.

Its adaptive reuse aligns with cases like Chen's Lineage Hall, Sai Kwan Mansion, and the Sun Yat-sen Memorial Hall in Guangzhou, all of which preserve historical identity while integrating modern functions. The Tate retained key industrial features (e.g., turbine hall and chimneys), similar to how Chen's Lineage Hall and Sai Kwan Mansion preserved Lingnan architectural elements. These sites now serve modern cultural and social roles, from education to tourism. Economically, all four sites have spurred local development through

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increased tourism, commerce, and services. Socially, they promote community engagement through exhibitions, educational programs, and public events, transforming once private or underutilised spaces into inclusive cultural assets.

However, the historical context and cultural environment have a profound impact on the remodelling strategies and effects. Western projects like Tate Modern often emphasise structural integrity and architectural symbolism while incorporating cutting-edge design. In contrast, Chinese projects focus more on cultural heritage transmission and community integration, e.g., Lingnan traditions at Chen's Lineage Hall or revolutionary history at the Sun Yat-sen Memorial Hall. In addition, Tate Modern also leads in environmental sustainability, employing energy-efficient systems and sustainable materials. Its expansions, such as the new 'Switch House' (now known as the Blavatnik Building) in 2016 has increased exhibition space and public facilities, further raising its profile in the international art world.

Therefore, both Western and Chinese cases illustrate the transformative power of adaptive reuse. While strategies differ due to historical, cultural, and economic contexts, they collectively demonstrate how heritage buildings can evolve into dynamic platforms for sustainable cultural, economic, and social development.

DISCUSSION

Jane Jacobs, in The Death and Life of Great American Cities, emphasised that reusing existing building stock can foster vibrant, diverse urban environments (Morel & Dorpalen, 2023). As sustainability becomes a core concern in architecture, incorporating new uses into existing structures has become a defining feature of contemporary design (Tam & Hao, 2019). From an urban development perspective, adaptive reuse serves as a key strategy to revitalise post-industrial areas, mitigate urban sprawl, and regenerate shrinking cities.

Globally, adaptive reuse projects like New York's High Line and Paris's Louvre demonstrate how historic preservation can simultaneously enhance a city's global image and improve residents' quality of life. Industrial heritage buildings, in particular, have become focal points in adaptive reuse research for their historical and technological significance, offering opportunities to retain cultural identity while adopting new, functional roles (De Gregorio et al., 2020).

A comparison of classic cases of adaptive reuse of historic heritage buildings in China and Western countries shows the gap between the two (Table 4). China focuses more on cultural heritage and community functions, utilising cultural connotations as a driver for development. In contrast, Western countries aim to transform historic heritage buildings into cultural or artistic centres with global impact. Tate Modern not only considers the inheritance and innovation of

history and culture but also global art exchange, sustainability, social responsibility, economic benefits, and urban development.

Table 4: Comparison of Tate Modern with Chen's Lineage Hall, Sai Kwan Mansion, and Sun Yat-sen Memorial Hall.

Aspect	Tate Modern	Chen's Lineage Hall	Sai Kwan Mansion	Sun Yat-sen Memorial Hall
Original Function	Bankside Power Station	Ancestral hall and Academy	Residential Buildings	Memorial and Assembly Hall
Location	London, UK	Guangzhou, China	Guangzhou, China	Guangzhou, China
Preservation Strategy	Retained industrial exterior, modernized interior	Preserved Lingnan architectural style	Preserved traditional Lingnan style	Preserved historical structure
Modern Adaptation	Modern art exhibitions, community and education centre	Cultural exhibition, tourist attraction	Cultural exhibition, community use	Modern exhibition and public service functions
Cultural Impact	Significant cultural destination, promotes modern art	Promotes Lingnan culture and attracts scholars	Showcases historical and cultural heritage	Educates about revolutionary history
Economic Impact	Boosts local economy through tourism	Increases tourism, boosts local businesses	Economic benefits through tourism	Economic benefits through cultural tourism
Community Engagement	Extensive public and educational programs	Cultural activities and heritage education	Community cultural events and education	Educational and commemorative activities
Digital Transformation	Comprehensive digital strategy, digital skills training	Limited digital transformation	Limited digital transformation	Limited digital transformation
Environmental Sustainability	Implemented energy-saving technologies	Focus on cultural and social sustainability	Focus on cultural preservation and modern use	Emphasis on historical and educational significance

Source: Author's Summarizes and Self-made

Stephen Hepworth highly praised Tate Modern for influencing London and the international art map, prompting other institutions to redefine their roles. Rem Koolhaas commented that its success lies not only in its design but also in its multiple cultural, social, and economic impacts. Tate Modern was established to support art and its value to society. Behind this is the Western emphasis on innovation, global art exchange, and international status. In China, adaptive reuse is more culturally and socially sustainable, whereas in Western countries, both environmental and economic sustainability are considered. This gives historic heritage buildings a more significant sustainability capability.

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CONCLUSION

This study examines the adaptive reuse of three landmark heritage buildings in Guangzhou, China. It evaluates their economic performance, social functions, and cultural vitality after conversion. The analysis also compares these cases with London's Tate Modern.

This study shows that Chinese examples protect heritage and benefit local communities. There are many similarities between these buildings in terms of preserving historical features and introducing modern uses. Meanwhile, the adaptive reuse of historical heritage buildings in China and the West not only differs in strategies and goals but also in processing techniques and functional settings. This result provides an important lesson for future research and practice in China and similar studies: that is, historic heritage buildings need to focus not only on the realisation of cultural heritage and community functions but also on innovation and global artistic exchanges in adaptive reuse renovation. By preserving and innovating cultural values, economic benefits can be further enhanced. In addition, sustainability needs to be considered in the transformation process, not only cultural sustainability, but also architectural and economic sustainability.

ACKNOWLEDGEMENT

This research received no external funding. Data are contained within the article. Thanks for the guidance provided by Dr Ruhizal Roosli during this research.

DISCLOSURE STATEMENT

The author declares that there are no conflicts of interest.

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Received: 2nd February 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 32 – 46

LAND USE SIMULATION TO FOSTER ENVIRONMENTAL SUSTAINABILITY OF THE RANU PANE VOLCANIC LAKE, INDONESIA

Syamsul Bachri[1], Rajendra P Shrestha[2], A. Riyan Rahman Hakiki[3], Mellinia Regina Heni Prastiwi[4], Nanda Regita Cahyaning Putri[5]

[1,4,5]*Department of Geography, Faculty of Social Sciences,*
UNIVERSITAS NEGERI MALANG, INDONESIA
[2]*Department of Development and Sustainability,*
ASIAN INSTITUTE OF TECHNOLOGY, THAILAND
[3]*Department of Geography Education,*
UNIVERSITAS LAMBUNG MANGKURAT, INDONESIA

Abstract

Sedimentation in the Ranu Pane Volcanic Lake (RPVL) has increased due to land use change (LUC) in the surrounding area and the considerable outflow of materials from the Semeru volcanic eruption. The continued sedimentation will have negative consequences for humans and the sustainability of the RPVL. This research was aimed at building a LUC simulation model for 2024-2036 using a land change modeler (LCM) with the Logistic Regression/Markov Chain algorithm and a built-up land scenario based on historical land use (LU) data to investigate future sedimentation. The secondary data were mosaics from Planet Labs® Norway's International Climate and Forest Initiative (NICFI) imagery, roads, rivers, slopes, elevation, rainfall, and soil types. The primary data collected through fieldwork for validation of the LU were processed using remote sensing and the Geographic Information System (GIS). The simulation model for 2024-2036 was built using the LU data for 2016, 2020, and 2024. The LCM model detected that there would be a decrease in forest area but an increase in built-up land and agriculture in the study area between 2024–2036. The findings indicate that the increased land area and agriculture around Mount Semeru will lead to further sedimentation. The study findings can help planners understand LU patterns and their impacts, which can be useful in designing sustainable lake development strategies and management plans for the area.

Keywords: Land Change Modeler, Land Use Change, Ranu Pane Volcanic Lake, Semeru Volcano

[1] Corresponding author. Email: syamsul.bachri.fis@um.ac.id

INTRODUCTION

The Ranu Pane Volcanic Lake (RPVL) is located in the highest village enclave (2100 m above sea level) within the Bromo Tengger Semeru National Park (TNBTS) among hilly areas with remarkably productive soil. As the majority of the people (92%) living in Ranu Pane are farmers (Putri et al., 2022), therefore, this affects their way of life. Agricultural activities on the steep-sloping land have intensified due to population growth and strong demand for agricultural land in the TNBTS (Maulana et al., 2021). Consequently, Ranu Pane is prone to erosion and sedimentation, giving rise to siltation. Rapid land use change (LUC) and unsustainable agricultural practices threaten the sustainability of the RPVL, especially during the rainy season.

Sedimentation in the RPVL is caused by erupted materials and the LUC in agriculture and settlements (Suharto et al., 2023). In addition, agricultural activities are the main cause of the high sedimentation in the RPVL. The management pattern for the agricultural land has changed from terraced to vertical farming. Trees have been replaced with crops to ecologically prevent erosion. Therefore, water carrying soil material flows directly from upstream agricultural areas to the RPVL downstream (Smith et al., 2017). Due to its ecological aspects, the TNBTS can be used as a conservation enclave. However, from a socio-economic perspective considering the livelihoods of the community, this has resulted in the LUC not being in keeping with the principles of conservation.

According to a study carried out by the Japan International Cooperation Agency (JICA) in Ranu Pane, the soil material that is taken away is made up of the topsoil from agricultural land on a 45° sloping hill. Another factor that contributes to sedimentation in the RPVL is the Green Revolution, which has led to the use of chemical fertilisers to boost agricultural output (Putri et al., 2022). Changing land characteristics combined with high rainfall contribute to the erosion and sedimentation processes that have resulted in the narrowing and siltation of the RPVL. This condition indicates that comprehensive and sustainable lake planning and management efforts are needed.

The rehabilitation of the RPVL poses a significant challenge to land management, given Indonesia's growing concern over its commitment on a worldwide scale to preserve the sustainability of the ecological functions of the lake. This is based on the Sustainable Lake Management Draft Resolution that was presented at the United Nations Environment Assembly (UNEA 5.2). This resolution has been integrated with the Sustainable Development Goal (SDG) 6 to protect water ecosystems, especially lakes. Indonesia's commitment was then implemented at the 10th World Water Forum in 2024, resulting in a ministerial declaration proposing the establishment of World Lake Day as a concrete manifestation to save critical lakes worldwide (Kemenparekraf, 2024).

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Numerous studies on lake planning and management have been carried out, yielding many important conclusions. For example, Cao et al. (2021) highlighted the importance of an ecosystem approach to lake management, which includes understanding the interactions between various ecosystem components, such as water, soil and biota, and the influence of human activities on the balance of these ecosystems. Brown et al. (2018) emphasised that adaptive management involving local stakeholders can help in adapting conservation strategies to changing environmental conditions and ensuring long-term sustainability. Turner and Gardner (2015) mapped the LUC around Lake Tahoe and identified significant sources of sediment and nutrient pollution.

This study was designed to address the gap in the application of spatial mapping techniques that have not been commonly employed in sustainable lake planning and management. An LCM is a model that can be used to predict the past and future effects of LU on sedimentation. The LCM model provides a more thorough method and excellent anticipated accuracy by dynamically adjusting the parameters in response to real-time data. To foresee the growing possibility of siltation due to sedimentation in the RPVL, this research aimed to construct a simulation model of LUC from 2024–2036 using a land change modeler (LCM) with a Logistic Regression algorithm and a built-up land scenario based on historical LU data. The findings of this research can be used as a consideration in the management of land and agricultural areas and in efforts to restrain the sedimentation rate in the RPVL.

LITERATURE REVIEW

Land Use (LU) and Its Dynamics

The dynamics of LUC are considered a significant factor that contributes to environmental degradation, The problem of LU dynamics in various parts of the world has generally had an impact on multiple aspects of life, such as on the demand for crop water for agricultural practices in various countries, hydrological responses (Sujana et al., 2024), biodiversity (Masolele et al., 2024), and disasters (Satir et al., 2023). Studies indicate that the landscape or LUC at local and regional scales is often driven by the consequences of biophysical variables (climate and extreme events) and human factors (demographic, institutional, and cultural), and a complex mosaic of anthropogenically induced natural patches that vary in size, shape, and arrangement (Faheem et al., 2024). Therefore, it is very important to analyse LU and LUC to understand the environmental, social, and ecological impacts.

Land Change Modeller (LCM)

One of the most popular approaches for analysing LU over time and predicting LUC distribution is modelling. An LCM is a model that allows users to obtain

information about potential patterns of LU and its consequences across the study area for various purposes (Wiwoho et al., 2024). While some LCMs have weaknesses, such as the complexity of environmental dynamics, data uncertainty and difficulty in predicting human decisions that impact LUC, an LCM can offer a more integrated approach, improving the accuracy of predictions and dynamically adjusting parameters based on actual data (Bachri et al., 2024).

Land change modeller (LCM)-based research is widely used around the world for various case studies, such as in studies on the control of surface water pollutants (Motovalibashi Naeini et al., 2024), disasters (Bachri et al., 2024), urban growth (Badshah et al., 2024), and water resources (Haider & Rashid, 2024). Based on the research conducted, the LCM is a very effective method for analysing and predicting LU around the lake to support environmental management and sustainable spatial planning. It allows researchers to identify patterns of LUC, analyse the factors that influence them, and predict long-term impacts on lake ecosystems.

RESEARCH METHODOLOGY

This research was conducted at the RPVL, which is administratively located in the Senduro subdistrict, Lumajang Regency. The RPVL, which is located at latitude 8°0'45.7" south and latitude 112°56'45.6" east with an area of 1.0 ha, is within the TNBTS. The research steps and location are shown in Figures 1 and 2, respectively.

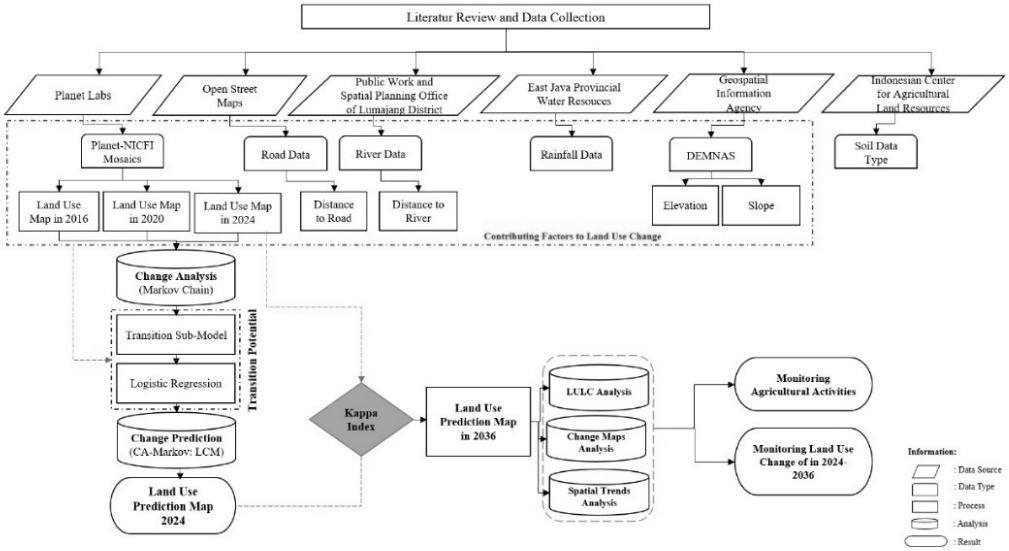


Figure 1: A Flow Chart of the Research

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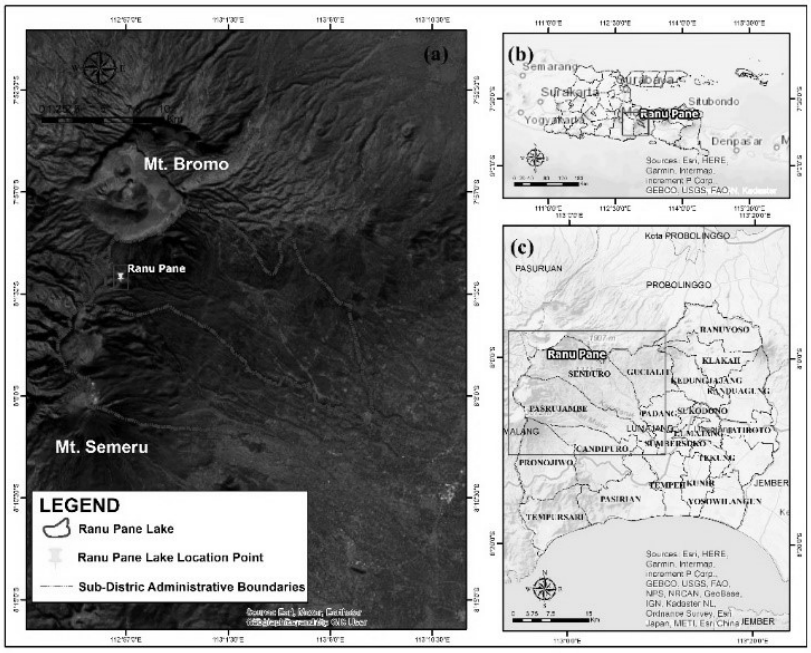


Figure 2: The Research Location

Data Collection

This research used primary and secondary data. The primary data was used as the validation data for LU, while the secondary data, such as rainfall, elevation, slope, roads, rivers, and soil types, was obtained from several agencies (Table 1).

Table 1: The research materials

No	Material	Source
1.	Planet Lab®-NICFI Mosaics	Planet Labs®
2.	Road data	Open Street Map (OSM)
3.	River data	Public Work and Spatial Planning Office of Lumajang District
4.	Slope	DEMNAS
5.	Elevation	
6.	Rainfall	East Java Provincial Water Resources Public Works Office
7.	Soil type	Indonesian Centre for Agricultural Land Resources Instrument Standard Testing (BBPSI SDLP)

Data Analysis

1. Land use (LU) data processing, classification, and validation

The data in this research used mosaics from Planet Labs® Norway's International Climate and Forest Initiative (NICFI) imagery, with a spatial resolution of 3-5 m, from recordings in 2016, 2020, and 2024, which were processed using Google® Earth Engine. A four-year interval was chosen because the mapping was based on a detailed scale, and the available data included Planet Labs® NICFI mosaics with a lower percentage of cloud distortion. The PlanetScope® Analytic had four bands, including three visual bands (RGB) and near-infrared, and it was orthorectified and calibrated to sensor radiance.

The LU classification in this study was done using the Classification and Regression Tree (CART) algorithm integrated with Google Earth® Engine cloud computing. The CART model is a machine learning algorithm that is widely used in land cover classification (Feizizadeh et al., 2023). Regarding the validation of the LU map, an accuracy assessment was carried out using the confusion matrix by utilising Google Earth® Engine cloud computing. The accuracy obtained in 2016 was 0.8116, in 2020 was 0.8561, and in 2024 was 0.8154. Then, the map results were compared with the results of the ground checking that was carried out with 216 validation points of LU scattered in the Senduro and Pasrujambe subdistricts, which resulted in a Kappa (κ) accuracy of 0.94. The map accuracy was > 0.80 for the studied years. This value was acceptable and had very strong agreement and interpretation.

2. Using a land change modeller (LCM) with a Logistic Regression/Markov Chain algorithm to predict land use (LU) in the Senduro and Pasrujambe subdistricts in 2024 and 2036

As suggested by Hosmer (1989), binary logistic regression, including data on roads, rivers, slops, elevation and rainfall, was used in this study to analyse the factors driving LUC in the Senduro and Pasrujambe subdistricts. A general logistic regression equation was formulated as follows:

$$Logit\ (Pi) = \propto + \beta_1 \mathrm{X1} + \beta_2 \mathrm{X2} + \ldots\ldots + \beta_n \mathrm{Xn} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where, Pi is chance of LUC, ∝ is the intercept, β_1 is the coefficient of the 1st to *n*th independent variable, and X1 is 1st to *n*th independent variable.

To determine the validity of the results, the regression results were tested using relative operating characteristics (ROC) of between 0.5-1.0, with 0.5 indicating an insignificant influence, and 1 indicating a significant influence on LUC.

Logistic regression was used to determine how much LUC occurred between 2016-2020 so as to predict the LUC, agricultural conditions and

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sedimentation in the RPVL area in 2024 and 2036. The results of the LU modelling by the LCM in 2024 were compared with the observed LU in 2024 using the κ index statistics. The map produced in the LCM model became a prediction map, which was then validated using several κ parameters: κ for grid cell level location (κlocation), κ for no information (κno), κ for strata level location (κlocationStrata), and standard κ (κstandard) (Pontius Jr. & Millones, 2011).

RESULT AND DISCUSSION

1. Land use (LU) in the Senduro and Pasrujambe subdistricts between 2016-2024

Based on the processing results, it was found that there was a significant LUC between 2016-2024. The forest area was significantly reduced from 279.38 to 235.24 km^2, which means that the forest area had decreased by 44.14 km^2. During the same period, the agricultural sector increased from 51.48 to 71.13 km^2 (Table 2).

Table 2: The categories of LU in the Senduro and Pasrujambe subdistricts in 2016, 2020, and 2024.

LU	LUC in the Senduro and Pasrujambe Subdistricts								
	Area (km^2)			Difference in Area (km^2)			Percentage of Area (%)		
	2016	**2020**	**2024**	**2016-2020**	**2020-2024**	**2016-2024**	**2016**	**2020**	**2024**
Aquatic	4.17	8.80	8.12	-4.63	-0.68	3.95	1.18	2.50	2.30
Settlements	1.62	2.58	5.76	0.96	3.18	4.14	0.46	0.73	1.63
Agriculture	51.48	80.14	71.13	28.66	-9.01	19.65	14.60	22.72	20.17
Forest	279.38	247.17	235.24	-32.21	-11.93	-44.14	79.21	70.08	66.70
Cloud Cover	1.16	0.67	24.06	-0.49	23.39	22.90	0.33	0.19	6.82
Vacant Land	14.88	13.33	8.38	-1.55	-4.95	-6.50	4.22	3.78	2.38
Total	**352.69**	**352.69**	**352.69**				**100.00**	**100.00**	**100.00**

Meanwhile, aquatic, agricultural, forest, and vacant land areas significantly decreased between 2020-2024 due to the large-scale activities of Mount Semeru in 2021 and 2022. Therefore, the community settlement at the foot of Mount Semeru was converted to *Huntara* (Temporary Housing) because it was covered by volcanic material and had to be switched (Thouret et al., 2022). Between 2016-2024, the forest area decreased by 12.52% while settlements and agricultural areas increased by 4.14 km^2 (1.17%) and 19.65 km^2 (5.57%),

respectively. The higher demand for land was inversely proportional to the availability of land, resulting in land conversion (Entahabu et al., 2023). This condition posed a severe challenge in managing land resources to minimise other environmental problems such as flooding and sedimentation in downstream areas, such as the RPVL, due to agricultural land management that was not in accordance with conservation principles.

2. Land change modeller (LCM) simulation of an increased settlement scenario in the Senduro and Pasrujambe subdistricts in 2024 and 2036

The five factors supporting LUC include slope, elevation, rainfall, distance to road, and distance to river. From the north to southwest, the Senduro and Pasrujambe subdistricts have predominantly steep to very steep slopes at 15-45% (Figure 3a) and altitudes of > 2000 m (Figure 3b). Rainfall in the area is classified as moderate to high, with rainfall amounts ranging between 2500 to > 3500 mm per year between 2016-2024 (Figure 3c). The high rainfall can increase soil erosion due to LUC from forest to agricultural land so that erosion can deposit sediment into the lake. In addition, rainwater runoff carrying pollutants, such as pesticides from agricultural land, can degrade the water quality in the RPVL.

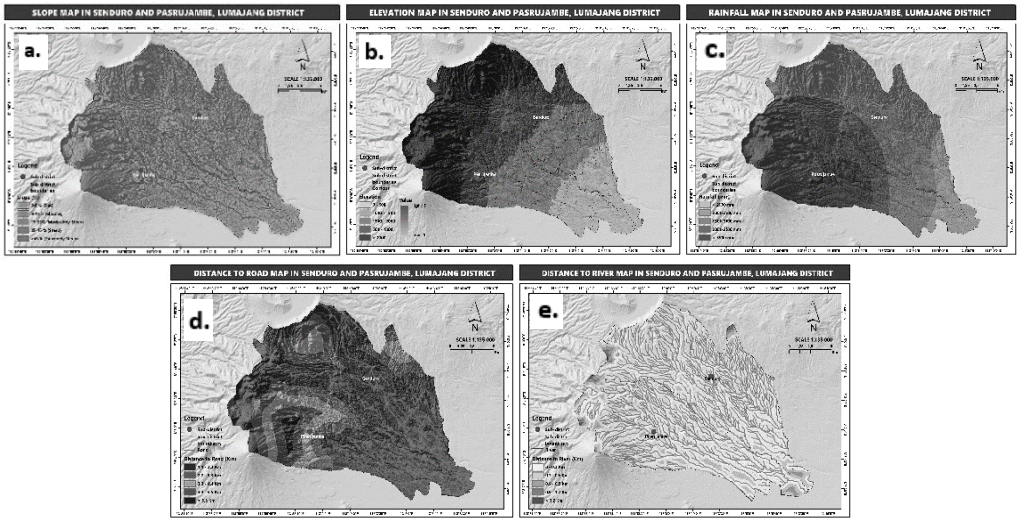


Figure 3: The Bound LUC Variables for the Senduro and Pasrujambe Subdistricts: (a) Slope, (b) Elevation, (c) Rainfall, (d) Distance-to-Road, and (e) Distance-to-River.

A relative operating characteristic (ROC) of 1 indicates excellent and appropriate results, while values of < 0.5-0.5 indicate that the results are random

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(Pourghasemi et al., 2020). The ROC in this research was > 0.80. The coefficients of the LUC regression equation are shown in Table 3.

Table 3: The regression coefficients of the LUC equation

Bound LUC Variables	Constant (β)	Estimator Variable					ROC
		Elevation	Rainfall	Distance -to-River	Distance -to-Road	Slope	
Aquatic to Settlements	7.179	-2.73	0.28	0.97	-0.53	-0.40	0.978
Forest to Settlements	3.899	-0.67	-0.28	1.12	-0.88	-0.63	0.883
Vacant Land to Settlements	4.541	-0.91	-0.57	0.19	-0.08	0.039	0.891

Based on the logistic regression results, the calculated ROC of 0.97-0.88 fell between 0.5-1.0 (Table 3), indicating that the five variables were significant and affected the LUC. The most dominant factors in the LUC at the settlements for the LCM prediction of each model for 2024 were the distance to rivers and the slope. A positive value in each predictor factor would indicate that the increase would consequently increase the distribution/emergence of LU in the Senduro and Pasrujambe subdistricts. Meanwhile, negative values for all the predictor components would suggest that an increase in the predictor factors would decrease the LU distribution in the Senduro and Pasrujambe subdistricts.

3. Land change modeller (LCM) simulation of an increased built-up land scenario in the Senduro and Pasrujambe subdistricts in 2024 and 2036

The results of the LU modelling by the LCM, with an additional scenario on the settlements classification for 2024, as shown in Figure 4b, were compared with the observed LU map of the Senduro and Pasrujumbe subdistricts in 2024 using the overall accuracy (Figure 4a). A κ statistic for quantity and location was derived based on the evaluation of the predicted LU with the observed LU. The statistics showed that κno = 0.8212, κlocation = 0.8118, κlocationStrata = 0.8118, and κstandard = 0.7475. Based on the κ accuracy according to Landis & Koch (1977), all κ indices between 0.61-0.80% show that the results are in substantial agreement, and between 0.81-0.99% show that the results are in almost perfect agreement (Viera & Garrett, 2005).

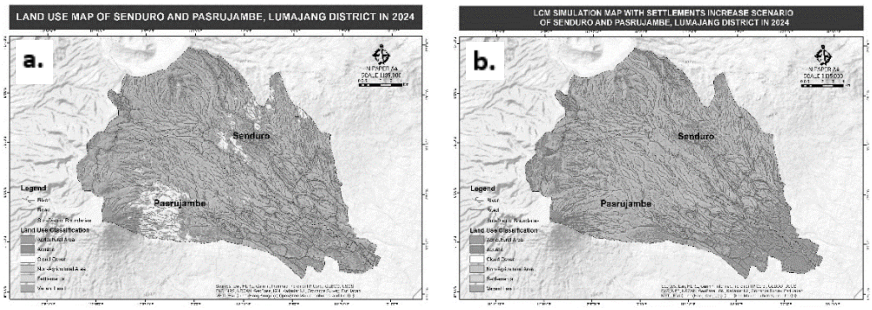


Figure 4: (a) The LU Map of the Senduro and Pasrujambe Subdistricts in 2024 and (b) the LCM Simulation Map of an Increased Settlement Scenario in the Senduro and Pasrujambe Subdistricts in 2024.

Furthermore, the LCM results for 2024 were used to model an increased built-up LU scenario for 2036. From the predicted LU map for 2036 (Figure 5), it was found that there would be a decrease for each LU classified as forest and cloud cover areas. In comparison, other uses of aquatic, settlements, agricultural areas, and vacant land would increase. The aquatic area would increase by 0.16%, settlements by 0.29%, agricultural land by 2.60%, and vacant land by 0.63%. Meanwhile, the forest and cloud cover areas would decrease by 0.37 and 6.64%, respectively, between 2024-2036.

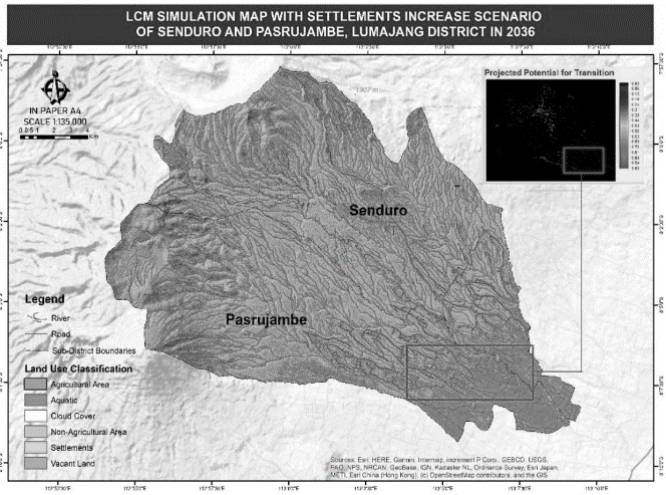


Figure 5: The LCM Simulation Map of a Settlement Increase Scenario in the Senduro and Pasrujambe Subdistricts in 2036.

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4. Land use (LU) in the Senduro and Pasrujambe subdistricts and its impacts on the Ranu Pane Volcanic Lake (RPVL)

Based on the LCM simulation results, the LU in the RPVL would be changed significantly in 2036. Based on the visualisation in Figure 6, many LUCs would occur in the agricultural areas. The agricultural area here would increase by 0.85% from 2024, which would be an increase of 0.03 km^2 or 3 ha.

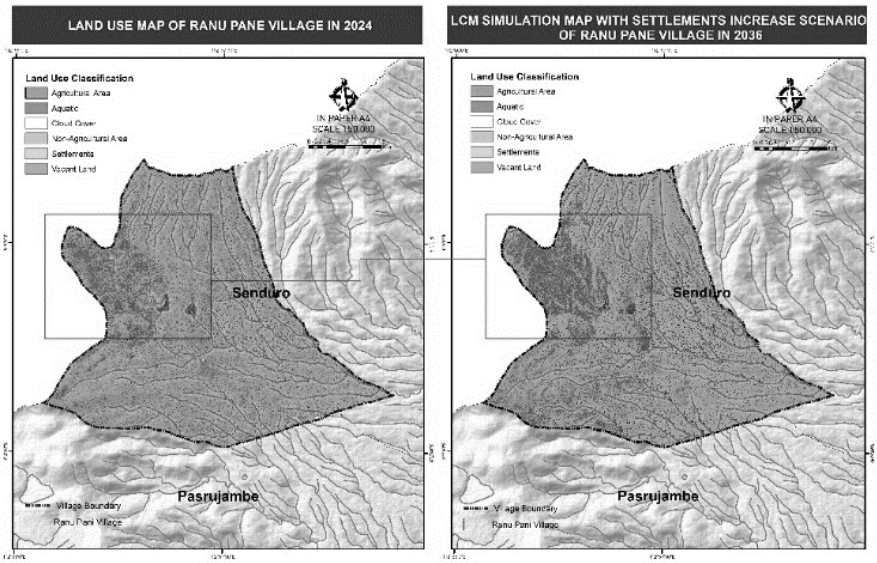


Figure 6: A Comparison of the LU of the Ranu Pane Village in 2024 with the LCM Simulation Results for 2036.

The people would prefer to convert LU to support the socio-economic sector, especially the agricultural sector in the north to the southwest of the Senduro and Pasrujambe subdistricts, located on steep slopes leading to the RPVL. Agriculture on the steep slopes is generally focused on increasing production, thus ignoring conservation principles. In addition to being located in a fragile ecosystem, it is also surrounded by extensive forests on very steep slopes, making the Ranu Pane Village area vulnerable to erosion. The high rainfall intensity in the area, accumulating at > 2500 mm per year, results in a high increase in soil erosion due to agricultural patterns in which no terraces are used. When the various driving aspects are integrated and the community engages in unsustainable agricultural practices, it will result in sedimentation and narrowing of the RPVL area.

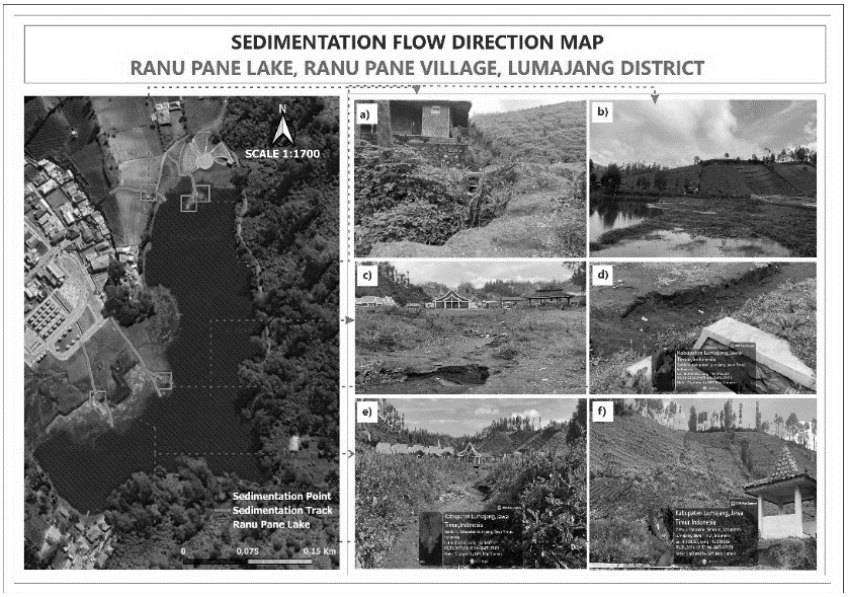


Figure 7: A Map of the Sedimentation Flow to the RPVL.

Based on the sedimentation flow direction map (Figure 7), Ranu Pane Village has many steep hills that farmers utilise as agricultural land, according to the direction of the slope without terracing patterns. Based on the flow direction, and considering the location of the RPVL in the downstream area, the water carrying sedimentation material will flow directly into the RPVL. Siltation in the lake is not caused by natural disasters alone. However, unsustainable community activities through farming that do not comply with conservation principles will threaten the sustainability of the RPVL.

In addition to agriculture, the RPVL is also used as a tourism destination and as a support sector for the main hiking route to Mount Semeru. Consequently, many tourism support sectors have emerged, such as community shops around the lake area. However, due to the unavailability of land for waste disposal, visitors, who are unaware of environmental sustainability, throw garbage around the lake. In addition, household waste disposed in the sewers is carried into the RPVL. As a consequence, the quality of the lake is being degraded by pollution and siltation.

Towards SDG 2030, land management must be based on the principles of conservation by regulating certain types of LU to restrain the rate of land quality degradation and erosion. Moreover, the status of the RPVL, which is within the enclave area, requires efforts to restore the condition of the lake and preserve its nature. Therefore, the results of the research can be used as a basis

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for the local government and also the TNBTS to formulate policy directions for the integration of certain types of LU with effective regional spatial planning in preserving the RPVL so that the people of Ranu Pane Village can prioritise economic growth in synergy with environmental sustainability as a unity of ecosystem functions.

CONCLUSION

The accuracy and precision of the LCM stem from its integration of various real data at a detailed scale, such as historical and current data on LU, elevation, slope, rainfall, distance to roads, and distance to rivers. The simulation results of LU in the Senduro and Pasrujambe subdistricts in 2036 showed that there would be a decrease in LU with the classification of forest and cloud cover areas. Waterbodies, settlements, agriculture, and vacant land would increase in future, as predicted by the model. The results of the LCM visualisation map for 2024 and 2036 for the area surrounding the RPVL showed many LUCs, especially in agricultural areas. The LUC to agricultural activities around Ranu Pane caused an increase in surface runoff and erosion, which led to sedimentation and narrowing of the lake. Given that sedimentation is likely to increase in future due to the anticipated LUC, resulting in damage to the lake environment, as shown by the findings of this study, this serves as an important input for the local government as well as the TNBTS and policy planners to formulate some policy directions to discourage certain types of LU to control sedimentation by integrating more effective spatial planning practices for the management and preservation of the RPVL.

ACKNOWLEDGEMENT

The authors are grateful to the Universitas Negeri Malang for supporting this research through the International Collaboration grant scheme (contract no. 4.4.538/UN32.14.1/LT/2024). The author is also grateful to Prof. Dr. Sumarmi, M. Pd, Prof. Dr. Sugeng Utaya, M. Si, Dr. Ari Sapto, M. Hum, and Syarifah Hikmah Julinda Sari, SPi, M. Sc, Ph. D for their assistance in this research. The Bromo Tengger Semeru National Park (TNBTS) is also appreciated by the researcher for permitting and facilitating research in the Ranu Pane region. We are grateful to all organizations and individuals who supported us accomplish this research.

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Received: 6th January 2025. Accepted: 15th November 2025

PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 47 – 61

CULTURAL LANDSCAPE HERITAGE SUPPORT SUSTAINABLE RURAL DEVELOPMENT: A CASE FROM RONGCHENG, CHINA

Chen Yanhui[1], Mohamad Reza Mohamed Afla[2], Wang Zhenhua[3], Peng Xinyi[4]

[1,2]*School of Housing, Building and Planning,*
UNIVERSITI SAINS MALAYSIA
[3] *School of Rong Cheng,*
HARBIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
[4] *School of Art and Design,*
CHONGQING VOCATIONAL INSTITUTE OF ENGINEERING

Abstract

The protection and development of cultural landscape heritage play a crucial role in the sustainable development of rural areas. Previous studies have predominantly focused on the identification and evaluation of cultural landscapes, with limited attention paid to the relationship between these landscapes and sustainable rural development. Utilizing Rongcheng, China as a case study, this research identifies six genetic themes of the landscape—ecological landscape, spatial layout, traditional houses, spiritual culture, and behavioral culture—through literature review and field observation. This study demonstrates that these cultural landscapes are interconnected and do not exist in isolation. The insights gained from this research aim to support rural policymakers and managers in the sustainable conservation and development of rural cultural landscapes.

Keywords: Cultural landscape, Cultural landscape genes, Cultural heritage, Sustainable Development, Rural revitalisation

[1] Corresponding author. Email: Chekecui@student.usm.my

INTRODUCTION

Cultural landscapes have garnered extensive attention as a pivotal factor in the sustainable development of rural settlements. Recent research has concentrated on the identification and value of cultural landscapes (Xinyi et al., 2025), the evolution of rural cultural landscapes, the protection of cultural heritage, and the sustainability of rural landscapes. Cultural landscapes are recognized as multifunctional and complex socio-ecological systems (Bidegain et al., 2020) where humans interact with nature, serving as a bridge linking nature and culture, tangible and intangible heritage, and cultural and biological diversity.

As a comprehensive concept, cultural landscapes encompass both material and immaterial entities shaped by the dynamic interplay between humans and nature (Oikonomopoulou et al., 2023). However, rapid urbanization is irrevocably altering rural agricultural environments, impacting the original structure, function, and identity of cultural landscapes (J. Liu et al., 2022). In this context, the sustainability of rural cultural landscapes extends beyond mere preservation or restoration of cultural heritage; it has become a central objective of rural revitalization.

The preservation of traditional villages is related to sustainable rural development and is defined as a form of rural settlement with a long history (Fu & Zhou, 2021), which not only functions as a historical heritage, but also has an important value for cultural legacy and sense of place (J. Li et al., 2023). Therefore, traditional villages are regarded as vital carriers of both tangible and intangible cultural heritage. However, urbanization and economic development have led to the significant hollowing out of rural areas (Liu & Xu, 2021), adversely affecting rural cultural landscapes. Although cultural heritage protection has been strongly advocated, with tourism emerging as a means to promote local economic development and support rural areas (Šťastná & Vaishar, 2020), the rapid expansion of tourism has also had detrimental impacts on the regional cultural landscape.

In China, within the framework of rural revitalization, landscape renovation, industrial development, and talent attraction have been prioritized as strategies to address the issue of hollowed-out villages (Liu & Xu, 2021). Relevant research has begun to focus on traditional and historic landscape elements, as well as the evolution of the landscape, aiming to regenerate and adapt villages in ways that facilitate coexistence with a growing tourism industry (Cattaneo et al., 2018).

This study employs an integrative review methodology to explore the evolution of rural cultural landscapes and their contributions to rural sustainability. It also examines strategies and measures for the sustainability of rural cultural landscapes in various contexts. The following research questions guide this study:

RQ1: How do cultural landscapes contribute to rural tourism and management?
RQ2: What features of cultural landscapes contribute to sustainable rural development?

CONCEPTUALISING CULTURAL LANDSCAPES

The concept of cultural landscapes and cultural landscape genes

The concept of cultural landscapes first emerged in geography, with Carl Sauer's Berkeley School attributing temporal and spatial relationships to geographic landscapes. Cultural landscape features have been identified from socio-ecological system perspectives (Arnaiz-Schmitz et al., 2018) and land use perspectives, and the evolution of landscapes has been studied in terms of traditional and historical landscape elements (Cattaneo et al., 2018). These efforts aim to regenerate and transform rural landscapes by identifying their distinctive cultural features.

Based on studies in these various disciplines, cultural landscapes are defined as unique landscapes that reflect a region's cultural content, influenced by the environment and shaped by the combination of natural and human creativity (Marc, 2005). In 2006, the World Heritage Committee included cultural landscapes in its strategy for expanding the World Heritage List, recognizing the importance of human interaction with the environment (Aplin, 2007). Cultural landscapes are characterized by the action and interaction of natural and human factors, reflecting environmental, social, economic, and cultural needs (Bohnet & Konold, 2015).

According to the World Heritage Committee's concept of cultural heritage, Cultural landscape heritage includes three types: landscapes intentionally designed and constructed by humans, organically evolved landscapes, and associative cultural landscapes. Among these, rural cultural landscapes should be valued as organically evolved landscapes that reflect regional characteristics and cultural connotations.

Cultural landscape gene theory identifies cultural landscapes from the perspective of their heritage (Cao et al., 2024). The term "gene" was first introduced to the study of rural settlements as a biological concept, and researchers have found that the replication and transmission characteristics of cultural heritage are similar to those of biological genes. Therefore, these factors are referred to as "memes" (S. Yang et al., 2023). Liu Peilin proposed the concept of cultural landscape genes of traditional settlements to address the challenge of identifying cultural landscape genes in traditional Chinese settlements. He suggests that rural cultural landscape genes encapsulate traditional Chinese philosophical ideas during their formation and development, expressing the characteristics and values of traditional Chinese settlement habitats (P. Liu et al., 2023).

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Rural cultural landscapes are valued for their heritage appeal and cultural carrying capacity. Many rural settlement landscapes have evolved over hundreds and thousands of years, now presenting a genetic character that reenacts history (G. Li et al., 2024). Various disciplines have studied them from different perspectives, while the perception of cultural landscapes converges in the interplay of ecological and historical dimensions (Sahle & Saito, 2021). Therefore, the study of the sustainable development of rural cultural landscapes must delve into both their external material manifestations and their internal development and changes (Harun et al., 2021). It is necessary to treat the rural cultural landscape as a synthesis, focusing on a deeper understanding of the ethnicity, history and regionality of rural culture (W. Yang et al., 2022). And new methods and tools are needed both to protect cultural landscapes and to revitalise them from a sustainable development perspective in order to achieve a strategic role in sustainable rural development.

METHODOLOGY

Rongcheng, China, as an example

The case study is located in Rongcheng City, Weihai, China (Figure 1), situated at the easternmost tip of the Shandong Peninsula. It is bordered by the Yellow Sea to the north, east, and south and lies at the eastern end of the Jiaodong low mountainous and hilly area. Rongcheng features complex topography and a warm-temperate continental monsoon humid climate, with prominent marine climatic characteristics.

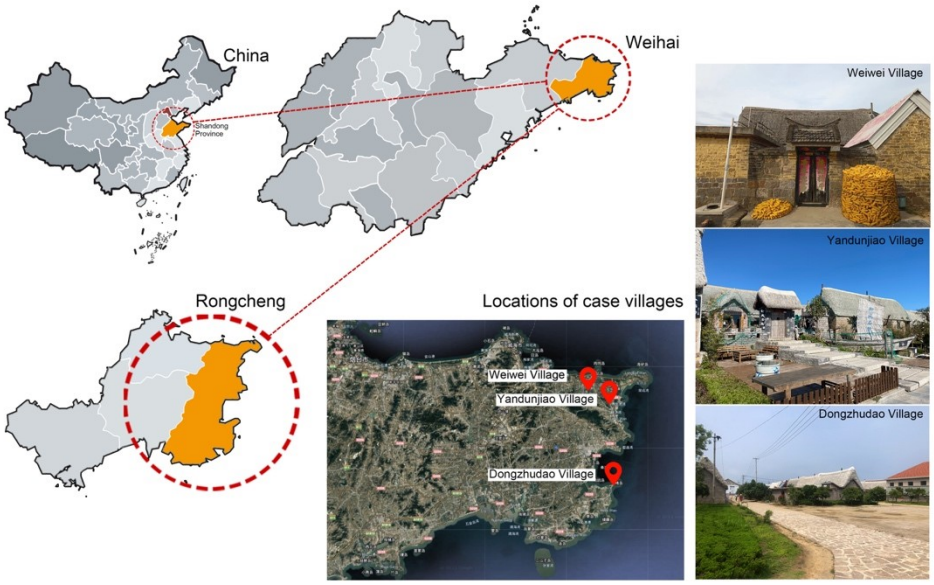


Figure 1: Location of Rongcheng and case villages.
Source: National Centre for Basic Geographic Information, redrawn by the author.

Method and data

The primary data for this study come from three main sources: (1) Traditional villages. Thirteen typical villages located in Rongcheng, recognized by the Chinese Ministry of Housing and Construction, were selected based on principles of good protection of traditional dwellings, integrity of village types, and sustainable development. (2) Network text. Textual data related to Rongcheng's cultural landscapes were obtained from the Rongcheng government website. (3) Field survey. Data such as mapping, photography, and interviews were collected through field surveys.

This study observes and records the cultural landscape genes implicit in the six cultural landscape narratives through fieldwork, ultimately summarizing the cultural landscape gene mapping of Rongcheng's rural settlements. The research analyzes the challenges and opportunities of sustainable rural development by examining the relationships between cultural landscape genes. The research design of this paper is shown in Figure 2.

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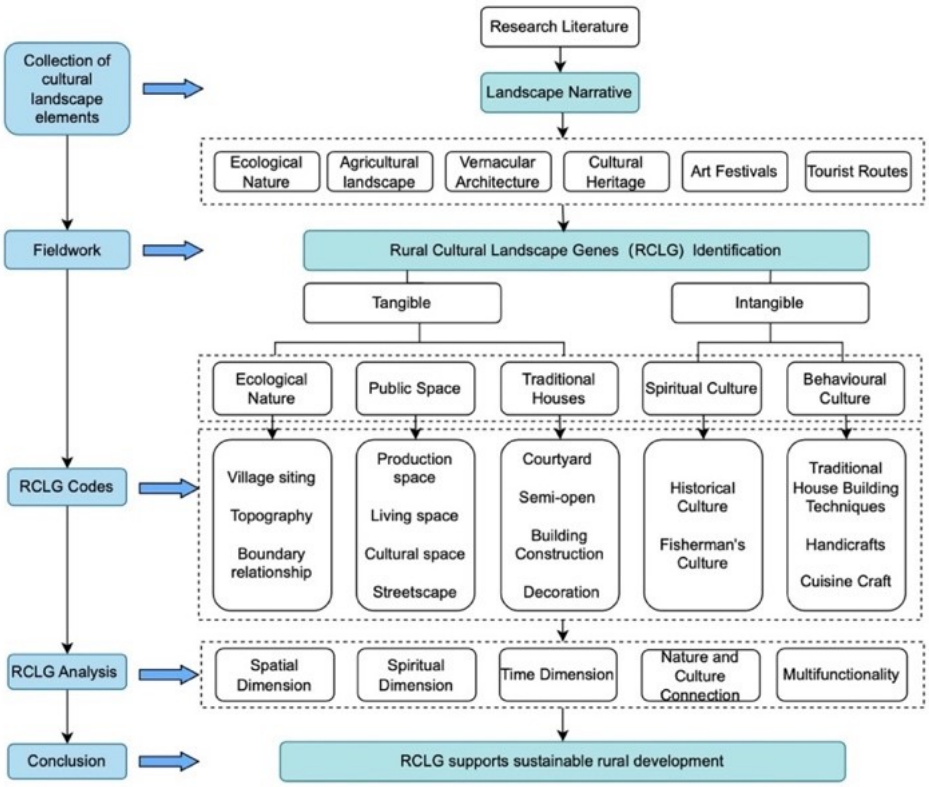


Figure 2: Research design
Source: Author.

RESULTS AND DISCUSSION

Identify cultural landscape genes

Ecological nature

The layout of traditional Chinese villages is formed under the principles of Feng Shui, typically featuring "mountains at the back and water at the front". This spatial layout reflects adaptability to the natural ecology and emphasizes a harmonious relationship between people, nature, and culture (Figure 3).



Figure 3: Rongcheng natural landscape.
Source: Rongcheng government website.

Ecological nature plays a crucial role in maintaining ecological balance and biodiversity (Lind et al., 2019). These ecological landscapes provide rich natural resources for local residents and serve as important tourism assets, attracting visitors and promoting the sustainable development of the local economy (Pirselimoglu & Demirel, 2012).

Space layout

The spatial layout of Rongcheng villages is characterized by well-organized public spaces and street patterns. These public spaces are highly interactive and interconnected, fostering emotional connections among residents in traditional villages (Zakariya et al., 2025). There are three main types of public spaces: (1) Public production spaces. These areas are used for agricultural and marine production activities, such as drying crops and seafood. (2) Public living spaces. These spaces often feature ancient wells and leisure areas centered around large trees, serving as focal points for community interaction and carrying significant emotional and historical memories. (3) Public cultural spaces. These include auditoriums, temples, and ancient tombs, which host various folk activities, gatherings, entertainment, and rituals. The utilization and preservation of village public spaces enhance community cohesion and a sense of place (Philokyprou & Michael, 2021). As shown in Figure 4, these spaces include: (a) a public production space where villagers dry kelp, (b) a productive living space centered around an ancient well, now abandoned, and (c) a public cultural space featuring an ancient Yuan Dynasty tomb, over 700 years old.

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Figure 4: Public space.
Source: Photo by the author.

Vernacular Architecture

Rongcheng's coastal location, characterized by rainy and humid summers and snowy, cold winters, significantly influences its vernacular architecture. The primary consideration for residential houses is to maintain warmth in winter and provide shade in summer. This has led to the development of unique architectural practices, as illustrated in Figure 5. Traditional houses in Rongcheng not only reflect the region's historical and cultural characteristics but also play a crucial role in preserving local architectural skills and lifestyles (Le & Cao, 2023). Protecting and restoring these traditional dwellings promotes cultural diversity and reinforces local identity.

Intangible Cultural heritage

Rongcheng City is rich in traditional resources and well-preserved cultural landscapes. Its tangible cultural heritage includes ecologically representative seagrass houses and other traditional dwellings. Additionally, the city boasts a wealth of intangible cultural heritage, as detailed in Table 2.

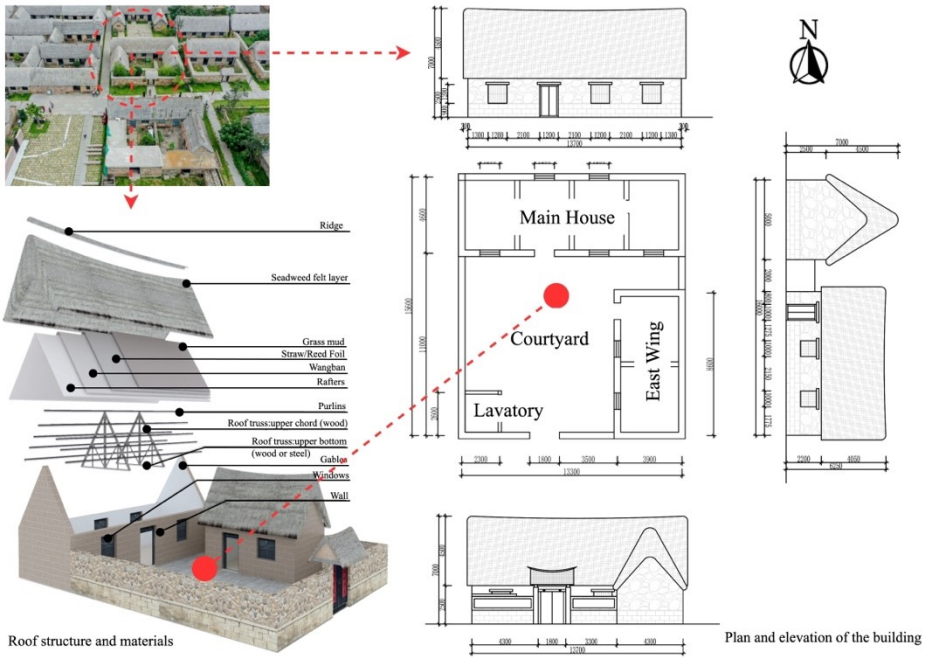


Figure 5: Seagrass house residential structure.
Source: Author.

Table 2: Main intagible cultural heritage in Rongcheng

Intangible Cultural Heritage	Type	Descriptions	Photo（Source: author）
Fishermen's Festival	Folklore	The "Sea Festival" is a folkloric event where fishermen express gratitude to the sea and celebrate a bountiful harvest upon the safe return of their boats.	
Seagrass House Construction Technique	Traditional Skills	The primary building material is seaweed. The construction process is intricate, with the roof being a distinctive feature.	
Fishermen's Horn	Traditional Music	It involves the sounding of fishing horns to boost morale, embodying the fishermen's bold and unrestrained spirit.	

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Intangible Cultural Heritage	Type	Descriptions	Photo（Source: author）
Cuisine (Hua-Bobo)	Traditional Arts and Crafts	This cuisine represents ancient folklore and is a significant part of the coastal cultural heritage of Shandong.	

The spiritual and cultural heritage of Rongcheng, encompassing local beliefs and festivals, is a crucial source of community cohesion and identity (Xu & Wang, 2021). These cultural activities not only enrich the spiritual life of residents but also contribute to building a harmonious social environment by promoting social interaction and cooperation. Behavioral cultural genes, such as local customs and lifestyle habits, have a positive impact on promoting environmentally friendly behaviors and sustainable lifestyles. For example, the construction practices of Rongcheng residents highlight the reuse of building materials and environmental consciousness, which are essential for achieving sustainable development goals.

Based on extensive fieldwork and measurements, this paper identifies the cultural landscape genes of Rongcheng's seagrass hut villages. These include tangible cultural components like ecological nature, spatial distribution, architectural patterns, and decorations, as well as intangible cultural heritage elements such as traditions, myths, folklore, cuisines, and handicrafts, as shown in Figure 3.

Correlation and sustainable development of cultural landscape genes

By examining the relationships between cultural landscape genes, this study summarizes both the complementary and conflicting interactions among them. Ecological nature serves as a material carrier, enhancing the physical experience of tourists engaging with ecological landscapes. A harmonious and symbiotic relationship between rural tourism and ecological landscape resources is fundamental for sustainable rural development. Cultural heritage, encompassing both temporal and spatial dimensions, provides valuable resources for sustainable rural growth. Vernacular architecture, as a significant aspect of tangible cultural heritage, influences the socio-economic and cultural characteristics of rural areas. Balancing cultural heritage with economic development enhances cultural values and satisfies the residents' increasing desire for a rural lifestyle. This balance is achieved through cultural exchanges, reviving latent cultural heritage, and boosting rural resilience and economic value, as illustrated in Table 5.

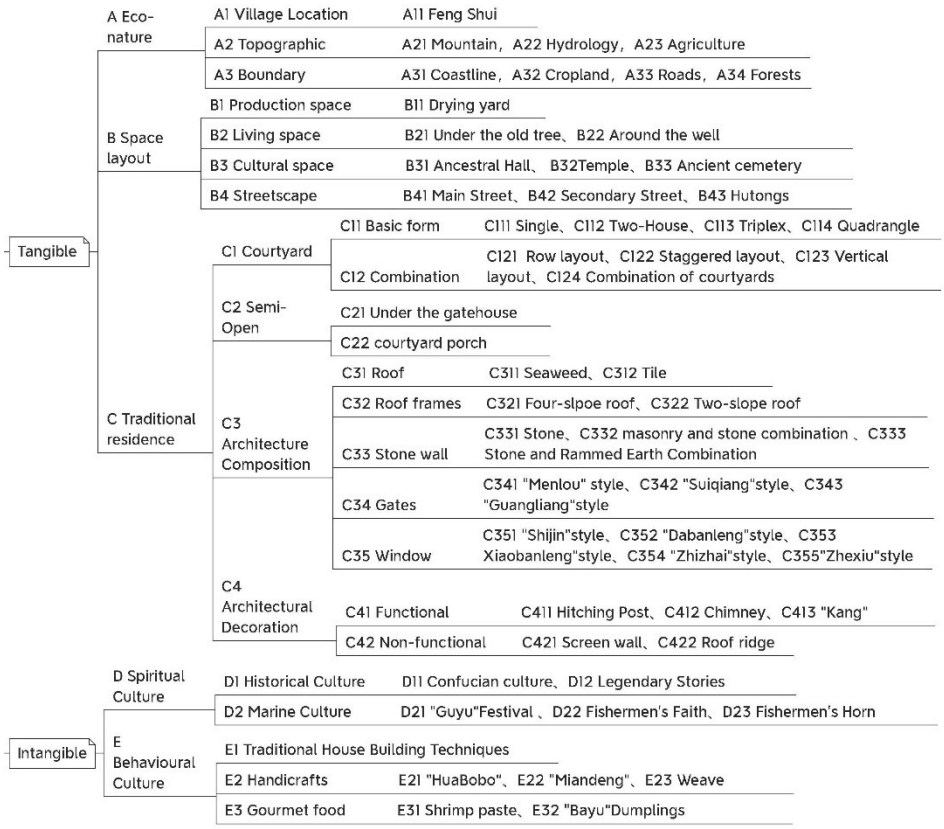


Figure 3: Genetic Mapping of the Cultural Landscape of Rongcheng Seagrass House Villages

Table 5: Relationships between cultural landscape genes

Cultural Landscape genes	**Sustainable development**	**Complementarity between cultural landscapes genes**	**Tension between cultural landscapes genes**
Ecological Nature	Environmentally sustainable:：It not only supports biodiversity but also provides aesthetic enjoyment through beautiful scenery.	Focus on ecological landscape restoration, combining agricultural landscape tourism with the preservation of ancient villages, and transforming agricultural landscapes into commercialized cultural heritage projects.	Emphasis on economic development may lead to neglect of the original ecological landscape. Prioritizing ancient village tourism over agricultural landscapes.

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Cultural Landscape genes	**Sustainable development**	**Complementarity between cultural landscapes genes**	**Tension between cultural landscapes genes**
Public Space	Socially sustainable development: Meeting diverse needs and activities through multiple utilizations of space.	Integrating shared spaces with intangible cultural heritage to form creative marketplaces, thereby realizing the multifunctionality of space.	Neglecting the multifunctionality and sense of place in public spaces. Modernized public spaces may not harmonize with traditional settings.
Vernacular Architecture	Cultural and economic sustainability: The adaptive reuse of traditional houses has become an economic resource for local residents.	Adaptive reuse involves creating a spatial model of front shops and back houses, restoring houses to showcase crafts and heritage, and transforming traditional practices into experience-based tourism activities.	Residents might disregard vernacular architectural heritage in favor of modern living. Stakeholders might view tradition as restrictive, creating tension between compliance and innovation.
Spiritual culture	Sustaining traditional folklore and handicrafts by processing and redeveloping them to meet public aesthetics, thus ensuring the conservation and sustainable development of intangible culture.	Conducting creative activities that utilize natural landscapes and traditional architecture as cultural and artistic carriers.	Over-exploitation and commercialization of cultural heritage might occur, leading to a lack of integration with traditional values.
Behavior culture		Balancing cultural heritage with economic development by transforming traditional customs and crafts into experience-based tourism activities. Intangible cultural heritage can be packaged as tourism products.	Neglecting cultural heritage can lead to resource decline. Excessive focus on intangible cultural heritage for tourist experiences may harm the ecological and natural values of cultural heritage.

CONCLUSION AND SUGGESTIONS

This paper focuses on the protection and development of traditional villages in Rongcheng, emphasizing the rural cultural landscape as a vital support for sustainable village development. Using Rongcheng, China, as a case study, the research thoroughly analyzes six landscape gene themes: ecological landscape, spatial layout, traditional dwelling, spiritual culture, and behavioral culture, through literature review and field observation. This demonstrates the comprehensive value of cultural landscape genes in the sustainable development of villages.

The study reveals that these cultural landscape genes do not exist in isolation in Rongcheng's Haigaofang villages but are interdependent and

mutually reinforcing, forming a social-ecological system with intrinsic connections. Identifying and protecting these genes can promote the coordinated development of the economy, society, and environment. Rongcheng's Haicaofang Village model offers valuable insights for other rural areas, showcasing the pivotal role of cultural landscape genes in fostering balanced economic, social, and environmental development. This model emphasizes the conservation and utilization of cultural landscape genes, alongside community participation and multi-stakeholder cooperation.

Based on the findings, the following recommendations are proposed for policymakers and practitioners:

1. Expand the protection and restoration efforts beyond seagrass houses to maintain the cultural diversity and historical continuity of rural areas.
2. Foster public engagement and multi-stakeholder cooperation in intangible cultural practices and leverage behavioral culture to cultivate spiritual culture, aiming for inclusive and sustainable rural development.
3. Enhance the connections between cultural landscape genes and encourage local innovation and adaptive management to achieve multi-dimensional sustainable development in ecological, social, cultural, and economic terms.

ACKNOWLEDGEMENT

We would like to extend our sincere thanks to Dr. Reza for his valuable guidance and ongoing support, as well as to the HBP Academy for their assistance. We also appreciate the reviewers for their careful evaluation and constructive suggestions.

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Received: 18th December 2024. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 62 – 78

ENVIRONMENTAL, SOCIAL AND GOVERNANCE (ESG) DISCLOSURE FOR CONSTRUCTION SECTOR IN BURSA MALAYSIA

Nurul Nabila Sulaiman[1], Abdul Jalil Omar[2], Muhammad Azwan Sulaiman[3], Nurul Hana Adi Maimun[4], Azima Abdul Manaf[5]

[1,2] *Faculty of Technology Management and Business,*
[2] *Malaysian Real Estate Institute,*
UNIVERSITI TUN HUSSEIN ONN MALAYSIA
[3] *College of Built Environment,*
UNIVERSITI TEKNOLOGI MARA MALAYSIA
[4] *Centre for Real Estate Studies,*
UNIVERSITI TEKNOLOGI MALAYSIA
[5] *Faculty of Social Science and Humanities,*
UNIVERSITI KEBANGSAAN MALAYSIA

Abstract

The Malaysian government has committed unequivocally to achieve zero net carbon emissions by 2050. Construction sector consequently faces challenges in embracing sustainable development with ESG disclosure becomes critical to investors and other stakeholders in making investment decisions to prevent imminent risk. This study analyses the ESG disclosures of 52 construction firms listed on Bursa Malaysia from year 2020 to 2022 by employing a content analysis approach. Utilising a binary scoring system, the analysis assesses the firms' adherence to the three pillars of ESG. The findings reveal a strong emphasis on the social pillar, with health and safety receiving significant weight. Environmental concerns, particularly pollution and resource disclosure are the highest due to strict regulatory oversight. Meanwhile, the governance pillar, anti-corruption emerged as a primary focus reflecting a commitment to maintaining business integrity. These findings assist regulators, investors, and stakeholders in fostering sustainable business practices within Malaysian construction sector.

Keywords: ESG Disclosure, Construction Sector, Bursa Malaysia

[2] Corresponding author. Email: jalil@uthm.edu.my

INTRODUCTION

Construction sector is an evolving sector that is marked by rapid development, the growth of infrastructure, and the evolution of regulatory frameworks. As Malaysia works towards attaining its sustainable development goals, stakeholders in the construction industry have grown increasingly conscious of the importance of adopting environmental, social, and governance (ESG) principles to reduce environmental damage, mitigate social inequalities, and improve governance processes. Due to the significant environmental impacts of construction operations, practitioners of sustainable construction aim to incorporate sustainable development principles into traditional construction methods and expedite the adoption of sustainable management approaches in construction firms (Chen et al., 2016). A different study on sustainable construction development city demonstrates the interrelation and cumulative effect of compact city components, including diversified land use, public transportation, proximity, and community inclusivity, on fostering a sustainable urban environment. When effectively incorporated, these components diminish environmental impact, augment resource efficiency, and boost social connectivity (Nor'Azmi & Sahrir, 2024). Furthermore, the evaluation of organisational success is currently experiencing an evolution, embracing not just financial performance but also the evaluation of an organisation's achievements with respect to ESG objectives and practices within the company (Sulaiman et al., 2024). Consequently, firms tend to report their ESG practices actively to attract more attention from investors.

Sustainability statement and reports are the most effective in assessing ESG of firms. ESG management has evolved from being a discretionary activity to becoming a necessary requirement. Corporate investment decisions are now widely acknowledged as a vital element, in addition to the pursuit of sustainable growth and the improvement of corporate image (Park et al., 2023). Major construction firms in Malaysia produce sustainability reports at the corporate level. Given the enhanced global sustainability standards specified in the Global Reporting Initiative (GRI) Standards, it is crucial to take a strategic approach to the construction order market. Nevertheless, there is an absence of clarity and uniformity in the data sources, weightings, and procedures. Therefore, it is recommended that investors align their investing objectives with the ESG evaluation measures while utilising the ESG rating matrix. It is advisable to access the sustainability reports together with its ESG rating to improve investment decision (Abhayawansa & Tyagi, 2021). This entails conducting comprehensive research on Malaysia's construction market and acquiring important insights from around the world. Examining ESG management strategies and addressing significant ESG concerns is essential for attaining

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global industrial competitiveness in the Malaysian construction industry in terms of ESG sustainability. Therefore, the objective of this study is to assess the sustainability strategies and orientations of the construction sector from an ESG perspective. To achieve this goal, this study conducted a comprehensive investigation of sustainability concerns and viewpoints, as well as global issues, in Malaysia and the global construction sector.

This study presents a unique contribution to ESG studies by delivering the sector-specific examination of ESG disclosure patterns for year 2020 until 2022 within Malaysia's construction industry, utilising a systematic, theme-based coding framework in accordance with Bursa Malaysia's sustainability requirements. It shows how construction firms prioritise ESG issues across ESG pillars, unlike previous research that focused on environmental practices or took broad cross-sectoral perspectives. This study also maps disclosure activity using a structured binary assessment to reveal disclosure emphasis and gaps, offering practical and theoretical value to the emerging-market construction-sector sustainability discourse.

LITERATURE REVIEW

Trends in ESG Disclosure

Sustainability reporting approaches are now widely recognised as a strategic tool in the global corporate sector. Furthermore, increasing of media attention on ESG practices has prompted ESG into the spotlight. The greater the company's media attention, the more pronounced the financial performance impact of ESG disclosure becomes (Chen & Xie, 2022). Firms in this context have implemented the practice of disclosing their non-financial data by publishing their ESG pillars, which are considered critical components of sustainability (Singh et al., 2023). Throughout history, ESG disclosure has been an inherent and fundamental component of corporate existence. The release of enterprise-related information is crucial to the functioning of our economies, as it enables investors and other stakeholders to make well-informed capital allocation decisions and mitigate potential risks. Nowadays, ESG disclosure are currently incorporated into sustainability reports which enhanced transparency and has potential to foster investment attraction and maintain confidence in the stock market (Alareeni & Hamdan, 2020b). As a result, the global industry's starts to emphasis on green buildings, green labels, and focus more on sustainability (Cajias, 2021).

As reported by KPMG International, (2020) the rate of sustainability disclosure in the Asia Pacific region has increased by 6% in 2020 since 2017, reaching a level of 84 percent. Several countries and jurisdictions in the region, such as Japan 100%, Malaysia 99%, India 98%, Taiwan 93%, and Australia 92%, are among the top performers worldwide. However, the increased number of the ESG disclosure since 2017, show that there has been a noticeable enhancement

in the number of firms who recognise climate change as a potential threat to their business. Nevertheless, fewer than 50% of corporations provide reports on social and governance concerns that affect their business (KPMG Asia Pacific, 2022). Compare to other developed countries, Malaysia achieved a 97% disclosure rates in 2017, and increase to 99% for year 2020 and 2022 (KPMG Asia Pacific, 2022; KPMG International, 2020). Based on this outcome, we can conclude that Malaysia, a developing country, can achieve a comparable degree of ESG disclosure as developed countries.

International ESG Framework and FTSE Russell Bursa Malaysia

Several international frameworks, such as Global Reporting Initiative (GRI), Sustainability Accounting Standards Board (SASB) and Task Force on Climate-related Financial Disclosures (TCFD), shape the global ESG reporting landscape. All frameworks have different conceptual approaches. The following standards are widely used; GRI which offers extensive, multi-stakeholder disclosures and is the most prominent global standard (Alareeni & Hamdan, 2020a), SASB highlights financially significant, industry-specific KPIs that coincide with investor decision-making (Singh et al., 2025) and TCFD enhanced climate governance and preventive risk evaluation (Chen & Li, 2023).

Bursa Malaysia rates firms' ESG transparency and performance across 300 metrics and 14 categories using the FTSE Russell ESG Rating model (Sulaiman et al., 2024). The sector-based materiality weighting matches SASB's financial materiality perspective, and its thematic coverage of pollution, resource management, labour standards, human rights, governance, and anti-corruption meets GRI's topic-specific structure. Climate metrics from FTSE Russell follow TCFD principles for carbon control and climate governance, although without scenario analysis. In purpose and methodological transparency, FTSE Russell differs from GRI, SASB and TCFD because it does not prescribe how firms should report, relies exclusively on publicly disclosed information, and uses proprietary scoring algorithms that may not fully capture the qualitative depth or strategic intent of corporate sustainability disclosures (Abhayawansa, 2021). FTSE Russell corresponds with international standards in breadth, thematic structure, and materiality logic, although it provides benchmarking and evaluation tools for Malaysia's ESG ecosystem rather than a disclosure framework for reporting.

ESG Practices in Malaysia Construction Sector

The Eleventh Malaysia Plan has includes the promotion of sustainable construction as a component of the Government's Sustainable Development policy, which acknowledges the interrelated nature of the economy, environment, and well-being (Economic Planning Unit, 2015). This is because, the construction

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sector makes a significant contribution to the overall carbon emissions worldwide, particularly in the case of skyscrapers which have a high density of emissions (Mulya et al., 2024). GreenRE is an organisation in Malaysia that offers certification services to support the country's objective of attaining net-zero status by 2050. GreenRE aims to increase the number of buildings with green certification to 1750 by 2030 (Green Technology Master Plan Malaysia (2017-2030), 2017). It is recommended to improve Green Building System (GBRS) criteria towards achieving low-carbon buildings include relaxing the energy-related credit limit for GreenRE to reduce emissions by an additional 12.5% and incentivizing stakeholders to reduce embodied carbon (EC) in both Leadership in Energy and Environmental Design (LEED) and GreenRE. Mulya et al., (2024) hot spot analysis further indicates that over a period of 30 years, the initial building accounts for 9.87% of emissions from EC and 90.1% from operational carbon (OC) emissions. Meanwhile, the building's glass façade design, which has limited concrete walls where paint is applied and results in low paint emissions.

In order to optimise the performance of the construction industry without disregarding the importance of our ESG, new approaches have been implemented to improve its efficacy. It is by incorporating Building Information Modelling (BIM) to reduce uncertainty related to waste estimation and management in construction projects. BIM plays a significant role in optimising construction costs, facilitating the implementation of green building practices, minimising environmental effect, and reducing waste (Rahim et al., 2023). In another study by Waqar et al., (2023) which aims to evaluate the influence of BIM on resource efficiency, energy performance, waste reduction, and collaborative decision-making in small-scale green buildings has shown a results of strong positive correlations between the adoption of BIM and various aspects of the design process, including early-stage design optimisation, energy efficiency analysis, material selection, life cycle assessment, waste reduction, and prefabrication. The application of BIM is crucial for the effective execution of sustainable housing construction projects in Malaysia.

In addition to BIM, Industrialised Building System (IBS) can also be recognised as an effective approach for improving building performance in terms of quality, cost-effectiveness, safety and health standards, waste reduction, and productivity. In Abdullah Abkar et al., (2024) study investigates the impact of Reuse, Reduce and Recycle (3R), IBS, BIM and Material Management Adoption (MMA) on improving Construction Site Performance (CSP) in the construction industry of Malaysia. The findings emphasise the significance of integrating technology, managing materials efficiently, and implementing competitive tactics to effectively reduce material waste. On-site storage facilities need to be sufficient for materials, and constant surveillance is crucial to track amounts and prevent theft. It is important to highlight that inventory control, storage, and

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warehousing play a vital role in determining the efficiency of building site operations. Considering different levels of waste reduction in construction materials to improve construction site efficiency, information exchange significantly influences the relationship between technology adoption and site performance.

Table 1: ESG Disclosure Framework

ESG Pillar	Sustainability Themes	Thematic Disclosure
Environmental	Pollution and Resources	Precautions and Assessment Policy Adherence Technology Advancement
	Climate Change	Precautions and Assessment Policy Adherence Technology Advancement & Renewable Sources
	Water Use	Precautions and Assessment Policy Adherence Technology Advancement & Renewable Sources
	Biodiversity	Precautions and Assessment Policy Adherence Technology Advancement
	Supply Chain	Precautions and Assessment Policy Adherence Technology Advancement
Social	Safety & Health	Precautions and Assessment Policy Adherence Benefits & Training
	Labour Standard	Good Employee Welfare Practices Policy Adherence Learning & Training
	Customer Responsibility	Provide Quality Services & Assessment Policy Adherence
	Human Right	Good Social Welfare Practices Policy Adherence Social Involvement
	Supply Chain	Customer Satisfaction Policy Adherence Technology Advancement
Governance	Risk Management	Precautions and Assessment Policy Adherence Training & Benefits
	Corporate Governance	Precautions and Assessment Policy Adherence Training & Benefits
	Anti-Corruptions	Precautions and Assessment Policy Adherence Training & Benefits
	Tax Transparency	Precautions and Assessment Policy Adherence

Source: Sulaiman et al., (2024)

The above literature review mainly focuses more on environmental practices within the construction sector in Malaysia. Meanwhile, Sulaiman et al.,

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(2024) studies focus on three individual pillars and themes. Therefore, this study adopted an ESG framework in Table 1 as the main guideline to conduct this research from three individual pillar of ESG.

RESEARCH METHODOLOGY

Sample Selection

This study applied sample data from the ESG sustainability statements of 52 major construction firms in Bursa Malaysia, which concentrated on construction capacity evaluation. The analysis of the data was conducted by examining sustainability statement in annual reports from year 2020 until 2022. Collected from Bursa Malaysia, a comprehensive study of ESG disclosure from Malaysian construction firms was acquired. Sustainability statements in the annual reports were obtained from the Bursa Malaysia website (http://www.bursamalaysia.com/market/listed-firms) and firms' website for the three-year period (2020-2022). Qualitative content analysis is applied to 156 sustainability statement for this study.

Method

The research methodology analyses ESG practices in the Malaysian construction sector from 2020 to 2022 through using the methods of content analysis and a binary scoring technique. The process of data collection comprises procuring information from sustainability statements with a specific emphasis on firms listed on Bursa Malaysia that are involved in construction-related activities. Content analysis was used in this study because it is widely acknowledged as the most appropriate approach for examining the corporate reporting practices of firms due to its efficiency in data collection. It operates by categorising qualitative data, which may be presented in both literal and anecdotal form, into groups in order to construct quantitative scales that vary in complexity (Maama et al., 2019; Pillay, 2019). Data extracted from sustainability statement was based on the selected ESG framework provided by Bursa Malaysia.

Meanwhile, binary scoring system designates scores of 1 to represent disclosure and 0 to represent non-disclosure. Following this, trends and a descriptive summary of ESG performance will be determined, with intra-coder reliability test to maintain the consistency and reliability over time which enhance the validity of binary scoring. To check the reliability of the coding process, an intra-coder reliability test was done. The same coder reviewed the sustainability statements once again, and the results were checked for consistency. A strong agreement across coding rounds means that the coder used the scoring criteria consistently, which makes the content analysis process more valid. This process reduces bias in subjective interpretation and makes the study's results more methodologically reliable. Previous study from Sulaiman et al., (2024) has

published an ESG framework that adheres to the guidelines set by Bursa Malaysia.

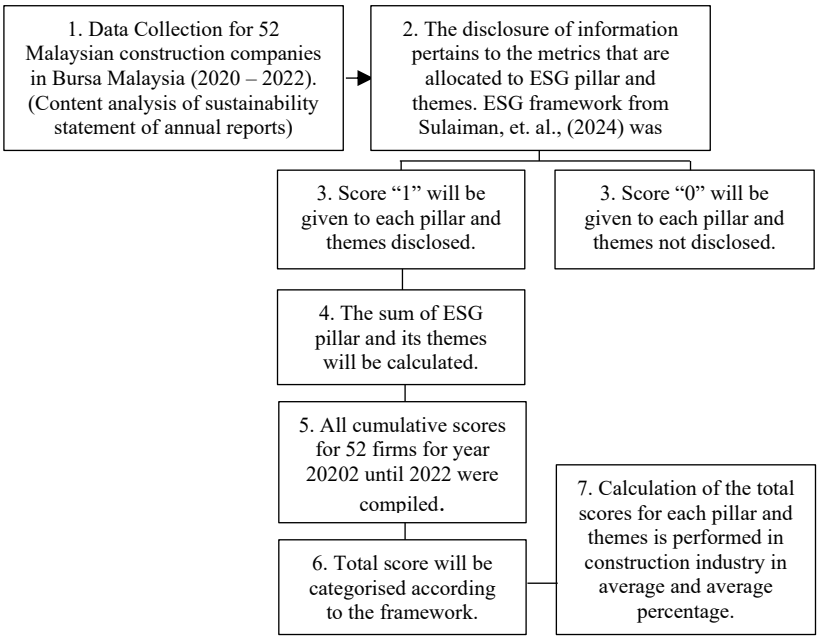


Figure 1: Binary Scoring Process of the Study
Source: Sulaiman et al., (2024)

Figure 1 show the binary scoring process of the study. Collected data on ESG practices were grouped under ESG pillars and themes as stated in the framework and score "1" for any practices adopted and "0" for not adopted. Total scores for each pillar and themes then calculated and were described in descriptive analysis.

Limitation

Although the sample includes 52 significant construction companies listed on Bursa Malaysia, there are some limitations that need to be acknowledged. The study may demonstrate sampling bias, as companies with inadequate disclosure practices or limited reporting capabilities are less likely to issue comprehensive sustainability statements, potentially resulting in their under-representation. This increases the chance of persistence bias, which could make the overall maturity of industry-wide disclosures seem higher than it really is.

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RESULTS

Environmental Disclosures in Malaysian Construction Sector

Table 2 show the result of themes and sub-themes of environmental pillar disclosure within the sector. The result indicate that pollution and resources represent 38% of the measured factors, with climate change following at 27%. Water use and biodiversity possess comparable importance, contributing 21% and 20% of the total assessment, respectively. Supply chain considerations form an insignificant 8% contribution to the overall evaluation.

In environmental pillar, the significant contribution of 38% to pollution and resources theme highlights its key contribution to business sustainability, while the other 62% does not specifically address pollution and resources. The analysis of the sub-themes demonstrates a sophisticated strategy for solving this problem, with pollution and waste management being the most significant at a frequency score of 35, highlighting the need to take proactive steps to reduce environmental damage. Meanwhile, conducting an environmental impact assessment (8) has the lowest score, as in Malaysia's construction sector, the Environmental Impact Assessment (EIA) receives the lower score due to the country's rapid development and urbanisation, which create a sense of urgency to accelerate construction projects, which can lead to less thorough or rushed EIAs.

Table 2: Frequency and Percentage of Environmental Theme Disclosure in Malaysian Construction Sector

Sustainability Themes	Thematic Disclosures	Frequency out of 52 firms	%
Pollution and Resources	Pollution and Waste Prevention	35	38
	Good Waste Management	34	
	Adherence to Policy and Regulations	16	
	Promote Awareness	15	
	Technology Advancement	12	
	Environmental Impact Assessment	8	
Climate Change	Energy consumptions or efficiency	20	27
	Technology improvement or maintenance	19	
	Renewable Energy	17	
	Reduce Carbon Emission	16	
	Management Action to Promotes Awareness	7	
	Climate Assessment or Policy Adherence	4	
Water Use	Water Efficiency & Conservation	20	21
	Water Management & Maintenance	19	
	Water Use Awareness	14	
	Alternative Sources from Water	11	
	Adherence to Policy & Regulations	6	
	Technology Advancement	5	
	Conservation & Preservation of Flaura & Fauna	14	

Sustainability Themes	Thematic Disclosures	Frequency out of 52 firms	%
Biodiversity	Adopt Green Policy	12	20
	Biodiversity Assessment	8	
	Green Building Practice	8	
Supply Chain	Supplier Assessment	5	8
	Established a Guideline or Policy	4	
	Green Supply Chain	3	

Source: Author (2024)

Climate change is the second most disclosed practice among firms, with 27% of them sharing information about their climate change practices. The remaining 73% of organisations have not disclosed any information about their climate change policies. Climate change is a complex issue that includes multiple sub-themes which focus on carbon emission and renewable energy. Energy consumption or efficiency is a significant aspect, with highest frequency of 20, while climate assessment or policy adherence receives the lowest frequency of 4.

The percentage score of water used of 21% highlights the significance of implementing sustainable water management approaches in Malaysia, particularly in considering concerns over water scarcity. Construction site in Malaysia involves a lot of pollution such as dust pollution. Therefore, water is an important resource to prevent or reduce the level of dust pollution at the construction site.

Meanwhile, 20% of firms in the sector have adopted biodiversity practices, while the remaining 80% have not. From our sample, only prominent firms in this sector adopt this practice due to high cost in adapting the practices. Supply chain obtained the lowest percentage, 8% in environmental pillar. This is because, supply chain in Malaysia is still in the early phase of implementing sustainability principles, which indicates a lack of awareness and capability among suppliers and contractors. Furthermore, constraints such as disintegrated supply chains, financial constraints, and insufficient governmental motivations for environment friendly supply chain could hinder advancements in this field.

Social Disclosures in Malaysian Construction Sector

In evaluating the theme in social pillar, important elements highlight critical elements of corporate accountability and involvement with stakeholders. Results in Table 3 highlights the significant importance of creating a safe and healthy work environment for employees, with safety & health being the main focus, making up 32% of the evaluation. Safety and health possess the highest percentage due to regulatory framework in Malaysia is anticipated to prioritise safety requirements in the construction sector to effectively avoid workplace

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accidents and preserve the welfare of workers as this sector has high risk exposure to occupational accidents at the construction sites.

Table 3: Frequency and Percentage of Social Theme Disclosure in Malaysian Construction Sector

Sustainability Themes	Thematic Disclosures	Frequency out of 152 firms	%
Safety & Health	Awareness & Prevention Measurement	30	32
	Policy or Regulation Compliance & Adoption	21	
	Safety & Health Training & Incentives	20	
	Health & Safety Assessment	14	
	Health & Safety Equipment Advancement & Maintenance	11	
	Health & Safety Committee	14	
	Provide Incentives & Good Remuneration Packages	7	
Labor Standard	Learning or Training	26	24
	Inclusivity & Fair Treatment	22	
	Good Remuneration & Incentives Package	18	
	Flexibility & Work Life Balance	12	
	Provide Conducive Work Environment	12	
	Policy or Regulations Adherence	10	
	Two-way Communications	8	
	Financial Supports	3	
Customer Responsibility	Provide Quality Services or Products	15	15
	Provide Customer Survey or Assessment	12	
	Two-way Communications	8	
	Third Party Assessment or Audit	3	
	Policy or Regulation Compliance	2	
Human Right	Charitable Activities	21	13
	Inclusivity, Equality & Diversity	18	
	Policy or Regulations Adherence	6	
	Prohibit Child or Illegal Labor	4	
	Established in-house Policy or Regulations	3	
	Public or Government Sector Engagement	3	
Supply Chain	Sustainable Supply Chain Policy	10	13
	Supplier Assessment	10	
	Established a Guideline or Policy	5	
	Technology involvement in Supply Chain	1	

Source: Author, (2024)

The Labor Standards category has a high score of 24%, which highlights the importance of maintaining fair labor practices and protecting employee rights. Furthermore, the inclusion of 15% customer responsibility stresses the duty of firms to prioritise the well-being and happiness of their

customers. Human rights (13%) and supply chain factors (13%) are given comparable importance, indicating the increasing acknowledgment of human rights concerns and the significance of ethical sourcing procedures in company operations. The complete evaluation highlights the complex and different aspects of social sustainability, requiring inclusive approaches to meet the interests of various stakeholders and maintain ethical standards across the supply chain. The construction sector frequently involves vast supply networks with multiple levels of subcontractors, hence posing difficulties in effectively monitoring and ensuring adherence to human rights norms across the whole supply chain.

Governance Disclosures in Malaysian Construction Sector

Table 4 shows the result of governance pillar, which includes risk management, corporate governance, anti-corruption measures, and tax transparency, invests 25% of its attention to risk management. This highlights the crucial significance of identifying, assessing, and minimising risks within organisations. The construction sector in Malaysia is particularly vulnerable to a range of hazards, including regulatory compliance, project complexity, environmental concerns, and supply chain disruptions. As a result, risk management has been a key focus in this industry. Meanwhile, corporate governance, accounting for 21% of the total, emphasises the importance of creating strong systems and procedures to guarantee responsibility, openness, and ethical behavior in decision-making. Furthermore, the decision to allocate 21% of resources to anti-corruption activities underlines the critical need of addressing corruption and promoting ethical behaviors in corporate settings.

Table 4: Frequency and Percentage of Governance Theme Disclosure in Malaysian Construction Sector

Sustainability Themes	Thematic Disclosures	Frequency out of 52 firms	%
Risk Management	Risk Assessment	21	25
	Established In-House Policy/ Regulations	16	
	Risk Management Committee	15	
	Policy or Regulations Compliance	11	
	Provide Training or Awareness Campaign to Minimise the Risk	3	
Corporate Governance	Compliance to Rules/ Regulations	22	21
	Promotes Good Sustainability Practices & Reporting Disclosure	19	
	Established an in-house Policy	9	
	Assessment or Audit of Governance Practices	9	
	Transparency in Nomination or Appointment of BOD	6	
	Training for Board of Directors	2	

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Sustainability Themes	Thematic Disclosures	Frequency out of 52 firms	%
Anti-Corruptions	Policy or Regulations Adherence	30	21
	Established in-house Policy or Regulations	19	
	Provide Training & Awareness Campaign	7	
	No Gift Policy	7	
	Anti-Corruptions Audit or Assessment	6	
	Direct Medium for Reporting Anti-Corruption	5	
	Formed Internal Integrity Department	4	
Tax Transparency	Compliance to Policy or Regulations	5	6
	In-House Tax Department	2	
	Outsource Audit Firm for Assessment	2	

Source: Author, (2024)

The last themes are tax transparency with 6% allocation to tax transparency which underscores the growing significance of transparency in tax processes, in line with international endeavours to foster equity and responsibility in tax reporting and adherence. In addition, public listed firms tend to not disclose their tax transparency in the sustainability statement because public listed firms are bound to report their tax disclosure in company's financial statement and notes to financial statement as one of requirement from Malaysian Financial Reporting Standard (MFRS).

DISCUSSION

ESG Disclosure in Malaysian Construction Sector

In ESG, each pillars place different levels of importance on ESG factors. Table 5 show that environmental pillar is given a weight of 58%, the social pillar 68%, and the governance pillar 59%. The significant investment of 68% towards the social pillar demonstrates a firm dedication to addressing social effect and responsibility in corporate activities. This covers various issues like labor standard, health and safety, supply chain, customer responsibility and human right which promoting effort in diversity and inclusion. In social pillar, health and safety is the most important ESG factor for contractor as it has the highest frequency with 49 firms disclose their health and safety practice out of 52 construction firms in the sample.

Table 5: Percentage of ESG Individual Pillars

ESG Pillars	ESG Themes	Frequency out of 52 firms	%
Social	Health & Safety	49	68%
	Labor Standard	47	
	Human Right	38	
	Customer Responsibility	27	
	Supply Chain	17	
Governance	Anti-corruption	42	59%
	Corporate Governance	37	
	Risk Management	36	
	Tax transparency	8	
Environmental	Pollution & Resources	45	58%
	Climate Change	34	
	Water Use	33	
	Biodiversity	28	
	Supply Chain	12	

Source: Author, (2024)

Construction sites are highly dynamic environments that present an extensive list of potential hazards. By giving priority to health and safety measures, not only the well-being and lives of workers are protected, but the chances of accidents, injuries, and fatalities are also reduced. Moreover, a safe and conducive working environment improves employee morale, productivity, and retention, resulting in enhanced project outcomes and cost-efficiency.

CONCLUSION

In conclusion, this study addressed ESG disclosures in Malaysian construction firms by integrating the Sulaiman et al., (2024) ESG framework. Content analysis has been used to collect data, and a binary scoring method has been used to analyse the data. This study highlights the crucial importance of ESG disclosure in influencing business sustainability strategies. Based on the disclosure percentages of 58% for the environmental pillar, 68% for the social pillar, and 59% for the governance pillar. As a result, firms place a higher priority on social concerns compared to environmental and governance factors, as health and safety are the most crucial factors in the construction sector. Result of this study advances ESG disclosure literature by demonstrating that firms in Malaysia's construction sector exhibit a distinctive prioritisation of social-related disclosures, particularly health and safety, relative to environmental and governance themes. This sector-specific evidence enhances understanding of how ESG transparency evolves in high-risk, project-based industries,

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contributing new empirical insights to ESG reporting practices in emerging economies.

ACKNOWLEDGEMENT

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM) through TIER 1 Grant (Vot Q530) and "Geran Penyelidikan Pascasiswazah" ("GPPS") (Vot Q328) and this research was made possible through monetary assistance by UTHM Publisher's Office via Publication Fund E15216.

DISCLOSURE STATEMENT

The analysis in this research is based solely on publicly accessible secondary data, including published reports and official documents. Since the study did not involve human participants, no human subject ethics approval was necessary.

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Received: 5th July 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 79 – 94

ENVIRONMENTAL SOCIAL GOVERNANCE IN PROSPERING THE MALAYSIA LISTED REAL ESTATE COMPANIES' PERFORMANCE

Rohaya Abdul Jalil[1], Muhammad Najib Razali[2], Muhammad Yusaimi Abdul Hamid[3], Azlina Binti Md Yassin[4] and Siti Azilah Mohd Amin[5]

[1,2,3,5]*Fakulti Alam Bina & Ukur,*
UNIVERSITI TEKNOLOGI MALAYSIA
[4]*Fakulti Pengurusan Teknologi dan Perniagaan,*
UNIVERSITI TUN HUSSEIN ONN MALAYSIA

Abstract

The COVID-19 pandemic and increased demand for improved international supply-chain management, Sustainability Reporting has been made compulsory for all listed companies in Malaysia, including LRECs. This reporting highlights the integration of ESG practices, with a more holistic approach compared to corporate governance and CSR previously practised. ESG is aimed at value creation through responsible environmental and social practices. This paper analyzes how ESG practices factor into the financial performance of Malaysian LRECs, including those involved in construction, plantations, REITs, and properties. Based on MRA analysis, this study found that the ESG criteria are substantially influencing the financial performance within the construction, plantation, and REITs sectors with R2 > 0.5. However, only the dividend yield was found to be significantly related to the ESG criteria for the properties sector. Sectoral differences are highlighted in this study as influencing the impact of ESG practices on financial performance.

Keywords: Environment Social Governance, Listed Real Estate Companies, Financial Performance, Earth Investment

[1] Corresponding author. Email: rohaya@utm.my

INTRODUCTION

Sustainability reporting has gained prominence and empowered stakeholders to assess the performance of an organization based on environmental, social, and governance (ESG) parameters. ESG considerations have also taken center stage in investment decisions because investors now prefer companies with responsible and socially relevant operations. The United Nations initiated the Principles for Responsible Investment in 2006, which placed greater emphasis on ESG factors in financial analysis to offer better investment returns in a sustainable manner. In the perspective of real estate, Malaysian LRECs faced several challenges amid disruptions caused by the COVID-19 pandemic, including market misreads and cost overruns that are better addressed through ESG good practices via improved governance and environmental and social considerations. The study determines how ESG factors from the Thomson Refinitiv ESG Database influence the financial performance of LRECs in Malaysia. The research focuses on three main areas that indicate high sensitivity to ESG issues: governance, risk management, and responsible supply chain practice. This study aims to evaluate the influence of ESG sub-criteria on LRECs and provide an analysis of strategies toward resilience development and compliance to mitigate future business challenges.

LITERATURE REVIEW

Introduction of ESG by corporate

Governance standards prioritize transparency, integrity, and accountability. In Malaysia, ESG practices have gained attention, with investors favoring companies with strong ESG strategies (Yan et al., 2020). Environmental criteria in ESG evaluation focus on climate policies, energy use, waste management, and resource conservation, addressing risks like emissions and toxic waste (Chartered Finance Institute, 2019). Companies are assessed on sourcing, supplier compliance, and community welfare (Cajias, 2021). ESG disclosure improves financial performance, reduces capital costs, and attracts investments (Chen & Xie, 2022; Wong et al., 2021). ESG certification can enhance firm value, especially during crises like COVID-19 (Feng & Wu, 2021).

Environmental Materiality Assessment Influence Toward Financial Performance

The Bursa Malaysia Sustainability Reporting Guideline V.3 (2023) outlines eight environmental criteria: (i) energy management, (ii) water management, (iii) waste management, (iv) emission management, (v) biodiversity, (vi) material use impact, (vii) supply chain management effects, and (viii) effluent discharge impact on the environment.

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Energy management is done in property to enhance efficiency through the use of technology and design. Smart HVAC systems adjust according to occupancy and external conditions, thereby reducing energy use. In Malaysia, malls have pursued upgrading their lighting to LED lighting for improved efficiency. Powers & Saad, 2022; Belany et al., 2021 Real-time energy monitoring identifies inefficiencies, while renewable sources of energy and energy-efficient appliances reduce reliance on and consumption of fossil fuels. Zou & Mishra, 2020

Effective water management in real estate optimizes usage and reduces waste. Strategies include drought-resistant landscaping, efficient irrigation, and rainwater harvesting as reported by Kurtaslan et al. (2019). Installing low-flow fixtures reduces consumption. In tandem with this observation, Tourigny & Filion (2019) observed that installing low-flow water fixtures resulted in reduced water consumption. Water-efficient HVAC systems, like cooling towers and heat exchangers, minimize water usage. Aligned with Rodrigues et al. (2020) demonstrated how water-efficient HVAC systems could reduce water consumption by large buildings. Rainwater harvesting reduces dependence on municipal supplies, providing water for non-potable uses like irrigation and toilet flushing. De Sá Silva et al. (2022) explained the need for rainwater harvesting based on reduced water scarcity.

Real estate waste management, the focus is on waste reduction, recycling, and proper waste disposal (Kariuki, 2023; Wahlström et al., 2019). Waste auditing facilitates determination of the type and quantity of wastes, enabling monitoring of progress over time (Ayfokru et al., 2023; Yu et al., 2021). The encouragement of tenants to reduce paper usage and avoid single-use plastics leads to a reduction in waste generation. An effective recycling program is facilitated by the provision of appropriate signage and education, increasing the likelihood of participation (Umar et al., 2021). Circular economy practices that support reuse and recycling are increasingly becoming the norm (Wang et al., 2021).

Emission management in construction puts forward a reduction in the GHG emission rate. Energy-efficient designs, like high-performance insulation and passive solar designs that minimize heating, cooling, and lighting needs, obviously reduce emissions. Aligned with Carlander & Thollander (2022), and Wilkinson & Sayce (2020). The carbon footprint is reduced by using low-carbon materials, like recycled alternatives to cement and steel (Chan et al., 2022). Investment in energy-efficient HVAC systems with smart controls decreases operational emissions and energy costs, as stressed by Mostafavi et al. (2021) and Prada et al. (2020).

Construction projects may positively or negatively affect the influence of biodiversity. Sustainable projects that preserve or restore habitats, such as wetlands and forests, contribute to biodiversity. Poorly designed projects that

cause habitat destruction or fragmentation, like deforestation and drainage of wetlands, damage ecosystems and disrupt ecological processes (Reid et al., 2019). Biodiversity conservation during project planning so that ecological balance can be maintained.

Different materials used in construction have huge impacts on the environment. The extraction of raw materials results in habitat destruction and depletion of natural resources (Vasilca et al., 2021). Production of cement and steel leads to the emission of greenhouse gases and other pollutants (Sandanayake, 2022). Recycled steel and low-carbon concrete are among the sustainable materials that lower these effects (Gong & Kong, 2022). Green certification aids in ensuring minimal environmental damage.

Construction supply chain management (SCM enhances environmental performance through optimized procurement, cost-effective sourcing of quality materials with minimal waste and emissions (Kim & Nguyen, 2022). Logistics ensure timely delivery to sites, while the accuracy in forecasting avoids waste accumulation. Sourcing from sustainable suppliers reduces carbon emissions and ultimately contributes to reducing environmental footprints. Sustainable SCM practices are extremely crucial for meeting the demand for green buildings (Gaurang, 2020).

The effluents from construction and agriculture can extensively destroy the environment. In the process of construction, effluents containing chemicals and pieces of debris deteriorate water quality and cause death to aquatic life (Ngounouno et al., 2023). Agricultural activities involving palm oil plantations have created pollution problems and soil degradation (Akhbari et al., 2020). In such contexts, effluent management should be properly addressed to safeguard health and wildlife (Shah & Ruparelia, 2022). Real estate increasingly uses sustainable approaches such as energy-efficient designs and waste reduction to ensure environmental protection for generations.

Social Materiality Assessment Influence toward financial performance

ESG practices in corporate participation and contribution to communities and societies have been focused on equity regarding economic and educational perspectives (Kucharska, 2019). Ignoring the needs of communities often ruins the image of a corporation and results in increased crime, thus burdens, in the long run (Churchill et al., 2023). Firms are supposed to contribute by investing in community engagement processes to assure commitment to shareholders and society. The social criteria portrayed in the Bursa Malaysia Sustainability Reporting Guideline V.3 (2023) have been primarily set to include four criteria: community contribution, health & safety, supply chain management, and the social assessment of suppliers.

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Communities benefit from corporations through the provision of infrastructure, affordable housing, and clean water (Gulakov et al., 2020). They also inspire employee volunteerism to participate in community service with either paid volunteer time or donation matching. Social impact investing uses money for projects that yield both social and financial returns. Further, investing in the welfare of the employees themselves, through fair wages and good health care, leads to economic development and helps to build sustainable and resilient communities.

The contribution of corporate social responsibility (CSR) to health and safety is very important for community well-being. The companies are supposed to train employees for the prevention of accidents, undertake emergency procedures, and maintain a healthy working environment (Obuobisa-Darko, 2022). This also involves active engagement with communities, healthcare initiatives, and the involvement of companies in health promotion programs. The company should take full responsibility to ensure environmental sustainability through reductions in pollution levels and preservation of resources, hence contributing to health and environmental well-being (Rondinelli & Berry, 2000), so there is assurance of a healthy and safe society.

Governance principles ensure that every corporate contribution to SCM is characterized by transparency and equitability (Bui, 2020). The SCM in real estate manages suppliers, materials, and labor; it ensures that suppliers follow legally set standards (Monczka et al., 2021). Clearly drafted contracts define the quality to be expected. In plantations, audits support transparency in SCM to ensure compliance (Chakraborty & Chakraborty, 2023).

Clear contracts spell out the quality expectations (Al Damaloji & Alzubaidy, 2023). Audits in plantations ensure SCM transparency for compliance (Koc & Gurgun, 2021). Corporate contributions in SSA for construction promote sourcing ethically, minimize risks, and ensure compliance (Tushar et al., 2022; Hoseini et al., 2021). SSA upholds labor standards and protects workers from exploitation (Guarnieri & Trojan, 2019). SSA ensures that there is appropriate labour and environmental behaviour, thereby offering sustainable development and company reputation (Marzouk & Sabbah, 2021).

Governance Materiality Assessment Influence toward financial performance

Governance incorporates mechanisms and procedures that guide a company and govern compliance with regulations to avoid associated risks, such as penalties and loss of reputation, stated by Shaikh (2022) and Albitar et al. (2020). In the context of real estate, conformance to legislations on transaction matters, financial reporting, and environmental standards would help sustain stakeholders' confidence in them. Thus, ESG frameworks boost transparency, accountability, and ethics in decision-making, among other parameters leading to long-term

sustainability. Therefore, the Bursa Malaysia Sustainability Reporting Guidelines (2023) have laid emphasis on governance attributes: anticorruption policy, diversity, labor practices, and data privacy compliance-the hallmarks of responsible corporate governance.

Anti-corruption initiatives in the construction and plantation industries are very important in reducing bribery, kickbacks, and collusion that undermine fairness and inflate contract prices. These lead to poor-quality construction and compromised safety. Promotion of integrity and transparency will engender public trust and help ensure quality and safety with sustainable economic development by protecting the interest of stakeholders (Lee & Liang, 2024).

Diversity and inclusion initiatives are internally essential for corporate governance and foster an environment that values demographic and socio-cultural differences (Choi et al., 2022; Hickey & Cui, 2020). A diverse board improves decision-making, innovation, and risk management and offers great benefits to companies and society (Wong, 2022; Purnomo & Rizki, 2020).. Diversity and inclusive practices in construction help in the attraction and retention of key talent, the creation of shareholder value, and the fostering of principles related to equity, equality, and sustainability (Chong & Loh, 2023; Currie et al., 2021).

Compliance with labor practices in the context of corporate governance ensures employees' well-being and productivity by promoting equal treatment, ensuring their safety, and taking into account their well-being in the organization (Manoharan et al., 2023). Compensation based on ESG metrics supports sustainable growth (Flammer et al., 2019). Sound employment policies create inclusivity, adherence to the law, trust, and prosperity (Kim et al., 2021). Protective data practices in running a company guarantee adherence to data regulations, such as GDPR (Saah et al., 2023; Patel & Patel, 2020). Company structures shield data from breach, minimize risks to finances, and even aid in complying with data regulations through practices such as encryption, access, training, and audits.

ESG in Real Estate Sector

Sustainability reporting is fundamental in promoting green policies, and the EU stimulates the adoption of new reporting guidelines (Andersson et al., 2022). The Energy Performance Certificate (EPC), established in the EU in 2002, works to eliminate info asymmetry and increase the energy performance of buildings (Thomas et al., 2021). ESG factors have a significant role in the real estate sector, with sustainability opportunities available throughout the occupier lifecycle (CBRE, 2021). A high ESG performance positively increases stock performance, particularly in the areas of energy and GHG emission performance (Erol et al.,

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2023; Brounen et al., 2020), or a method has been advocated by Kempeneer et al. (2021) to increase sustainability in the real estate market using smart real estate.

RESEARCH METHODOLOGY

The ESG criteria are recognized as independent variables influencing financial performance and simplified as the following such are (i) energy management's influence *(E_e)*; (ii) water management's influence *(E_w);* (iii) waste management's influence *(E_s)*; (iv) emission management's influence *(E_m)*; (v) biodiversity's influence *(E_b)*; (vi) effect of the material used on environment *(E_t);* (vii) effect of the supply chain management on the environment *(E_c)*; (viii) effect of the effluents discharge on the environmental *(E_L);*(ix) corporate's contribution effect on society or community *(S_{ac})*; (x) corporate's contribution effect on health & safety *(S_d)*; (xi) corporate's contribution effect on supply chain management *(S_{LP})*; (xii) corporate's contribution effect on supply chain (social)/ supplier social assessment *(S_{DP});* (xiii) anti-corruption initiatives to promote governance *(G_{ac});* (xiv) diversity and inclusion initiatives to promote governance *(G_d);* (xv) compliance of labor practices and standards in governance *(G_{LP})*; and (xvi) compliance of data privacy and security in governance *(G_{DP}).* Data collection dependent variable are from secondary for year 2022 and 2023 from Refinitiv Eikon Online Databases for Malaysian LRECs s and financial performance measurement' calculation are as the following:-

$Y_{1(TRI)}$= Total Return Index (TRI)

$$Y_{1(TRI)} = \frac{P_t - P_{t-1} + I_t}{P_{t-1}} \quad \text{..... Formula 1}$$

Where,
$Y_{1(TRI)}$ *= total return index in current time period t*
P_t *= price at the end of current time period t*
P_{t-1} *= price at the end of previous time period t-1*
I_t *= net income received in current time period t*

$Y_{2(Tq)}$= Tobin's Q

$$Tobin's\ Q = \frac{MV_e + MV_d}{RC} \text{ ..... Formula 2}$$

Where,
MV_e *= Market Value of Equity is the total market capitalization of the company's outstanding equity*
MV_d *= Market Value of Debt is the total market value of the company's outstanding debt*
RC *= Replacement Cost of Assets is the estimated cost of replacing all of the company's assets at their current market prices*

$Y_{3(P/E)}$= Price-to-Earnings (P/E)

$$Y_{3(P/E)} = \frac{MPS}{EPS} \quad \text{..... Formula 3}$$

Where;
$Y_{3(P/E)}$ = *the price -to -earnings*
MPS = *the market price per share*
EPS = *the earnings per share*

Y_4= Dividend Yield (DY)

$$Y_{4(DY)} = \frac{DPS}{MPS} \quad \text{..... Formula 4}$$

Where;
$Y_{4(DY)}$ = *the dividend yield*
DPS = *the dividend per share*
MPS = *market price per share*

Y_5= Return of Equity (ROE)

$$Y_{5(ROE)} = \frac{Net\ Income}{Shareholders' Equity} \quad \text{..... Formula 5}$$

Where;
$Y_{5(ROE)}$ = the return of equity
$Net\ income$= the net income generated by the company
SE = the shareholders' Equity

Data collection on assessment of the implementation of ESG criteria score by Malaysia's LREC are according to the disclosure on the materiality matrix published in LRECs Annual Report, such as following example of the water management's influence *(E_w)* implementation in the Figure 1, will be score as Important to Business Model = 8, Important to Stakeholders = 6, therefore the score of E_w = 46. The influence of ESG criteria implementation toward financial performance of Malaysia's LRECs is examined through multiple regression analysis (MRA) and the strength of R-squared is analysed.

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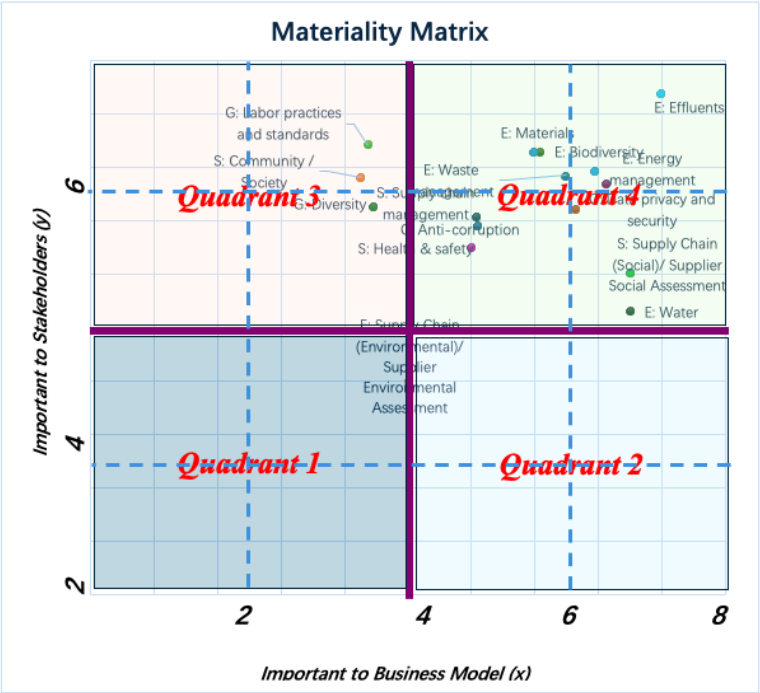


Figure 1: Scoring for ESG criteria element implementation

ANALYSIS AND DISCUSSION

The Table 1, indicates that the data analysis on MRA on the significant influence of the criteria of ESG towards Malaysia LRECs' financial performance. Under the Malaysian properties sector shows that the ESG criteria had significance relationship with the dividend yield Y4(DY)_*Msia Prop* performance *(R^2 = 0.545)* indicates impact of ESG for the long-term investment goal. While Malaysia construction sector highlights that the ESG criteria had significance relationship with all the financial performance such as Y1(TRI) *_Msia Const (R^2 = 0.531);* Y2(Tq) *_Msia Const (R^2 = 0.817);* Y3(P/E) *_Msia Const (R^2 = 0.505);* Y4(DY) *_Msia Const (R^2 = 0.875);* and Y5(ROE) *_Msia Const (R^2 = 0.548).* This seem explain that the impact of ESG factors on Tobin's q and price to earnings (P/E) can vary depending on industry, company-specific circumstances, and investor preferences.

Thus, the Malaysia plantation sector shows that the ESG criteria had significance relationship with all the financial performance such as Y1(TRI) *_Msia Plant (R^2 =0.751);* Y2(Tq) *_Msia Plant (R^2 =0.814);* Y3(P/E) *_Msia Plant (R^2 =0.663);* Y4(DY) *_Msia Plant (R^2 =0.793);* and Y5(ROE) *_Msia Plant (R^2*

=0.795). Plantation companies that effectively integrate ESG considerations into their strategy and operations may experience competitive advantages that contribute to sustainable profitability and enhanced ROE over the long term (Chong and Loh, 2023; Thomas et al., 2021). Similarly, the Malaysia REITs sector shows that the ESG criteria had significance relationship with all the financial performance such as Y1(TRI) *_Msia REITs (R^2 =0.923);* Y2(Tq) *_Msia REITs (R^2 =0.998);* Y3(P/E) *_Msia REITs (R^2 =0.882);* Y4(DY) *_Msia REITs (R^2 =1.00);* and Y5(ROE) *_Msia REITs (R^2 =0.998).*

Table 1: Data Analysis of Regression Analysis the significant influence of the criteria ESG of Malaysian listed real estate companies' financial performance

Malaysian Properties	Y1(TRI) *Msia Prop*	Y2(Tq) *_Msia Prop*	Y3(P/E) *Msia Prop*	Y4(DY) *Msia Prop*	Y5(ROE) *Msia Prop*
Multiple R	0.4442	0.6542	0.5576	0.7379	0.2768
R Square	0.1973	0.4280	0.3110	0.5446	0.0766
Malaysian Construction	Y1(TRI) *Msia Const*	Y2(Tq) *_Msia Const*	Y3(P/E) *Msia Const*	Y4(DY) *Msia Const*	Y5(ROE) *Msia Const*
Multiple R	0.7289	0.9041	0.7106	0.9353	0.7404
R Square	0.5313	0.8174	0.5050	0.8747	0.5482
Malaysian Plantation	Y1(TRI) *_Msia Plantation*	Y2(Tq) *_Msia Plantation*	Y3(P/E) *_Msia Plantation*	Y4(DY) *_Msia Plantation*	Y5(ROE) *_Msia Plantation*
Multiple R	0.8667	0.9024	0.8143	0.8903	0.8916
R Square	0.7511	0.8144	0.6630	0.7926	0.7950
Malaysian REITs	Y1(TRI) *_Msia REITs*	Y2(Tq) *_Msia REITs*	Y3(P/E) *_Msia REITs*	Y4(DY) *_Msia REITs*	Y5(ROE) *_Msia REITs*
Multiple R	0.9608	0.9991	0.9389	1.0000	0.9989
R Square	0.9232	0.9982	0.8816	1.0000	0.9978
All Malaysian LREC	Y1(TRI) *_Msia LRECs*	Y2(Tq) *_Msia LRECs*	Y3(P/E) *_Msia LRECs*	Y4(DY) *_Msia LRECs*	Y5(ROE) *_Msia LRECs*
Multiple R	0.2498	0.4712	0.3151	0.6503	0.4391
R Square	0.0624	0.2221	0.0993	0.4229	0.1928

The results showed that all ESG criteria impacted the financial performance of construction, plantation, and REITs sectors. ESG factors significantly affect REITs through operational efficiency, tenant satisfaction, regulatory compliance, investor perception, and financial performance (Erol et al., 2023). ESG performance variations among listed real estate companies drive value creation and differentiation (Newell et al., 2023; Lee & Liang, 2024), with varying impacts across sectors like plantation, construction, and real estate services (Brounen et al., 2021; Kempeneer et al., 2021). However, when MRA is

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conducted through all Malaysian LRECs (Y) and ESG Criteria (Xs), the results indicates that the ESG criteria had insignificance relationship with all the financial performance such as Y1(TRI) *_Msia LRECs (R^2 =0.062);* Y2(Tq) *_Msia LRECs (R^2 =0.222);* Y3(P/E) *_Msia LRECs (R^2 =0.099);* Y4(DY) *_Msia LRECs (R^2 =0.423);* and Y5(ROE) *_Msia LRECs (R^2 =0.193).* This result indicate each of Malaysia LRECs sector have a difference relationship with each of ESG criteria, such example biodiversity's influence *(E_b)* and effect of the effluents discharge on the environmental *(E_L)* for plantation sector and REITs sector are difference, as such plantation sector need to put on more efforts on handle biodiversity issue compare to how REITs were to handle the biodiversity. ESG factors impact Malaysian listed real estate companies (LRECs) differently based on business models, but embracing ESG principles enhances long-term financial performance and contributes to societal well-being and environmental stewardship (Chong & Loh, 2023; Zainon et al., 2020).

CONCLUSION

This study shows that ESG criteria impact the financial performance of Malaysian listed real estate companies (LRECs) differently across sectors. The construction, plantation, and REITs sectors exhibit significant ESG influence, while the property sector affects only dividend yield. MRA reveals varying financial performance effects by sector, with COVID-19 impacting the property sector. ESG plays a key role in resilience and investor confidence (R2 > 0.5).

ACKNOWLEDGEMENT

This is part of the research of the National Real Estate Research Coordinator (NAPREC), under the Allocation RMK-12 (Phase 2B) (INSPEN), Valuation and Property Services Department (JPPH), Ministry of Finance Malaysia

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Received: 5th July 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 95 – 108

ADVANCING MALAYSIAN HOUSE PRICE INDEX PREDICTIONS: THE POTENTIAL OF ARTIFICIAL NEURAL NETWORK

Aida Julia Aminuddin[1], Nurul Hana Adi Maimun[2], Hishamuddin Mohd Ali[3], Tan Shang Yin[4], Abdul Jalil Omar[5]

[1,2,3,4] *Centre for Real Estate Studies (UTMCRES),*
Institute for Smart Infrastructure and Innovative Construction (ISIIC),
UNIVERSITI TEKNOLOGI MALAYSIA
[5] *Malaysian Real Estate Institute,*
Faculty of Technology Management and Business,
UNIVERSITI TUN HUSSEIN ONN MALAYSIA

Abstract

This study develops a localized house price index by employing an Artificial Neural Network (ANN) forecasting model to enhance the organization and efficiency of the Malaysian property market. Traditional Malaysian House Price Index (MHPI), based on a hedonic model, exhibits multicollinearity among house attributes, limiting its ability to accurately capture house price trends. While MHPI provides aggregate indices, the construction of disaggregate indices remains underexplored, potentially reducing the effectiveness of local housing market analysis and long-term planning. This research aims to identify key house attributes influencing prices and to evaluate the capability of ANN in forecasting the Johor Bahru house price index. The study applies ANN to disaggregate transaction data of double-story terrace houses in Taman Mutiara Rini and Taman Bukit Indah, comparing actual and forecasted prices using R-squared (R^2), Mean Absolute Percentage Error (MAPE), Root Mean Square Error (RMSE), and Mean Absolute Deviation (MAD). Findings reveal significant differences between forecasted and actual indices, demonstrating ANN's superior ability to capture local price variations. The study highlights ANN as a robust tool for constructing disaggregate house price indices, offering improved insight and efficiency for monitoring and planning within local housing markets in Malaysia.

Keywords: Localized house price index, Artificial Neural Network, Johor Bahru, Disaggregate housing data, Forecasting

[1] Corresponding author. Email: ajulia3@graduate.utm.my

INTRODUCTION

The housing market plays a critical role in national economic performance and local development, as housing price movements influence wealth distribution, investment decisions, and consumer confidence (Gobalkrishnan & Md Yusof, 2023; Yalpir, 2014). Accurate forecasting of housing prices is therefore essential for homebuyers, investors, financial institutions, and policymakers in designing effective housing and economic policies (Gobalkrishnan & Md Yusof, 2023; Munusamy et. Al, 2015).

Historically, the Hedonic Price Model (HPM) has been widely used for modelling house prices in real estate economics. However, HPM's reliance on linear functional forms and its sensitivity to multicollinearity, heteroskedasticity, and nonlinearity limit its ability to capture complex relationships present in real estate data (Abd. Rahman et al., 2019; Sa'at et al., 2021). These limitations often lead to reduced predictive accuracy in real-world forecasting scenarios.

To address these limitations, machine learning approaches, particularly Artificial Neural Networks (ANN) have gained attention for housing price prediction due to their flexibility in modelling nonlinear and high-dimensional data without strong parametric assumptions (Aminuddin & Adi Maimun, 2022; Gobalkrishnan & Md Yusof, 2023; Sa'at et al., 2021). ANN models have shown superior forecasting performance compared to traditional econometric techniques by effectively capturing complex patterns in housing market data (Gobalkrishnan & Md Yusof, 2023; Sridhar & Sathyanathan, 2022).

Despite these advances, studies focusing specifically on the Malaysian context remain limited, especially in terms of integrating modern ANN approaches and comparing their forecasting performance directly with HPM. Existing Malaysian research demonstrates ANN's potential with Penang housing price index forecasting (Gobalkrishnan & Md Yusof, 2023) and Johor Bahru case studies (Abd. Rahman et al., 2019), but these studies are geographically narrow and not sufficiently comprehensive across Malaysian housing markets as a whole. This gap suggests a need for more extensive, updated investigations into ANN performance in Malaysian house price modelling (Aminuddin & Adi Maimun, 2022).

This study aims to address this gap by examining the effectiveness of Artificial Neural Networks (ANN) in forecasting Malaysian house price indices. By demonstrating ANN's capability to manage nonlinear relationships and complex market data structures, this research contributes to a more robust understanding and application of advanced forecasting techniques for stakeholders such as investors, policymakers, and real estate professionals. Furthermore, this study aligns with national strategies such as Rancangan Malaysia Ketiga Belas, 2026-2030 (RMK-13) and National Artificial Intelligence

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(AI) Action Plan 2030 by encouraging the adoption of advanced computational methods to improve housing market forecasting and informed policy design.

LITERATURE REVIEW

Importance of Accurate Housing Price Forecasting

Accurate forecasting of housing prices is a critical objective in real estate research because housing markets are fundamental to economic stability, household wealth, and financial decision-making. House price indices are used by policymakers, financial institutions, and investors to monitor market trends, assess affordability, and inform policy responses (Munusamy et al., 2015). Demand and supply dynamics, macroeconomic conditions like GDP and interest rates, and property heterogeneity make forecasting complex (Norazmawati Md. Sani @ Abd. Rahim, 2025). This complexity motivates the use of advanced forecasting techniques beyond traditional econometric models.

Hedonic Price Model (HPM): Traditional Approach and Limitations

The Hedonic Price Model (HPM) is one of the most established econometric methods for house price forecasting. It decomposes house prices into attributes such as location, size, age and estimates their implicit values (McCluskey et al., 2012; Selim, 2009). HPM's interpretability and grounding in economic theory explain its popularity in real estate literature. However, HPM assumes linear relationships among variables (Abd. Rahman et al., 2019; Sa'at, et al., 2021). This assumption often reduces forecasting accuracy when dealing with real-world housing market data, which tend to be nonlinear and high-dimensional.

In the Malaysian context, conventional forecasting has often relied on aggregated indices constructed from macroeconomic variables, which can mask local market nuances and result in limited usefulness for accurate pricing (Adi Maimun, 2011; Adi Maimun et al., 2012). Complementary work has proposed alternative econometric models to improve index construction (Nik Nor Amalina Nik Mohd Sukrri et al., 2025; Zamri et al., 2024), but these still face challenges capturing nonlinear effects.

Rise of Machine Learning and ANN in House Forecasting

The shortcomings of HPM have spurred increased interest in Machine Learning (ML) techniques, particularly Artificial Neural Networks (ANN), which are flexible in modelling complex, nonlinear relationships without strict parametric assumptions (Ja'afar et al., 2021). ANN comprises layers of interconnected nodes that simulate neural processing, enabling pattern recognition, adaptation, and generalization from training data (Agatonovic-Kustrin & Beresford, 2000; Maind & Wankar, 2014). ANN has been shown to outperform traditional models in

various forecasting contexts, especially where relationships among variables are nonlinear and interactive (Li, 2025).

Comparative Studies: ANN vs HPM

A growing body of research has compared Artificial Neural Networks (ANN) with Hedonic Pricing Models (HPM) and other traditional forecasting approaches in the housing market. For instance, Sa'at et al. (2021) evaluated forecasting performance using Malaysian housing transaction data and found that ANN consistently outperformed HPM across multiple statistical and predictive metrics, demonstrating higher accuracy, lower error rates, and greater robustness in capturing market dynamics. The study highlighted that while HPMs rely on linear assumptions and are sensitive to the specification of independent variables, ANNs are capable of modeling non-linear relationships and complex interactions among multiple housing attributes, including land size, building size, tenure type, and age of the property.

International studies similarly underscore ANN's strengths in housing market forecasting. Sa'at and Adi Maimun (2019) reported that ANNs are particularly effective in learning complex patterns from historical data, yielding lower forecasting errors and stronger predictive generalization than traditional regression-based models. These findings indicate that ANNs are more adaptable to diverse datasets and can account for multifactor influences—such as economic indicators, demographic changes, and spatial heterogeneity—that often challenge traditional models.

The collective evidence from both local and international studies suggests that ANNs not only improve forecasting accuracy but also offer practical advantages for stakeholders. Real estate developers, policymakers, and investors can leverage ANN models to anticipate market trends, optimize pricing strategies, and inform investment decisions. Moreover, the flexibility of ANN frameworks allows researchers to incorporate a wide range of variables and tailor model structures, such as the number of hidden layers and nodes, to specific housing contexts, thereby enhancing their applicability across different regions and housing markets.

ANN Applications in Malaysian House Price Index Modelling

Despite the growing global momentum in applying Artificial Neural Networks (ANN) to housing market forecasting, evidence from Malaysia remains limited. Gobalkrishnan and Md Yusof (2023) applied ANN to the Penang House Price Index using quarterly data and reported high forecasting accuracy, demonstrating the model's ability to capture complex, localized patterns in housing market dynamics. Their study highlighted how ANN can effectively incorporate

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temporal trends and non-linear interactions among multiple market variables, outperforming conventional models in predictive performance.

Similarly, Abd. Rahman et al. (2019) applied ANN to forecast housing prices in Johor Bahru and observed superior predictive results compared to traditional regression-based methods. Their findings suggest that ANN models are capable of accommodating diverse housing attributes and local market characteristics, providing more accurate and reliable forecasts for property developers, investors, and policymakers.

Collectively, these studies underscore the potential of ANN for housing market forecasting in Malaysian contexts, while also revealing gaps in current research. Most existing studies focus on specific regions, such as Penang or Johor Bahru, and often rely on a limited set of variables or aggregate data. This highlights the need for broader application of ANN models across other regions and property types in Malaysia, as well as the exploration of micro-level datasets that capture property-specific characteristics, market demand, and socio-economic influences. Expanding ANN applications in this manner can enhance understanding of regional housing market dynamics, improve forecast accuracy, and provide a more robust foundation for data-driven policy and investment decisions.

Malaysian House Price Index Challenges

The Malaysian House Price Index (MHPI), published quarterly by the Valuation and Property Services Department (JPPH), provides an aggregated measure of housing market trends by compiling transaction data derived from stamp duty records. While the MHPI serves as an important benchmark for tracking national housing price movements, it faces several limitations that can constrain its accuracy and practical utility. One key limitation is its insufficient hyperlocal granularity; by aggregating transactions at state or district levels, the index often masks variations in micro-markets, such as specific neighbourhoods or property subtypes, where price dynamics may differ substantially.

Additionally, generally the HPI relies heavily on macroeconomic variables and aggregated transaction data, which may not fully capture property-specific factors such as land size, building age, tenure type, or ownership structure. Discrepancies between listed and actual transaction prices, regional market heterogeneity, and aggregation bias further reduce the precision of the index, potentially leading to under- or overestimation of housing market trends in particular areas (Lim, 2019; Saudin et al., 2020; Tan & Razali, 2016). These limitations are particularly consequential for stakeholders such as policymakers, developers, and investors, who require accurate, high-resolution data to make informed decisions about pricing, investment, and planning. Consequently, there is a growing need for alternative forecasting methods, such as Artificial Neural

Networks (ANN), which can integrate micro-level housing attributes and capture non-linear relationships across multiple variables. By addressing the MHPI's aggregation and granularity limitations, ANN models provide a more nuanced and precise tool for analyzing local housing markets and supporting data-driven decision-making.

Comparative Analysis: ANN vs HPM

Table 1 synthesizes key differences between ANN and HPM across forecasting criteria, illustrating ANN's advantages in predictive accuracy, adaptability, and handling of complex datasets, while acknowledging HPM's simplicity and interpretability.

Table 1: Comparison of ANN and HPM in Housing Price Forecasting

Criteria	Artificial Neural Network (ANN)	Hedonic Price Model (HPM)	References
Prediction Accuracy	High – captures nonlinear patterns and interactions	Moderate – assumes linearity, less accurate with complex datasets	Gobalkrishnan et al. (2023), Li (2025), Sa'at et al. (2021)
Data Requirements	Large datasets preferred for training	Can work with smaller datasets, but limited by data structure	Abd. Rahman et al., (2019), Munusamy et al. (2025)
Handling of Nonlinearity	Excellent – inherently models nonlinear relationships	Poor – linear assumptions restrict flexibility	Aminuddin et al. (2022), Sa'at et al. (2021)
Model Complexity	High – multiple layers, parameters, training required	Low – straightforward regression-based estimation	Agatonovic-Kustrin & Beresford (2000), Maind & Wankar (2014)
Interpretability	Moderate – results harder to explain	High – coefficients clearly indicate attribute effects	Li (2025), Munusamy et al. (2025)
Scalability	High – can handle larger datasets and features	Moderate – scalability limited by linear regression assumptions	Sa'at et al. (2021)
Computational Power	High – requires significant computation for training	Low – analytical solution, less computational demand	Abd. Rahman et al., (2019), Li (2025)
Flexibility in Modelling	High – can integrate macro and micro variables, time-series, or hybrid inputs	Limited – relies on predefined variables and linear forms	Gobalkrishnan & Md Yusof (2023)

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Criteria	Artificial Neural Network (ANN)	Hedonic Price Model (HPM)	References
Ability to Handle Missing Data	Moderate – can impute or learn patterns from incomplete data	Low – missing data may require preprocessing or exclusion	Li (2025), Sa'at et al. (2021)
Real-Time Forecasting	Yes – capable of dynamic updates and retraining	No – static estimation based on historical data	Gobalkrishnan et al. (2023), Li (2025)
Robustness	High – less sensitive to model misspecification	Moderate – errors can propagate due to model assumptions	Peterson & Flanagan (2009), Sa'at et al. (2021)

Source: Author's Review

Studies by Abidoye (2017) have reported that by adopting the ANN approach, their datasets for testing purposes can be processed at a greater speed and the results produced are more reliable and accurate. According to McCluskey et. al (2013), the greater improvement in the learning efficiency of ANN is due to the effort of many researchers. Previous comparative property modelling studies by Ng and Skitmoreb (2008), Nguyen and Cripps (2001), Julio and Esperanza (2004), Khalili and Nowbahar (2010; 2011), Khashei and Bijari (2011), Amanpour et al. (2015), Ghorbani and Afgheh (2017), Sa'at et al. (2019), and Stubnova et al. (2020) demonstrate the superiority of ANN model in forecasting performance compared to the other model.

Specifically, the ANN model illustrates a lower forecasting error between five per cent and ten per cent only. Several studies in real estate have used the ANN approach as the subject because of its ability to examine relationships in complex non-linear data sets due to the absence of the restrictive assumption of linearity about the nature of data relationships and functional form (Lin & Mohan, 2011; Nguyen & Cripps, 2001; Zurada et. al, 2006). Their findings demonstrated that ANN could perform tasks in the same way as traditional, parametric statistical techniques such as regression and other classification techniques, but with better prediction performance.

RESEARCH METHODOLOGY

This study adopts a quantitative analytical approach, grounded in empirical datasets obtained from the Valuation and Property Services Department (JPPH) Johor and the National Property Information Centre (NAPIC), covering the period from 2000 to 2016. A total of 2,325 residential sale transactions were sourced from the Valuation and Property Services Department Johor Bahru (VPSDJB). The dataset exhibits variation in transaction volume across years, reflecting fluctuations in market activity over the 17-year period. Within Mukim Pulai, two residential areas consistently recorded double-storey terrace house

transactions, making them suitable for longitudinal analysis. These areas were selected as the core samples to assess the capability of the ANN model in forecasting localised house price trends. Emphasising well-defined, smaller samples is crucial for constructing a robust and representative local House Price Index (HPI), as it enables the model to capture micro-market dynamics that may be diluted when analysing broader geographic datasets.

In the context of neural network modelling, three principal domains are required to hypothesise and demonstrate the locality of house prices: input variables, hidden layers, and the output variable. These components collectively define the structure and learning capability of the Artificial Neural Network (ANN). A detailed description of the specific neural network architecture employed in this study is presented in Table 2.

Table 2: Prime selection of variables

Type of Variables	The Variables
Output	House Transaction Value
Input	• Land Area • Main Floor Area • Ancillary Floor Area • Age of Building • Type of Lot • Type of Ownership • Type of Tenure • Scheme

Prior to applying the backpropagation algorithm, it is essential to preprocess and organise the dataset. This includes identifying the property attributes that significantly influence the output variable, house transaction value. The selection of appropriate and relevant input variables ensures that the ANN undergoes an effective learning, testing, and validation process.

The validation of the ANN model is essential to determine whether the network is capable of accurately forecasting local house prices. After generating the predicted values from the trained network, these outputs are transferred into a validation dataset to assess the model's generalisation performance. The forecasted observations are evaluated by examining the coefficient of determination (R^2), which indicates how well the model explains the variance in actual house prices. This step ensures that the neural network has successfully learned the underlying patterns in the data.

Additionally, the overall performance and predictive accuracy of the model are assessed using established error metrics, including the Mean Absolute Deviation (MAD) (*Equation 1*), Mean Absolute Percentage Error (MAPE) (*Equation 2*), and Root Mean Square Error (RMSE) (*Equation 3*). These

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measures collectively provide a comprehensive evaluation of the ANN's forecasting capability and reliability.

The test accuracy metrics MAD, MAPE, and RMSE are employed to evaluate whether the ANN model provides reliable and robust forecasts of local house prices. A higher R^2 value combined with a lower RMSE indicates that the model fits the data well and successfully captures the underlying price patterns. Additionally, MAD serves as an alternative to MAPE, particularly suitable for datasets with low transaction volumes.

$$MAD = \frac{\sum_{t=1}^{n} |A_t - F_t|}{n} \qquad \textit{(Equation 1)}$$

$$MAPE = \frac{\sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right| \times 100}{n} \qquad \textit{(Equation 2)}$$

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n} (A_t - F_t)^2}{n}} \qquad \textit{(Equation 3)}$$

where At represents actual house price, Ft represents forecasted house price, n represents number of samples.

In this study, the Root Mean Square Error (RMSE) is used to assess the mean squared difference between actual and forecasted local house price values. While RMSE is conceptually similar to the Mean Squared Error (MSE), it is preferred because RMSE provides the error in the same units as the original data, facilitating more intuitive interpretation of model accuracy. Consequently, RMSE is selected over MSE as the primary metric for testing the predictive performance of the ANN model.

ANALYSIS AND DISCUSSION

In house price forecasting, assessing the regression coefficient (R^2) is a crucial step to evaluate the predictive capability of an ANN model. As highlighted, the

input variables, specifically Land Area (LA) and Main Floor Area (MFA), exhibited multicollinearity in preliminary analyses. However, this study addresses potential multicollinearity issues by leveraging the nonlinear mapping capabilities of the ANN, allowing the network to capture complex relationships that linear regression alone may not fully represent. Table 3 summarises the regression analysis outcomes across the training, testing, and validation datasets. The proportion of data allocated follows the specifications outlined.

Table 3: Regression Coefficient (R^2) Observations of Local House Price Forecasting

Neural Network Scheme	Dataset	Taman Mutiara Rini (R^2)	Taman Bukit Indah (R^2)
Set 1	**Training**	0.178	0.352
	Testing	1.000	0.922
	Validation	0.999	0.927
Set 2	**Training**	0.063	0.387
	Testing	0.643	0.923
	Validation	0.960	0.887

The results indicate that linear regression produced by the ANN is formed progressively during the validation process. For Taman Mutiara Rini, the initial training phase shows low responsiveness of neurons, with R^2 values of 0.178 (Set 1) and 0.063 (Set 2), suggesting a weak linear relationship between input and output variables at early stages. Conversely, Taman Bukit Indah exhibits relatively stronger linearity, with R^2 values of 0.352 (Set 1) and 0.387 (Set 2) during training.

These findings demonstrate that, despite initial multicollinearity concerns, the ANN effectively captures the underlying patterns between inputs and the house price output. By the testing and validation stages, R^2 values markedly improve, indicating successful learning and strong predictive performance. Empirical observations thus support the claim that the ANN model is capable of overcoming multicollinearity effects while providing robust local house price forecasts.

The best-fitting ANN model for forecasting local house prices is summarised in Table 4. The network architecture is simplified into three layers, consistent with the pattern 2-1-1, to facilitate clear interpretation and efficient learning.

Table 4: Optimal ANN Model Parameters

No	Parameter	Value
1	Input layer	2 (Main Floor Area and Land Area)
2	Hidden Layer	1 (node of first hidden layer = 10)
3	Output layer	1 (house price)

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Training, testing, and validation of each sample set were conducted using a learning rate of 0.01 and a momentum coefficient of 0.1. These parameters were carefully selected to ensure that the ANN could effectively learn the underlying relationships between input features and house prices, while maintaining stability and convergence during the learning process. The resulting network demonstrates strong predictive performance, validating the model's suitability for constructing a reliable local House Price Index (HPI). Moreover, the performance of MAPE, RMSE, and R^2 was evaluated for both sets of Taman Mutiara Rini and Taman Bukit Indah, as summarized in Table 5.

Table 5: Final Observations of ANN Model Accuracy

Accuracy Performance	Taman Mutiara Rini		Taman Bukit Indah	
	Set 1	Set 2	Set 1	Set 2
R^2	0.999	0.960	0.927	0.887
MAD	0.104	0.118	0.034	0.035
RMSE	0.112	0.125	0.039	0.039
MAPE (%)	14.321	16.308	4.407	4.549

The results indicate that Set 1 and 2 of Taman Bukit Indah achieved the lowest MAPE, demonstrating superior predictive accuracy compared to Taman Mutiara Rini. These observations suggest that a larger sample size improves the ANN model's ability to capture accurate forecasted trends, as more data enables the network to generalize effectively. For Taman Mutiara Rini, Set 1 also demonstrated higher predictive accuracy, with R^2 indicating strong agreement between forecasted and actual house prices. The observed price trends for both sets closely align, confirming that the ANN model can accurately capture local market fluctuations.

Overall, these results validate the study's hypotheses. Increasing the number of samples in the training and testing processes enhances the ANN model's robustness by reducing bias and balancing the influence of actual house prices. Consequently, Set 1 for both residential areas is identified as providing the strongest performance in terms of MAPE, MAD, and RMSE, highlighting its suitability for forecasting local house price trends with high accuracy.

CONCLUSION

In the overall analysis of forecasting local house prices, the neural network was structured with a single hidden layer comprising ten nodes, forming a 2-1-1 topology. The parameter settings for the variables remained constant throughout the formation of the neural network pattern, ensuring stability and consistency in the training process. A small learning rate was predominantly applied, which contributed to a substantial reduction in the sum of errors between actual and forecasted house prices, indicating effective model convergence.

Model accuracy was evaluated using statistical measures, including Mean Absolute Deviation (MAD), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE). Additionally, the regression coefficient (R^2) was considered to assess the goodness-of-fit of the ANN model relative to these error metrics. The results demonstrated that the ANN model is well-fitted, as evidenced by higher R^2 values compared to the RMSE, confirming the model's predictive reliability. Furthermore, the development of the local House Price Index using the ANN forecasts allowed for the identification of undervalued and overvalued properties, providing insightful implications for local market assessment and decision-making.

This study also addresses a notable gap in Malaysian housing research. Unlike previous studies that primarily relied on macro-level variables, the use of microdata in the ANN framework enables a more nuanced and precise understanding of housing market dynamics. The study's findings underscore the potential of ANN models as a reliable tool for policymakers, real estate developers, and investors to anticipate market trends, assess risks, and make informed decisions in the Malaysian context.

In terms of research implications, this study highlights the importance of careful model design and parameter selection such as the number of hidden layers and nodes to optimize ANN performance. The results suggest that ANN frameworks can be adapted and applied to other geographic regions in Malaysia, potentially improving forecasting accuracy in diverse housing markets. Future research could focus on further optimizing ANN models for Malaysian housing data, exploring alternative machine learning architectures, or integrating additional socio-economic and spatial variables. Comparative studies across different Malaysian states could also provide insights into regional housing market variations, enhancing the applicability and generalizability of ANN-based forecasting models.

In conclusion, this study demonstrates that ANN models provide highly accurate and reliable forecasts of housing market trends in Johor, effectively capturing complex, non-linear relationships among diverse housing attributes. By outperforming traditional HPM approaches, ANNs offer a powerful tool for policymakers, developers, and investors to anticipate market movements and make informed decisions. The findings also highlight the potential for applying and optimizing ANN models across different regions in Malaysia, paving the way for more precise, data-driven housing market analyses in future research.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial support from the UTM Young Scholars Grant, managed by the School of Graduate Studies and the Postgraduate Scholarship Unit, Universiti Teknologi Malaysia. Sincere appreciation is also

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extended to colleagues and supervisors whose guidance and support contributed to the completion of this research.

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Received: 5th July 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 109 – 125

STRATEGIC LAND DEVELOPMENT MODEL FOR MALAY RESERVE LANDS (MRLs) IN MALAYSIA

Siti Hasniza Rosman[1], Rohayu Ab Majid[2], Abdul Hadi Nawawi[3], Mohd Hasrol Haffiz Aliasak[4], Edie Ezwan Mohd Safian[5]

[1,2,3] *Real Estate Studies, Faculty of Built Environment,*
UNIVERSITI TEKNOLOGI MARA (UiTM) SHAH ALAM, MALAYSIA
[4] *Real Estate Studies, Faculty of Built Environment,*
UNIVERSITI TEKNOLOGI MARA (UiTM) PERAK, MALAYSIA
[5]*Department of Real Estate Management,*
Faculty of Technology Management and Business,
UNIVERSITY TUN HUSSEIN ONN MALAYSIA

Abstract

There is currently no comprehensive strategic land development model to guide Bumiputera developers and landowners in developing Malay Reserve Lands (MRLs) in Malaysia. This study develops an evidence-based strategic land development model to support stakeholders involved in MRL development. A mixed-method approach is adopted, beginning with an inductive literature review to identify key success factors, followed by a questionnaire survey to empirically assess these factors. Quantitative data were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) via SmartPLS 3 to evaluate the significance and strength of relationships among the constructs. The findings indicate that the establishment of research institutes exerts the strongest positive influence on strategic MRL development ($\beta = 0.799$), followed by special financial institutions ($\beta = 0.223$) and the enactment of a dedicated MRL Act ($\beta = 0.146$). In contrast, Bumiputera land development units show a negative relationship ($\beta = -0.151$), suggesting structural or implementation challenges. The proposed model provides a robust framework to inform policy formulation and enhance MRL development effectiveness in Malaysia.

Keywords: Strategic Land Development, Malay Reserve Land (MRL), Partial Least Squares Structural Equation Modeling (PLS-SEM)

[1] Corresponding author. Email: sitihasniza@uitm.edu.my

INTRODUCTION

Malay Reserve Lands (MRLs), which are predominantly owned by Malays and Bumiputeras, represent a significant land resource with substantial potential to contribute to Malaysia's socio-economic development. MRLs play a crucial role in promoting equitable wealth distribution, supporting Bumiputera participation in the property sector, and ensuring inclusive urban and regional development. Despite this importance, many MRLs remain underdeveloped or inefficiently utilised, limiting their contribution to national development objectives. Previous studies have highlighted that structural, legal, financial, and institutional constraints continue to hinder the optimal development of these lands (Omar & Mohsen, 2020).

Although MRLs possess development potential comparable to non-MRL land, existing development strategies have largely been implemented in a fragmented and ad hoc manner. Prior research has emphasised the need for more comprehensive and coordinated strategies to guide MRL development (Rosman et al., 2021). Current approaches tend to focus on isolated policy instruments or institutional measures without integrating them into a holistic strategic framework. As a result, persistent challenges such as limited access to financing, weak institutional coordination, regulatory constraints, and insufficient technical expertise remain unresolved.

The literature indicates a clear absence of a dedicated strategic land development model specifically tailored to the unique legal, socio-economic, and institutional characteristics of MRLs. While several strategic measures have been proposed such as the establishment of research institutes, a specific MRL Act, Bumiputera land development units, and specialised financial institutions these initiatives have not been systematically assessed or integrated into a unified development model. Consequently, existing strategies often fail to achieve sustainable and effective outcomes. To address this gap, there is a critical need to identify the key success factors underpinning these strategies and to develop a holistic strategic land development model that can serve as a practical guideline for stakeholders involved in MRL development (Md. Azmi, 2021).

LITERATURE REVIEW

The development of effective and sustainable strategies is essential to ensure the successful development of Malay Reserve Lands (MRLs) in Malaysia. Given the complex legal, institutional, and socio-economic characteristics of MRLs, the formulation of a holistic strategic framework must first be underpinned by clearly defined success factors. Identifying these factors enables policymakers and practitioners to understand why previous initiatives have produced limited outcomes and how future strategies can be strengthened. As highlighted by Md. Azmi (2021), the absence of an integrated strategic approach has resulted in

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fragmented implementation and weak institutional coordination, thereby constraining the long-term viability of MRL development.

Success Factors for the Establishment of a Research Institute

The establishment of a dedicated research institute has been widely identified as a critical enabler of strategic land development, particularly in addressing data gaps, technical limitations, and policy fragmentation. In the context of MRLs, research institutes serve as benchmarks and catalysts by providing evidence-based guidelines, standard operating procedures, and technical expertise to support informed decision-making (Nawawi & Rosman, 2021). Key success factors include clear guidelines and procedures, effective monitoring mechanisms, systematic evaluation of tasks, workforce diversity, and strong internal and external communication (Varjoranta, 2018; Abdul Hamid, 2020; Omar et al., 2020).

Recent literature also emphasises the importance of technological advancement and digital transformation in land governance, including the use of database management systems, integrated data coordination, and geospatial technologies to enhance transparency and efficiency (Sharif, 2022; Sahabuddin, 2019; World Bank Group, 2017). While existing land development models recognise the role of research and data, they often fail to institutionalise these functions within a dedicated entity, resulting in weak knowledge transfer and limited continuity. In the MRL context, this gap is particularly critical due to the unique legal restrictions and fragmented land ownership structures.

Success Factors for the Establishment of an MRL Act

A specific MRL Act is widely regarded as fundamental to safeguarding Malay land ownership while facilitating development in a structured and consistent manner. The literature highlights that effective legal frameworks require alignment of procedures, clear structural and content dimensions, regular evaluation, and strong inter-agency cooperation (Abdul Wahid, 2013; Varjoranta, 2018). Political stability and sustained government intervention further influence the effectiveness of land-related legislation, particularly in countries with plural legal systems such as Malaysia (Gudiene et al., 2014; Tsiga et al., 2016).

However, existing land development models tend to rely on general planning or land acquisition laws, which are often ill-suited to address the specific constraints of MRLs. The lack of uniformity across state enactments, inconsistent enforcement of replacement provisions, and limited integration of MRL issues into high-level policy agendas have weakened past initiatives (Omar & Mohsen, 2020). This highlights the need for a dedicated MRL Act supported by comprehensive guidelines and strong enforcement mechanisms to ensure both protection and development objectives are achieved.

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Success Factors for the Establishment of a Bumiputera Development Unit

The establishment of a Bumiputera development unit is intended to strengthen institutional capacity and provide targeted support for MRL development projects. Key success factors identified in the literature include effective project team cooperation, feasibility assessments, skills upgrading, innovation, and the adoption of sustainable development principles (Tsiga et al., 2016; United Nations, 2021). Strategic approaches such as joint ventures, smart partnerships between public and private sectors, and comprehensive infrastructure provision have also been highlighted as important mechanisms to unlock MRL development potential (Omar, 2017).

Despite these strengths, existing development units often suffer from overlapping roles, limited authority, and insufficient technical expertise, which reduce their effectiveness. Many conventional land development models assume streamlined ownership and financing structures, making them less applicable to MRLs, where multiple stakeholders and legal restrictions complicate implementation. This underscores the need for a clearly defined and well-coordinated Bumiputera development unit within a broader strategic framework.

Success Factors for the Establishment of a Special Financial Institution for MRLs

Access to financing remains one of the most significant barriers to MRL development. The literature consistently highlights the importance of specialised financial institutions in strengthening Bumiputera purchasing power, providing development funds, and offering financial incentives tailored to the unique characteristics of MRL projects (Omar & Mohsen, 2020; Aliasak, 2018; Saleh et al., 2025). Government support, innovative financial models, and the integration of Islamic financial structures are particularly relevant within the Malaysian context (Carol, 2022; Kementerian Kewangan Malaysia, 2020).

While conventional land development models often rely on commercial banking systems, these systems tend to perceive MRLs as high-risk due to legal restrictions and limited marketability. As a result, existing financial strategies frequently fail to optimise the value of MRLs located in strategic areas. A dedicated financial institution with tailored policies and procedures is therefore essential to bridge this gap and enable inclusive and sustainable MRL development.

Synthesis and Research Gap

Overall, the literature demonstrates that while individual strategies and institutional mechanisms have been proposed to support MRL development, they are often implemented in isolation and lack integration within a coherent strategic model. Existing land development frameworks inadequately address the legal, institutional, and financial complexities unique to MRLs, resulting in persistent

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underdevelopment. This study addresses this critical gap by systematically identifying and assessing the success factors underpinning these strategies and integrating them into a comprehensive strategic land development model for MRLs in Malaysia.

RESEARCH METHODOLOGY

At the outset, in accordance with objective one, success factors were identified through an in-depth literature review. Objective two of this research is to assess the key success factors in strategic land development of MRLs. In order to achieve this objective, the research instrument used is the questionnaire which involves close-ended and open-ended questions. The questionnaire was designed to obtain primary data from the targeted perspective respondents consisting of academics, government officers, industry players, and Non-Governmental Organisations (NGOs). The distribution of this questionnaire was aimed at getting the expert opinions regarding the success factors that need to be considered in the development of MRLs. A survey was performed on ninety-one (91) experts in MRL field to reflect all the procedures of the main study. The PLS-SEM approach was used in the assessment of internal consistency of the variables and to gauge the development of a model of strategic land development for MRLs. Objective three is to develop a strategic land development model for MRLs. The researcher has used the Partial Least Squares Structural Equation Modeling (PLS-SEM) method to develop the model. Upon construction of the model, the researcher will proceed with semi-structured interviews with experts for the purpose of validating the model that has been developed.

This study adopts a mixed-method research design that integrates qualitative and quantitative approaches to comprehensively address the research objectives. The mixed-method approach is appropriate for studies that involve both the exploration of constructs and the empirical assessment of relationships among variables, as it enhances methodological rigor through triangulation (Creswell & Plano Clark, 2018). In this research, the qualitative phase through an in-depth literature review was used to identify potential success factors influencing the strategic development of Malay Reserve Lands (MRLs). This was followed by a quantitative survey to empirically assess the significance and interrelationships of these factors, thereby supporting theory development and model construction.

To achieve the second research objective, a structured questionnaire consisting of close-ended and open-ended questions was developed to collect primary data from key stakeholders involved in MRL development, including academics, government officers, industry practitioners, and representatives of Non-Governmental Organisations (NGOs). A purposive sampling technique was employed to ensure that respondents possessed relevant expertise and experience related to MRLs. A total of ninety-one (91) valid responses were obtained. This

sample size is considered adequate for Partial Least Squares Structural Equation Modelling (PLS-SEM), which is well suited for studies with relatively small to medium sample sizes and complex models (Hair et al., 2019). In addition, the sample satisfies the "ten-times rule", whereby the minimum sample size should be at least ten times the maximum number of structural paths directed at any construct in the model (Hair et al., 2017).

PLS-SEM was selected as the primary analytical technique due to its suitability for exploratory research, prediction-oriented studies, and theory development. Unlike covariance-based SEM, PLS-SEM has fewer distributional assumptions and is robust when dealing with non-normal data and formative or complex constructs (Hair et al., 2017; Sarstedt et al., 2017). In this study, PLS-SEM was used to assess the measurement model in terms of internal consistency reliability and construct validity, as well as the structural model through path coefficient analysis, thereby enabling the development of a strategic land development model for MRLs.

For the third research objective, the proposed strategic land development model was subsequently validated through semi-structured interviews with selected experts. This qualitative validation phase provided deeper insights into the practicality, relevance, and feasibility of the model, ensuring that the proposed framework is grounded in real-world MRL development practices (Yin, 2018).

ANALYSIS AND DISCUSSION

This section will discourse in detail the analysis of data and present the results of the research involving the qualitative and quantitative methods of analysis. The analyses of primary data are based on the objectives to be achieved by using several analytical methods such as thematic analysis and SmartPLS 3 software for Partial Least Square Structural Equation Modeling (PLS-SEM) to assess the development of the model.

Inductive Literature Review and Thematic Analysis

The researcher uses inductive literature review as a method in identifying success factors for the proposed MRL development strategy. Table 1 below displays the success factors that have been identified for each MRL development strategy that has been formulated.

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Table 1: Success Factors Related to Strategic Land Development for MRLs

Proposed Strategy	Success Factors	Coding
Establishment of Malay Reserve Land Research (MRL) Institute	1) Guidelines and Procedures	RI1
	2) Monitoring	RI2
	3) Evaluating	RI3
	4) Workforce Diversity	RI4
	5) Communication	RI5
	6) Partnership Project	RI6
	7) Organizational Agility	RI7
	8) Collaboration and Cooperation	RI8
	9) Technological Development	RI9
	10) Digital Transformation	RI10
	11) Database Management System	RI11
	12) Coordination Data and Information.	RI12
	13) Knowledge	RI13
	14) Experience	RI14
	15) Technical Capabilities	RI15
	16) Quality of Research	RI16
Establishment of Malay Reserve Land (MRL) Act	1) Evaluating the Current Issues of MRL at State and Federal Level	ACT1
	2) Aligning Procedures	ACT2
	3) Content Dimension	ACT3
	4) Structure Alignment	ACT4
	5) Political Stability	ACT5
	6) Government Intervention	ACT6
	7) Agenda at a Meeting of the Malay Rulers	ACT7
	8) Uniformity of the Act and Enactment	ACT8
	9) Enforcement of MRL Replacement	ACT9
	10) Collaboration	ACT10
	11) National Level Coordination	ACT11
	12) Protect the Ownership Status	ACT12
Establishment of Bumiputera Land Development Unit	1) Cooperation	BLDU1
	2) Feasibility Research	BLDU2
	3) Up-skilling and Retraining	BLDU3
	4) Sustainable Development.	BLDU4
	5) Highest and Best Use	BLDU5
	6) Potential Development	BLDU6
	7) Joint Venture Project	BLDU7
	8) Infrastructure Development	BLDU8
	9) Management Competencies	BLDU9
	10) Ownership Right	BLDU10
	11) Evaluate of Plan Implementation	BLDU11
	12) Innovativeness of the Project	BLDU12
	13) Coordination of Land Development	BLDU13
	14) Comprehensive Development Proposal	BLDU14

Proposed Strategy	Success Factors		Coding
Establishment of Special Financial Institution	1)	Strengthen the Purchasing Power of the Bumiputera.	SFI1
	2)	Provide Incentives to Encourage Innovation of Development	SFI2
	3)	Potential Development	SFI3
	4)	Provide Funds for the Development	SFI4
	5)	Government Support	SFI5
	6)	Financial Model	SFI6
	7)	Financial Incentives for Developer	SFI7
	8)	Optimize the Value of MRL	SFI8
	9)	Financial Sources	SFI9
	10)	Financial Policies and Procedures	SFI10
	11)	Islamic Financial Structure	SFI11

Partial Least Squares Structural Equation Modeling (PLS-SEM) Approach using SmartPLS 3 Software

Convergent Validity using Redundancy Analysis (Path Coefficients)

Redundancy analysis results (Table 2) show that the establishment of a research institute has the highest path coefficient (0.799), exceeding the recommended threshold of 0.700 and confirming adequate convergent validity. Consistent with Hair et al. (2017), coefficients above 0.60 are acceptable in exploratory research. In contrast, the path coefficients for the establishment of a special financial institution (0.223), the enactment of an MRL Act (0.146), and the establishment of a Bumiputera Land Development Unit (–0.151) fall below acceptable levels, indicating insufficient convergent validity. These findings suggest that the formative indicators require theoretical and conceptual refinement. Overall, the results highlight the establishment of a research institute as a key strategic factor in strengthening Malay Reserve Land development in Malaysia.

Table 2: Path Coefficients

Construct	Convergent Validity
Act	0.146
Bumiputera Land Development Unit	-0.151
Special Financial Institution	0.223
Research Institute	0.799

Collinearity Using Variance Inflation Factor (VIF) Analysis

Collinearity was assessed using the Variance Inflation Factor (VIF). VIF values below 5 indicate no critical collinearity issues in formative constructs (Hair et al., 2017). Indicators with VIF values above 10 may be removed, provided that content and nomological validity are maintained (Hair et al., 2022). The results (Table 3) show that four indicators exceeded the threshold and were removed: RI11 (13.818), RI12 (11.352), RI14 (11.740), and SFI10 (12.910). Only 7% of

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indicators were deleted, indicating that collinearity was effectively controlled without compromising model validity.

Table 3: Collinearity Statistics (VIF)

Constructs	Formative Indicators	VIF	Action
Act	ACT1	3.581	Maintain
	ACT10	5.576	Maintain
	ACT11	7.037	Maintain
	ACT12	5.366	Maintain
	ACT2	3.212	Maintain
	ACT3	9.322	Maintain
	ACT4	7.297	Maintain
	ACT5	2.548	Maintain
	ACT6	3.405	Maintain
	ACT7	3.404	Maintain
	ACT8	4.363	Maintain
	ACT9	3.533	Maintain
Bumiputera Land Development Unit	BLDU1	3.769	Maintain
	BLDU10	2.718	Maintain
	BLDU11	4.912	Maintain
	BLDU12	5.992	Maintain
	BLDU13	6.714	Maintain
	BLDU14	6.793	Maintain
	BLDU2	4.009	Maintain
	BLDU3	3.252	Maintain
	BLDU4	5.282	Maintain
	BLDU5	3.777	Maintain
	BLDU6	6.786	Maintain
	BLDU7	4.368	Maintain
	BLDU8	4.181	Maintain
	BLDU9	5.419	Maintain
Special Financial Institution	SFI1	3.303	Maintain
	SFI10	12.91	Removed
	SFI11	6.612	Maintain
	SFI2	6.832	Maintain
	SFI3	5.852	Maintain
	SFI4	5.860	Maintain
	SFI5	3.313	Maintain
	SFI6	7.404	Maintain
	SFI7	2.940	Maintain
	SFI8	6.479	Maintain
	SFI9	6.988	Maintain
Research Institute	RI1	3.597	Maintain
	RI10	4.626	Maintain
	RI11	13.818	Removed
	RI12	11.352	Removed
	RI13	8.262	Maintain

Constructs	Formative Indicators	VIF	Action
	RI14	11.74	Removed
	RI15	5.075	Maintain
	RI16	5.445	Maintain
	RI2	5.536	Maintain
	RI3	4.157	Maintain
	RI4	4.250	Maintain
	RI5	4.023	Maintain
	RI6	5.376	Maintain
	RI7	3.742	Maintain
	RI8	4.639	Maintain
	RI9	4.834	Maintain

Measurement Properties for Formative Construct

The results presented in Table 4 and Figure 1 indicate that the **best** strategy construct demonstrates the strongest convergent validity, with a path coefficient of 0.900. This suggests a high degree of alignment among its formative indicators. The establishment of a research institute follows with a substantial path coefficient of 0.776, indicating strong internal consistency and confirming its strategic importance in MRL development. In contrast, the establishment of a special financial institution for MRLs (0.168), the enactment of an MRL Act (0.144), and the establishment of Bumiputera land development units (0.054) record relatively weak path coefficients. Convergent validity reflects the extent to which indicators of a construct are closely related to one another, while remaining distinct from unrelated constructs (Streiner et al., 2015). In exploratory research, path coefficients above 0.600 are considered acceptable (Hair et al., 2017); therefore, constructs with coefficients below this threshold suggest limited interrelationships among their formative indicators.

For the MRL Act construct, the outer weight results show that ACT7 (0.489) and ACT2 (0.231) are the most influential indicators, emphasising the importance of strengthening governance mechanisms and aligning existing development procedures. This finding is consistent with Md Azmi (2021), who highlights the need to reinforce institutional control to safeguard Malay privileges and address governance weaknesses in MRL administration. Conversely, ACT10, which relates to inter-agency cooperation, records the lowest contribution (–0.034), reflecting persistent coordination challenges. Previous studies have similarly stressed the lack of uniformity and collaboration among stakeholders involved in MRL development (Nawawi & Rosman, 2021).

With respect to the Bumiputera land development unit construct, feasibility studies (BLDU2 = 0.357) emerge as the most critical indicator, underscoring the importance of informed decision-making prior to development. This aligns with Mukherjee and Roy (2017), who argue that feasibility analysis is essential for project selection and risk mitigation. Joint venture arrangements

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(BLDU7 = 0.293) also contribute meaningfully, supporting Omar's (2017) recommendation that collaborative development between landowners and developers enhances development viability. In contrast, coordination of approval standards (BLDU13 = 0.048) and infrastructure provision (BLDU8 = 0.000) are perceived as less influential, suggesting that these factors are secondary unless directly linked to market demand and development potential (Omar & Raji, 2015).

The research institute construct exhibits strong indicator contributions related to organisational capability. The most influential indicator is RI7, which highlights the importance of effective organisational management, consistent with Varjoranta (2018), who emphasises organisational agility as a key driver of institutional performance. Clear guidelines and procedures (RI1 = 0.425) are also identified as critical, echoing findings from the Auditor General's Report (2019) on the need for clearer administrative frameworks in land governance. However, indicators related to monitoring (RI2) and communication (RI5) show weak contributions, reflecting persistent administrative and record-keeping challenges noted in previous studies (Md Azmi, 2021).

Finally, for the special financial institution construct, the provision of core capital and financing mechanisms (SFI4 = 0.604; SFI9 = 0.492) emerges as the most significant success factor. This supports Omar's (2020) assertion that inadequate access to capital remains a major constraint on the development of Malay-owned land. In contrast, incentives, grants, and subsidies (SFI2 and SFI5) contribute less to the construct, reinforcing the view that structural financing solutions, rather than short-term assistance, are more effective in addressing long-standing financial barriers in MRL development (Nawawi & Rosman, 2021).

Table 4: Measurement Properties for Formative Construct

Constructs	Indicators	Convergent Validity	Weights	VIF	T-Value Weights	P Values
Act	ACT1	0.144	0.192	3.581	0.835	0.404
	ACT10		**-0.034**	**5.576**	**0.120**	**0.904**
	ACT11		0.220	7.037	0.700	0.484
	ACT12		-0.132	5.366	0.467	0.641
	ACT2		**0.231**	**3.212**	**1.157**	**0.248**
	ACT3		0.145	9.322	0.432	0.666
	ACT4		0.069	7.297	0.213	0.831
	ACT5		-0.198	2.548	0.875	0.382
	ACT6		-0.201	3.405	0.828	0.408
	ACT7		**0.489**	**3.404**	**1.851**	**0.065**
	ACT8		0.228	4.363	0.866	0.387
	ACT9		-0.039	3.533	0.166	0.868
Bumiputera Land Development Unit	BLDU1	0.054	0.133	3.769	0.472	0.637
	BLDU10		-0.101	2.718	0.432	0.666
	BLDU11		0.105	4.912	0.369	0.712
	BLDU12		0.173	5.992	0.477	0.634
	BLDU13		**0.048**	**6.714**	**0.117**	**0.907**
	BLDU14		-0.263	6.793	0.788	0.431

Constructs	Indicators	Convergent Validity	Weights	VIF	T-Value Weights	P Values
	BLDU2		**0.357**	**4.009**	**1.133**	**0.258**
	BLDU3		0.192	3.252	0.778	0.437
	BLDU4		0.082	5.282	0.249	0.803
	BLDU5		-0.218	3.777	0.662	0.508
	BLDU6		0.209	6.786	0.710	0.478
	BLDU7		**0.293**	**4.368**	**0.965**	**0.335**
	BLDU8		**0.000**	**4.181**	**0.001**	**0.999**
	BLDU9		0.074	5.419	0.231	0.817
Research Institute	**RI1**	0.776	**0.425**	**3.470**	**1.838**	**0.067**
	RI10		0.030	4.226	0.126	0.900
	RI13		0.202	3.594	0.673	0.501
	RI15		0.339	4.222	1.312	0.190
	RI16		0.145	4.226	0.672	0.502
	RI2		**-0.028**	**5.084**	**0.112**	**0.911**
	RI3		0.115	4.035	0.412	0.680
	RI4		0.220	3.385	1.119	0.264
	RI5		**-0.012**	**3.389**	**0.050**	**0.960**
	RI6		0.168	3.088	0.974	0.330
	RI7		**-0.517**	**3.150**	**2.327**	**0.020**
	RI8		0.110	3.536	0.683	0.495
	RI9		-0.148	4.663	0.497	0.620
Special Financial Institution	SFI1	0.168	-0.290	3.153	1.021	0.308
	SFI11		-0.172	4.527	0.491	0.624
	SFI2		**-0.108**	**6.569**	**0.265**	**0.791**
	SFI3		0.448	5.126	1.306	0.192
	SFI4		**0.604**	**5.036**	**1.613**	**0.107**
	SFI5		**0.100**	**3.273**	**0.343**	**0.732**
	SFI6		0.223	7.073	0.663	0.507
	SFI7		-0.214	2.929	0.965	0.335
	SFI8		-0.151	6.478	0.501	0.617
	SFI9		**0.492**	**4.832**	**1.687**	**0.092**
Best Strategy	**BS1**	0.900	**0.775**	**1.831**	**3.094**	**0.002**
	BS2		0.264	1.823	1.238	0.216
	BS3		-0.160	1.831	0.757	0.450
	BS4		0.247	1.728	0.955	0.340

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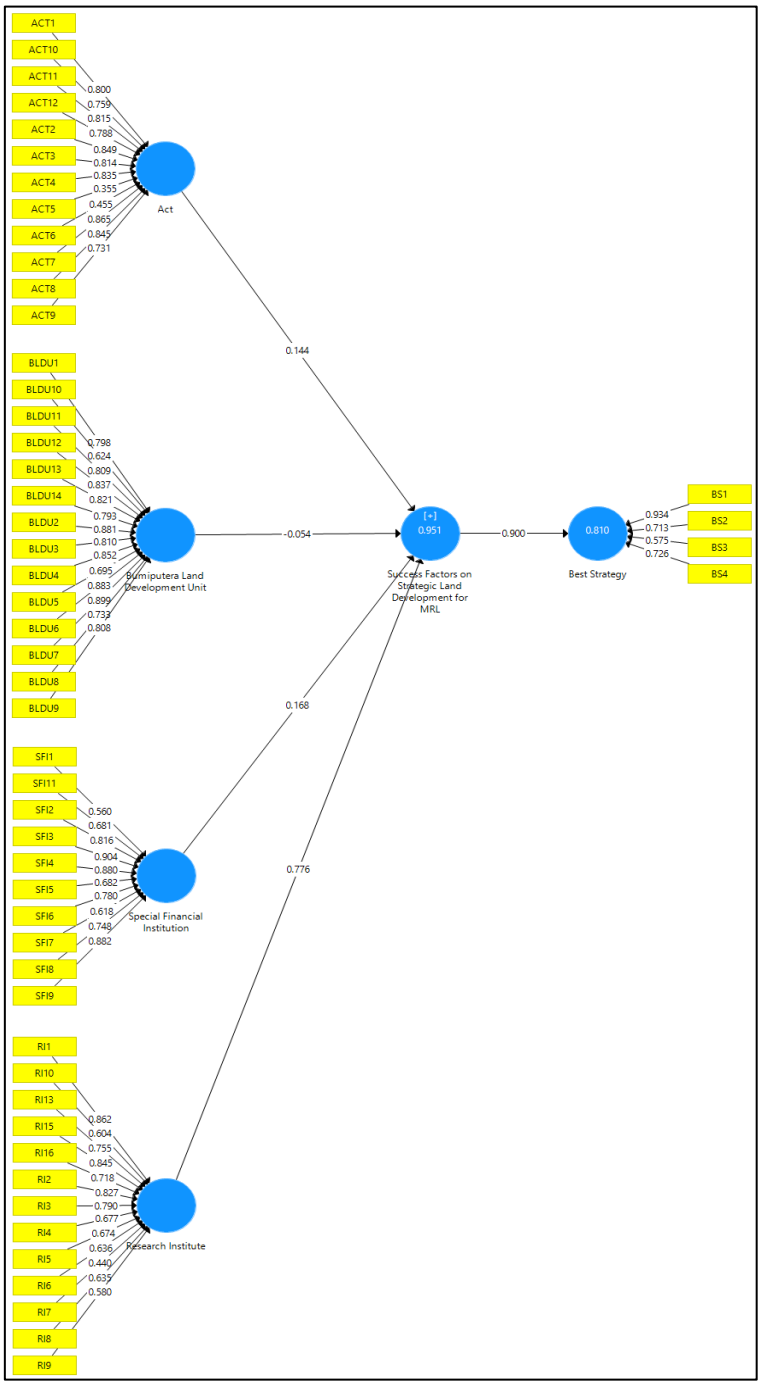


Figure 1: Output of Outer Loading, Path Coefficients and R-Square

Collinearity Assessment Inner VIF Values

Table 5 shows that all inner VIF values are below the threshold of 5, indicating no critical collinearity issues. The MRL Act (2.982), Bumiputera land development unit (3.400), research institute (3.329), and special financial institution (2.995) all fall within acceptable limits. Consistent with Hair et al. (2017), collinearity does not affect the estimation of the PLS-SEM model.

Table 5: Inner VIF Values

Construct	Inner VIF Value
Act	2.982
Bumiputera Land Development Unit	3.400
Research Institute	3.329
Special Financial Institution	2.995

Significance and Relevance of Path Coefficients

Figure 2 shows that only the research institute construct has a strong and meaningful relationship with the success factors of strategic Malay Reserve Land (MRL) development, with a path coefficient of 0.776. This indicates a substantial influence on the structural model. The special financial institution construct records the second-highest coefficient (0.168), followed by the MRL Act (0.144). In contrast, the Bumiputera land development unit shows a weak and negative relationship (–0.055). Overall, the findings confirm that the establishment of a research institute is the most significant construct influencing the success of strategic MRL development.

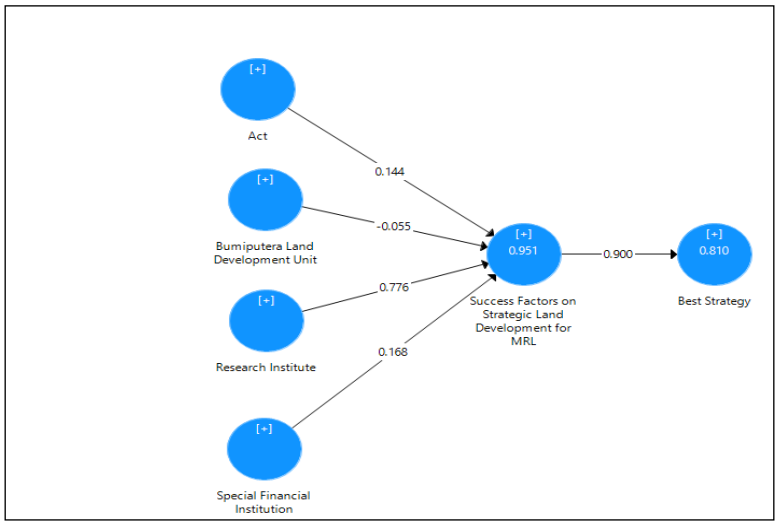


Figure 2: Structural Model of Strategic Land Development for Malay Reserve Lands (MRLs)

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Level of R2 of Endogenous Latent Variables

Table 6 shows that the R^2 values for the endogenous constructs are high. The success factors for strategic Malay Reserve Land (MRL) development record an R^2 of 0.951, while the best strategy construct records an R^2 of 0.810. These values indicate strong predictive accuracy, explaining 95% and 81% of the variance, respectively. R^2 reflects a model's explanatory power (Hair et al., 2021). According to established guidelines, R^2 values above 0.75 are considered substantial, values around 0.50 are moderate, and values around 0.25 are weak (Hair et al., 2014). Therefore, the proposed model demonstrates substantial explanatory power.

Table 6: Level of R-Square (R^2) of Endogenous Latent Variables

Endogenous Latent Variables	**R Square**	**R Square Adjusted**
Best Strategy	0.810	0.808
Success Factors on Strategic Land Development for MRL	0.951	0.949

Effect Size f^2 of Path Coefficients

Table 7 presents the effect sizes (f^2) of the exogenous constructs. The MRL Act ($f^2 = 0.141$) and special financial institution ($f^2 = 0.191$) show moderate effects on the model, as their values exceed the 0.15 threshold. In contrast, the Bumiputera land development unit records a negligible effect ($f^2 < 0.02$), indicating that its removal would not affect the model. The research institute construct demonstrates a strong effect ($f^2 > 0.35$), confirming its substantial influence on the model.

Table 7: Effects Size F-Square (f^2) of Path Coefficients

Act	0.141
Bumiputera Land Development Unit	0.018
Research Institute	3.678
Special Financial Institution	0.191

Effect Size Q2 of Path Coefficients

Table 8 shows that Q^2 values greater than zero indicate predictive relevance of the exogenous constructs for the endogenous constructs. As a guideline, Q^2 values of 0.02, 0.15, and 0.35 represent small, medium, and large predictive relevance, respectively. The results indicate that success factors for strategic MRL development ($Q^2 = 0.447$) and best strategy ($Q^2 = 0.343$) exhibit strong predictive relevance. These findings confirm the model's high predictive capability.

Table 8: Construct Cross Validated Redundancy

	SSO	SSE	Q^2 (=1-SSE/SSO)
MRL Act	1092	1092	
Best Strategy	364	239.217	0.343
Bumiputera Land Development Unit	1274	1274	
Research Institute	1183	1183	
Special Financial Institution	910	910	

CONCLUSION

This research developed and validated a strategic land development model for Malay Reserve Lands (MRLs) in Malaysia by identifying and empirically assessing the key success factors influencing effective implementation. Employing a mixed-method approach that combined an inductive literature review with Partial Least Squares Structural Equation Modeling (PLS-SEM), the study addresses a critical gap in the literature by offering a structured and evidence-based framework for MRL development. From a policy and practice perspective, the findings suggest that priority should be given to strengthening institutional coordination through a centralised research-driven mechanism, supported by aligned financial and legal instruments. Future research is encouraged to pilot-test the proposed model in actual MRL development projects and to examine its applicability across different state jurisdictions, development scales, and land-use contexts to enhance its generalisability and practical relevance.

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Received: 5th July 2025. Accepted: 15th November 2025

PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 126 – 140

OPTIMISING THE UTILISATION OF STATE-OWNED ASSETS USING A MULTICRITERIA APPROACH

Nurbiyanto[1], Yanuar Pribadi[2], Doni Triono[3], Dwi Rahmanto[4]

[1,2,3] POLYTECHNIC OF STATE FINANCE STAN (PKN STAN)
[4]*Directorate General of State Asset Management (DJKN)*,
MINISTRY OF FINANCE INDONESIA

Abstract

State-Owned Assets in Indonesia represent substantial economic potential, however, many remain underutilised, generating limited non-tax revenue and often being deployed without rigorous analytical support. This study aims to identify the most optimal utilisation of state-owned land by integrating the Highest and Best Use framework with asset utilisation schemes using a multicriteria decision-making approach. The findings reveal that Legally Permissible is the most influential criterion in determining optimal asset utilisation, underscoring the central role of zoning, regulatory compliance, and land-use permissibility. Among the evaluated development alternatives, Mixed-Use development emerges as the most optimal form of utilisation, outperforming hotel and apartment options in terms of overall priority. These results highlight the importance of aligning legal considerations with economic and investment feasibility to achieve sustainable and value-maximizing utilisation of SOAs. The study provides empirical support for evidence-based decision-making in public asset optimisation and offers practical insights for policymakers and asset managers in designing legally sound and economically viable utilisation strategies.

Keywords: Asset Optimisation, Analytical Hierarchy Process, Highest and Best Use, State-Owned Assets

[1] Corresponding author. Email: nurbiyanto@pknstan.ac.id

INTRODUCTION

State-Owned Assets (SOAs) constitute a significant component of public wealth and play a strategic role in supporting fiscal sustainability and public service delivery; therefore, their effective optimisation requires systematic planning and identification of assets with revenue-generating potential (Dorojatun & Purwanto, 2019). In many developing countries, including Indonesia, governments hold extensive portfolios of land and buildings that possess high economic potential but remain underutilised or idle. This condition is reflected in the relatively modest contribution of asset utilisation to non-tax state revenue and the continued reliance on conventional utilisation decisions that are not always supported by systematic analytical assessment. Recent studies indicate that suboptimal asset utilisation is frequently attributable to weak integration among regulatory constraints, economic feasibility, and strategic planning considerations (Kaganova & Amoils, 2020);Niekamp et al., 2015).

Existing literature on public asset management has emphasised the importance of adopting evidence-based approaches to optimise asset use. Applications of the Highest and Best Use (HBU) framework demonstrate its effectiveness in identifying alternative land uses that maximise economic value while satisfying physical, legal, and financial constraints (Fanning, 2014; Lennhoff & Parli, 2020). Empirical applications of HBU in the public sector have been conducted at both local and national levels, including analyses of municipal assets and state-owned enterprise land (Santoso & Nurbiyanto, 2021); (Susanto & Utomo, 2019). Alkausar et al. (2018) emphasise that the identification of the most optimal business form must be preceded by a systematic land-use analysis. However, these studies tend to focus primarily on land-use feasibility and valuation outcomes, with limited attention given to the institutional and contractual mechanisms governing asset utilisation.

More recent asset utilisation studies argue that optimal outcomes cannot be achieved solely through land-use analysis, but must also account for the utilisation schemes that define the relationship between the government and private investors (Kuntadi et al., 2022). In the Indonesian context, utilisation of SOA is subject to strict regulatory frameworks that determine permissible schemes such as leasing, utilisation cooperation, or build–operate–transfer arrangements. Legal feasibility, zoning compliance, and regulatory certainty therefore play a decisive role in shaping both government decisions and investor participation. Despite this, the legal dimension is often treated as a preliminary screening factor rather than a central criterion in optimisation models.

From a methodological perspective, multi-criteria decision-making (MCDM) approaches-particularly the Analytical Hierarchy Process (AHP)-have gained increasing attention in asset management and planning research due to their ability to integrate qualitative judgments with quantitative assessment (Saaty, 2008; Barić et al., 2016). Recent studies demonstrate that AHP is well

suited for resolving complex public-sector decisions involving multiple stakeholders, competing objectives, and regulatory constraints (Azizi, 2009; Berkman et al., 2017). Nevertheless, applications that combine HBU analysis, asset utilisation schemes, and MCDM methods in a single integrated framework remain relatively limited, especially in the context of state-owned land assets in Indonesia.

Based on this gap, the present study seeks to address the following research question: What is the most optimal utilisation alternative for state-owned land assets when legal, financial, physical, investor feasibility, and government capitalisation criteria are jointly evaluated within an integrated HBU and asset utilisation scheme framework?

By explicitly integrating HBU criteria with utilisation schemes through an AHP-based multicriteria approach, this study contributes to the existing literature in two ways. First, it provides empirical evidence on the dominant role of legal feasibility in determining optimal SOA utilisation. Second, it offers a structured decision-support model that aligns regulatory compliance with economic and investment considerations. The findings are expected to offer practical insights for policymakers, planners, and asset managers in developing more effective and legally robust strategies for optimising state-owned land assets.

LITERATURE REVIEW

SOA Utilisation and Public-Sector Planning

The utilisation of SOAs is a critical component of public-sector planning, as it affects asset productivity and fiscal sustainability. Effective SOA management therefore requires optimisation strategies, particularly through formal utilisation schemes that enable value creation while maintaining public ownership. Asset performance provides an essential basis for evaluating such strategies, as it reflects the efficiency and long-term value generated by asset utilisation decisions. (Puspitarini & Akhmadi, 2019) highlights that the proposed performance measurement framework supports more efficient public asset planning and reduces asset underutilisation.

SOA, particularly land and buildings, represent a strategic instrument for supporting public finance, urban development, and service delivery. Within the planning literature, asset utilisation is increasingly viewed not merely as an administrative function but as a form of spatial and economic policy intervention. Recent studies emphasise that ineffective utilisation of public land often stems from fragmented decision-making, weak analytical grounding, and insufficient alignment between regulatory frameworks and economic objectives (Kaganova & Amoils, 2020).

However, despite offering valuable planning perspectives, this body of literature provides limited guidance on explicit decision-support mechanisms for

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selecting optimal asset utilisation alternatives in contexts characterised by multiple criteria and diverse stakeholders. This limitation highlights the need for structured multicriteria approaches capable of integrating legal, economic, and planning considerations within a coherent analytical framework.

HBU as a Framework for Asset Optimisation

The HBU concept is a foundational framework in property appraisal and asset optimisation. HBU defines the use of a property that is physically possible, legally permissible, financially feasible, and maximally productive (Appraisal Institute, 2013; (Fanning, 2014). HBU is an essential competitive factor in investment decision-making (Bravi & Rossi, 2013). Within public-sector asset management, HBU analysis has been widely adopted to assess alternative land uses that maximise economic value while complying with planning and regulatory requirements.

Empirical studies applying HBU to public assets demonstrate its effectiveness in identifying value-maximising development options. Santoso & Nurbiyanto (2021) applied HBU analysis to municipal assets in Batam and found that legal permissibility and zoning constraints significantly influenced feasible development outcomes. Similarly, Susanto & Utomo (2019) combined HBU with life-cycle cost analysis to optimise state-owned enterprise land assets, highlighting the importance of financial feasibility alongside regulatory compliance. Rashid et al. (2023) propose a Sustainability HBU framework based on GIS-integrated multicriteria decision analysis to guide the sustainable optimisation of Federal Land Development Authority land.

Despite its strengths, prior HBU-based studies tend to focus primarily on land-use feasibility and valuation outcomes. These studies often fail to incorporate utilisation schemes-such as leasing, shared use, built-operate transfer, infrastructure utilisation cooperation, and limited concession schemes-as explicit criteria in assessing the optimal utilisation of government assets. This creates a conceptual gap, particularly in jurisdictions like Indonesia, where legal utilisation schemes are strictly regulated and directly affect both government returns and investor incentives. The present study addresses this gap by embedding HBU analysis within an explicit asset utilisation scheme framework.

AHP in Asset Management and Planning Decisions

AHP is a multicriteria decision-making (MCDM) method designed to handle complex decisions involving multiple qualitative and quantitative criteria (Saaty, 2008; Saaty & Vargas, 2012). Within the theoretical framework of MCDM methods, decision-making is understood as a value-based process in which individuals evaluate and select alternatives according to the relative importance of the criteria they consider (Berkman et al., 2017; Rangel et al., 2008). These subjective valuations enable decision-makers to systematically compare available

options and ultimately choose the alternative that maximises overall perceived value (Berkman et al., 2017). One of the main theories in value-based decision-making assumes that choices are made by optimizing the value of various goals, for example, the benefits obtained from the choice (Suri et al., 2020). According to Kaufman & Woodhead (2006), value-based decision-making constitutes a structured analytical process that seeks to maximise value by fulfilling essential functions at the minimum cost without compromising required levels of quality and performance. AHP decomposes decision problems into hierarchical structures and uses pairwise comparisons to derive priority weights, making it particularly suitable for public-sector and planning contexts where stakeholder judgments and regulatory considerations play a critical role.

Within asset management and planning studies, AHP has been increasingly employed to support transparent and systematic decision-making. Barić et al. (2016) demonstrate that AHP effectively integrates technical, economic, and regulatory criteria in infrastructure planning decisions. In the context of asset utilisation, shows that AHP allows decision-makers to balance financial performance with operational and institutional constraints (Azizi, 2009).

More specifically, AHP has been applied to public asset utilisation studies to prioritise development alternatives and evaluation criteria. Kuntadi et al. (2022) employ AHP to assess asset optimisation strategies in the public sector, finding that legal and institutional factors often outweigh purely financial considerations.

Previous Studies Combining AHP and HBU in Asset Utilisation

Although both AHP and HBU are well established independently, studies that explicitly integrate these frameworks remain relatively limited. Existing research often applies HBU as a qualitative screening tool, while AHP is used separately for ranking alternatives without full integration of regulatory utilisation schemes. Santoso & Nurbiyanto (2021) demonstrate HBU analysis enhances transparency in weighting legal, physical, and financial criteria. However, their study does not extend the analysis to contractual utilisation schemes. Internationally, Niekamp et al. (2015) propose a multicriteria framework for sustainable asset management but do not operationalise HBU criteria within regulated public asset utilisation systems.

These limitations reveal a clear research gap, namely the absence of an integrated decision-support model that simultaneously incorporates HBU criteria and utilisation schemes reflecting stakeholder preferences. Given that AHP is particularly effective in resolving such multidimensional decision problems, its integration with HBU and utilisation schemes represents a methodological advancement in asset utilisation studies.

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Research Positioning and Contribution to Literature

Based on the reviewed literature, it is evident that prior studies have either focused on HBU-based land-use optimisation or applied AHP to asset management decisions in isolation. Few studies, particularly in the Southeast Asian and Indonesian planning contexts, have integrated these approaches and explicitly incorporated asset utilisation schemes. Nevertheless, under the regulatory framework governing the utilisation of SOA in Indonesia, utilisation schemes constitute one of the officially recognised mechanisms for asset utilisation.

This study positions itself within this gap by integrating HBU analysis and asset utilisation schemes through an AHP-based multicriteria framework. By doing so, it responds directly to calls in the planning and asset management literature for more comprehensive, regulation-sensitive decision-support tools. The approach contributes not only to academic discourse but also to practical planning and policy formulation for SOA utilisation.

RESEARCH METHODOLOGY

Research Framework

The research framework is illustrated in Figure 1 and is developed based on insights derived from the literature review. The framework aims to optimise the utilisation of SOA, particularly fixed assets in the form of land, by integrating the HBU concept with SOA utilisation schemes through cooperative arrangements.

The land-use evaluation criteria are derived from the HBU framework, which comprises four main dimensions: legally permissible, physically possible, financially feasible, and maximum productivity. In addition, the asset utilisation scheme is assessed based on two key criteria, namely investor feasibility and government capitalisation.

Each criterion is further elaborated into a set of sub-criteria, drawing upon established HBU principles and relevant regulations governing SOA utilisation schemes. Based on the evaluation of these criteria and sub-criteria, alternative land development options are assessed to identify the alternative that most effectively optimises the utilisation of SOA.

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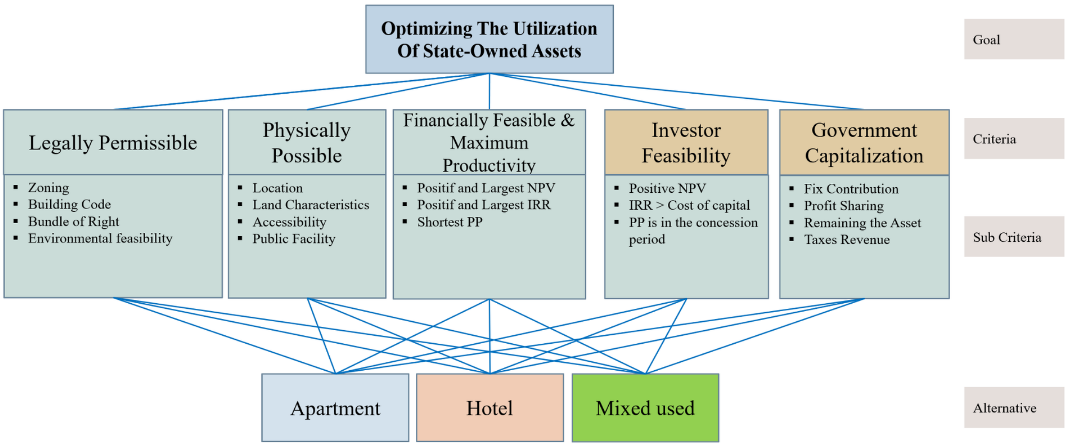


Figure 1: Framework
Source: processed by the Author

Research Design and Approach

This study adopts a quantitative decision-support approach using the AHP to determine the most optimal utilisation of state-owned land assets. AHP is employed to integrate multiple criteria derived from the HBU framework and legally defined asset utilisation schemes. The research design emphasises expert-based judgment to capture regulatory, financial, and planning considerations that are not fully observable through secondary data alone.

1. Data Collection and Questionnaire Design

Primary data were collected through a structured expert questionnaire designed specifically for AHP analysis. The questionnaire was developed based on an extensive review of the literature on HBU, public asset utilisation, and multicriteria decision-making. The structure of the questionnaire followed the hierarchical model of the study, which consists of four levels:

(1) research objective,
(2) evaluation criteria,
(3) sub-criteria, and
(4) utilisation alternatives.

The questionnaire was divided into three main sections. The first section gathered general information regarding the respondents' professional background and experience in asset management, planning, or valuation. The second section consisted of pairwise comparison questions to assess the relative importance of the main criteria and sub-criteria. The third section evaluated alternative asset utilisation options (hotel, apartment, and mixed-use

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development) using pairwise comparisons under each criterion. All comparisons followed the standard nine-point Saaty scale to ensure methodological consistency.

Prior to distribution, the questionnaire was reviewed internally by senior academics and practitioners to ensure clarity, logical consistency, and relevance to the Indonesian regulatory and planning context. Minor wording adjustments were made based on this review to improve comprehensibility and reduce ambiguity.

2. Expert Selection and Validation

The selection of experts followed a purposive sampling strategy, which is commonly applied in AHP-based studies where informed judgment is required. Experts were selected based on predefined eligibility criteria to ensure the credibility and relevance of their assessments. These criteria included:

(1) minimum of five years of professional or academic experience in asset management, urban planning, property valuation, or public-sector finance;
(2) direct involvement in decision-making, policy formulation, or research related to SOAs; and
(3) familiarity with regulatory frameworks governing public asset utilisation in Indonesia.

The expert panel comprised academics, practitioners, and government officials to capture diverse perspectives while maintaining substantive expertise. To validate expert input, consistency ratios (CR) were calculated for all pairwise comparison matrices. Responses with CR values exceeding the acceptable threshold of 0.10 were reviewed, and inconsistent judgments were clarified or excluded to ensure the reliability of the results. This validation process strengthens the robustness of the expert-based assessment.

3. Justification for the Use of the AHP

The AHP was selected for this study due to its suitability for complex decision-making problems involving multiple criteria, qualitative judgments, and regulatory considerations. Unlike purely quantitative optimisation models, AHP allows decision-makers to explicitly incorporate expert knowledge and institutional constraints, which are critical in public-sector asset utilisation decisions.

Alternative multicriteria methods, primarily rely on numerical performance indicators and assume stable, measurable criteria. In contrast, the optimisation of SOAs involves legal permissibility, regulatory compliance, and institutional feasibility, which are difficult to quantify directly. AHP is

particularly effective in this context because it enables structured comparison of qualitative factors and provides transparent priority weights for each criterion.

Furthermore, AHP has been widely applied in planning and asset management studies due to its ability to integrate diverse stakeholder perspectives while maintaining analytical rigour. Its hierarchical structure aligns well with the HBU framework, allowing legal, physical, and financial criteria to be evaluated systematically. For these reasons, AHP is considered the most appropriate method for achieving the objectives of this study, namely identifying an optimal asset utilisation alternative that balances regulatory compliance, economic feasibility, and planning considerations.

4. Analytical Procedure

The AHP analysis followed standard procedural steps:

(1) construction of the hierarchical decision model;
(2) pairwise comparison of criteria, sub-criteria, and alternatives;
(3) computation of priority weights using eigenvalue methods; and
(4) consistency testing to validate expert judgments.

The final priority scores were used to rank the alternative utilisation options and determine the most optimal form of state-owned land utilisation.

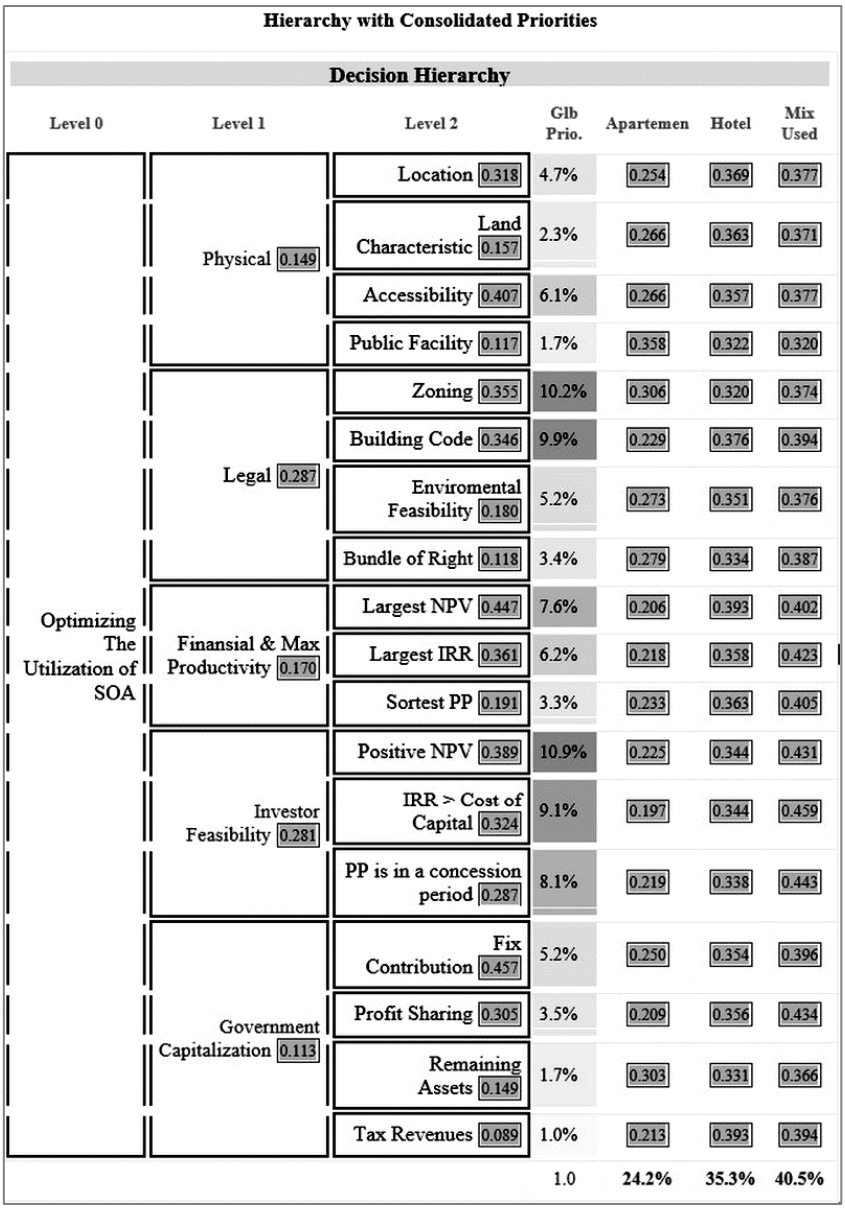
ANALYSIS AND DISCUSSION

1. Interpretation of Key Findings

The results of the AHP analysis indicate that legal feasibility emerges as the most influential criterion in determining the optimal utilisation of state-owned land assets, followed by investor feasibility and financial productivity considerations. This finding reinforces the argument that public asset optimisation is fundamentally shaped by regulatory and institutional constraints rather than purely economic or physical factors. Within the context of SOA management, legal permissibility-including zoning regulations, building codes, and land tenure arrangements-functions not merely as a preliminary screening condition but as a decisive determinant of feasible and sustainable utilisation outcomes.

From a theoretical perspective, this result contributes to asset management and planning literature by extending the HBU framework beyond its traditional appraisal-oriented interpretation. While classical HBU analysis assumes legal permissibility as one of four equal conditions, the findings of this study suggest that, in the public-sector context, legal feasibility holds a dominant position due to the statutory nature of SOA governance. This supports emerging views in public asset management theory that emphasise institutional embeddedness and regulatory alignment as central elements of value creation in public assets (see Figure 2).

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Hierarchy with Consolidated Priorities

Decision Hierarchy

Level 0	Level 1	Level 2	Glb Prio.	Apartemen	Hotel	Mix Used
Optimizing The Utilization of SOA	Physical 0.149	Location 0.318	4.7%	0.254	0.369	0.377
		Land Characteristic 0.157	2.3%	0.266	0.363	0.371
		Accessibility 0.407	6.1%	0.266	0.357	0.377
		Public Facility 0.117	1.7%	0.358	0.322	0.320
	Legal 0.287	Zoning 0.355	10.2%	0.306	0.320	0.374
		Building Code 0.346	9.9%	0.229	0.376	0.394
		Enviromental Feasibility 0.180	5.2%	0.273	0.351	0.376
		Bundle of Right 0.118	3.4%	0.279	0.334	0.387
	Finansial & Max Productivity 0.170	Largest NPV 0.447	7.6%	0.206	0.393	0.402
		Largest IRR 0.361	6.2%	0.218	0.358	0.423
		Sortest PP 0.191	3.3%	0.233	0.363	0.405
	Investor Feasibility 0.281	Positive NPV 0.389	10.9%	0.225	0.344	0.431
		IRR > Cost of Capital 0.324	9.1%	0.197	0.344	0.459
		PP is in a concession period 0.287	8.1%	0.219	0.338	0.443
	Government Capitalization 0.113	Fix Contribution 0.457	5.2%	0.250	0.354	0.396
		Profit Sharing 0.305	3.5%	0.209	0.356	0.434
		Remaining Assets 0.149	1.7%	0.303	0.331	0.366
		Tax Revenues 0.089	1.0%	0.213	0.393	0.394
			1.0	**24.2%**	**35.3%**	**40.5%**

Figure 2: Determining Decisions on Selecting Alternatives for Utilising SOA Assets
Source: Processed by the author

2. Discussion of Optimal Utilisation Alternatives

The prioritisation of mixed-use development as the most optimal utilisation alternative reflects a convergence of legal compliance, financial feasibility, and investor attractiveness. Mixed-use development benefits from regulatory

flexibility, diversified revenue streams, and greater resilience to market fluctuations compared to single-use alternatives such as hotels or apartments. From a planning perspective, this finding aligns with contemporary urban development principles that promote functional integration, land-use efficiency, and sustainable intensification, particularly in strategic urban locations.

Importantly, the preference for mixed-use development also illustrates how AHP enables the integration of competing objectives within a single evaluative framework. Rather than maximising a single outcome (e.g., highest financial return), the AHP results demonstrate a balanced optimisation that reflects public-sector priorities, investor constraints, and planning regulations simultaneously. This reinforces the relevance of multicriteria approaches in public asset utilisation decisions, where trade-offs are inherent and unavoidable (see Figure 3).

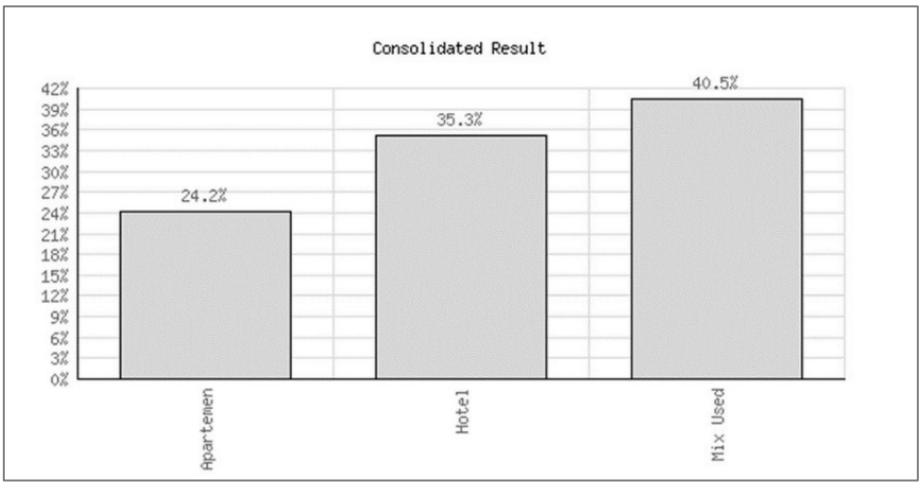


Figure 3: Results of Determining Alternative Use of SOA Assets
Source: Processed by the author

3. Practical Implications for Policy and Practice

The results of this study have several important practical implications. For policymakers, the findings suggest that asset utilisation policies should prioritise regulatory clarity and legal readiness before pursuing economic optimisation. Streamlining zoning approvals, clarifying permissible utilisation schemes, and reducing regulatory uncertainty can significantly enhance the attractiveness and effectiveness of SOA utilisation initiatives.

For public asset managers and practitioners, the study provides a structured decision-support model that can be applied prior to engaging with private investors. By adopting an AHP-based evaluation framework, asset managers can proactively identify utilisation options that align with legal,

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financial, and planning constraints, thereby reducing negotiation risks and improving long-term outcomes.

For investors, the results highlight the importance of regulatory certainty in investment decision-making involving SOA. Mixed-use development emerges as an attractive option not solely because of financial returns, but because it aligns with regulatory frameworks and public-sector objectives, thereby reducing institutional risk.

4. Implications for Future Research

The study opens several avenues for future research. First, further studies could apply the integrated HBU–AHP framework across different asset types or urban contexts to assess the generalisability of the findings. Second, future research may extend the model by incorporating dynamic market variables or stakeholder preference analysis to enhance predictive capability. Finally, comparative studies using alternative MCDM methods could further validate the relative strengths of AHP in public asset optimisation.

CONCLUSION AND RECOMMENDATION

This study examines the optimisation of state-owned land assets by integrating the HBU framework with legally defined asset utilisation schemes through a multicriteria decision-making approach using the AHP. The findings demonstrate that legal feasibility is the most influential determinant in optimising SOA utilisation, surpassing purely financial or physical considerations. Among the evaluated alternatives, mixed-use development emerges as the most optimal utilisation option, reflecting its ability to balance regulatory compliance, economic viability, and investor attractiveness.

The results offer several actionable insights for policymakers and practitioners. First, regulatory readiness should be treated as a strategic priority in SOA asset optimisation. Policymakers are encouraged to strengthen zoning clarity, streamline approval processes, and provide explicit guidance on permissible utilisation schemes to reduce uncertainty and improve asset attractiveness. Without legal and regulatory certainty, economically viable asset utilisation options may remain unrealised.

Second, public asset managers should institutionalize evidence-based decision-making tools, such as the integrated HBU–AHP framework proposed in this study, prior to engaging with private investors. Conducting structured multicriteria evaluations at the planning stage can help governments proactively identify optimal utilisation alternatives, minimise negotiation risks, and align asset utilisation decisions with long-term planning objectives.

Third, for private-sector investors, the findings highlight that regulatory alignment is as critical as financial returns when considering investment in SOAs. Mixed-use development is particularly attractive not only due to diversified

revenue streams but also because it offers greater flexibility within regulatory and planning frameworks, thereby reducing institutional risk.

While this study focuses on a single state-owned land asset in particular location, future research could extend the multicriteria framework to different regions, urban contexts, or asset types, such as buildings, infrastructure assets, or heritage properties. Comparative studies across cities or countries may provide insights into how regulatory environments influence asset optimisation outcomes.

Further research may also incorporate dynamic market variables, stakeholder preference analysis, or alternative multicriteria methods to compare robustness and sensitivity of results. Integrating spatial analysis tools or sustainability indicators could further enhance the applicability of the model within urban and regional planning contexts.

Overall, this study underscores the importance of integrating legal, financial, and planning considerations within a structured decision-support framework for SOA optimisation. By providing both analytical rigor and practical guidance, the proposed approach contributes to more transparent, accountable, and sustainable public asset management practices.

Limitations and Underlying Assumptions

Despite its contributions, this study is subject to several limitations that warrant acknowledgement. First, the analysis is based on a single case study of state-owned land in Medan, which may constrain the generalisability of the findings to other regions characterised by different regulatory regimes, market conditions, or institutional arrangements. Second, the AHP relies on expert judgment which, although systematically assessed through consistency ratio testing, remains inherently susceptible to subjective bias. Therefore, the credibility of the AHP results depends critically on the selection of experts with appropriate technical expertise, thereby ensuring that the analysis is scientifically justifiable.

In addition, several simplifying assumptions underpin the analysis. The study assumes stability in the regulatory framework throughout the evaluation period and presumes that the identified utilisation alternatives sufficiently capture the range of feasible development options. Furthermore, financial indicators such as NPV and IRR are assumed to reflect prevailing market conditions, without explicitly accounting for potential macroeconomic volatility or dynamic changes over time.

Future research is encouraged to apply the integrated HBU–AHP framework across multiple locations, asset types, and planning contexts to test its robustness and adaptability. Comparative studies between regions or countries could further clarify the role of institutional and regulatory environments in shaping asset optimisation outcomes. Methodologically, future studies may incorporate alternative multicriteria techniques or sensitivity analyses to assess the stability of expert-based evaluations under different assumptions.

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ACKNOWLEDGEMENT

The Ministry of Finance supported the research through the Polytechnic of State Finance-STAN Research Grant Scheme.

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Received: 5th July 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 141 – 155

ADAPTING TRADITIONAL HOUSES IN INDONESIA TO ENHANCE MODERN BUILDING'S SUSTAINABILITY

Galuh Mafela Mutiara Sujak[1], Hanif Noer Rofiq[2]

[1,2] *Directorate General of State Asset Management,*
MINISTRY OF FINANCE, INDONESIA

Abstract

Indonesia's growing population and climate change are driving a surge in sustainable housing demand. However, existing construction often falls short of sustainability standards. Meanwhile, traditional houses are recognized for their eco-friendliness and possess significant attributes applicable to modern buildings. Addressing the scarcity of research analyzing Indonesian traditional houses through the lens of green building standards, this study aims to explore the adaptability of East Javanese traditional housing elements to enhance modern building sustainability. Using a qualitative approach, data was gathered through a literature review and in-depth interviews with residents of traditional houses to identify key architectural features. The findings were mapped against the Green Building Council Indonesia's GREENSHIP rating tool. The analysis reveals that traditional elements specifically high ceilings, permeable woven walls, overstek (overhangs), and the use of local materials, align with seven GREENSHIP subcategories. This research confirms that traditional Javanese architecture offers viable, low-energy passive cooling strategies that can be integrated into contemporary designs.

Keywords: Green Building, Passive Cooling, Sustainable Housing, East Java, Vernacular Architechture

[1] Corresponding author. Email: galuh.mafela@kemenkeu.go.id

INTRODUCTION

The construction industry is recognized as a key driver of economic and social development, especially in developing nations. However, it remains one of the largest contributors to global energy consumption and carbon emissions (Zhang et al., 2022). In Indonesia, the sector is expanding rapidly to meet the demands of a growing population. For example, the Program Sejuta Rumah Indonesia (One Million Homes Programme), launched in April 2015, which aim at providing proper housing for low-to-middle-income citizens, the program successfully delivered 1,217,794 housing units in 2023. However, this rapid development often prioritizes speed and cost over sustainability. This approach leads to high levels of CO2 emissions and an over-reliance on Heating, Ventilation, and Air Conditioning (HVAC) systems, which account for 38% of building energy consumption globally. Furthermore, as a tropical country with year-round sun exposure, Indonesia faces an urgent need for residential construction that minimizes energy consumption from HVAC. As Indonesia commits to reducing greenhouse gas emissions by 29% by 2030 (Humas, 2021), the property sector faces a critical mandate to transition toward green building practices as it is one of the main contributors to global energy use and carbon contributor (Shi et al., 2023).

One emerging solution is the green building concept, which promotes sustainability by reducing energy usage and optimizing resource efficiency throughout a building's lifecycle (Abo El Kasem Ali, 2021). While residential construction continues to grow, many modern Indonesian houses overlook the passive design strategies inherent in the region's vernacular architecture. In contrast to modern developments, which rely heavily on mechanical cooling systems to combat heat and humidity which in turn contributing to higher HVAC and carbon emission, traditional Javanese architecture evolved over centuries to achieve thermal comfort naturally (Handoko, 2020).

Unfortunately, traditional houses are becoming increasingly abandoned in the modern era (Wijaya & Purwanto, 2017). To prevent its extinction, many researchers have documented the philosophy and design of traditional houses. However, existing literature often documents the philosophical or physical aspects in isolation (Prakoso & Wilianto, 2020), only few studies have evaluated these vernacular elements against contemporary green building rating tools to quantify their relevance for modern application. This gap presents a critical opportunity: understanding how traditional design principles align with modern sustainability benchmarks could offer a pathway to reduce carbon emit in Indonesia’s residential sector. Therefore, this study aims to explore the adaptability of traditional East Javanese housing elements to enhance the sustainability of modern buildings by seeking to identify the features of

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traditional Javanese houses that align with the Green Building Council Indonesia's GREENSHIP rating tool.

LITERATURE REVIEW

Green Building and GREENSHIP Criteria

The green building concept has emerged as a response to the construction industry's environmental impact. It is broadly defined as a practice of creating constructions and employing resource and environmentally-conscious methods for the duration of a building's life cycle (Wong & Zhou, 2015). Another definition of green building is a building that is designed, built, and maintained to minimise the negative environmental effects of building while reducing water and energy consumption as well as its construction costs (Chin Yee Ha et al., 2023). Thus, it is expected to curtail the harm done to the environment through carbon emission, pollution, and waste of its components (Ragheb et al., 2016).

Initial Green building standards mainly emerged from developed countries, for example, BREEAM (Building Research Establishment Environmental Assessment Method) in 1990 in UK; Leadership in Energy and Environmental Design (LEED) in 2000 in US; Green Star in 2003 in Australia; and Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in 2005 in Japan. In Indonesia, GREENSHIP provides local framework in assessing building performance in 2010 by Green Building Council Indonesia (GBCI) (Mollaoglu et al., 2016). According to GBCI in 2018, to be considered an eco-friendly or green home, a home should be wise in land use, water and energy efficiency, conservation of materials and resources, as well as the health and well-being of its occupants. To help self-assess the buildings, GBCI issued GREENSHIP, a rating tool to benchmark Indonesian green buildings. GREENSHIP has been used for building assessment in order to issue green building certification in Indonesia. Until now, there are 5 types of GREENSHIP, including GREENSHIP for New Buildings, Existing Buildings, Interior Spaces, Homes, and Neighborhoods. For home types, there are six categories, as elaborated in Table 1.

Table 1. GREENSHIP Categories

No.	Categories	Sub-Categories
1.	Appropriate Site Development (ASD)	Providing Green Areas, Encourage development in places that already have supporting infrastructure, Encourage community accessibility, Enforce pest management, Encourage public transportation usage, Stormwater management.
2.	Energy Efficiency and Conservation (ECC)	Electricity sub-metering provision, Artificial lighting incorporation to reduce energy

No.	Categories	Sub-Categories
		consumption, Thermal conditioning to reduce energy consumption, Heat reduction, Energy-saving home appliance implementation, Renewable energy sources utilization.
3.	Water Conservation	Water metering provision, Water-saving fixtures implementation, Rainwater harvesting, Water saving irrigation, Waste Water Management.
4.	Material Resource and Cycle (MRC)	Use of non ODP Refrigerant materials, Material Reuse, Use of environmentally friendly material source, Use of environmentally friendly processed material, Use of certified wood, Use of prefab material, Use of local material, Aware with the carbon footprints.
5.	Indoor Health and Comfort	Fresh air circulation, Use of natural lighting, Visual comfort, Pollutant Source Minimalization, Acoustic Level, Spatial Comfort.
6.	Building Environment Management	Sustainable Design and Construction, Home Guideline, Green Activity, Waste Management, Security, Innovation, Home Design Development.

Source: Green Building Council Indonesia, (2014)

Indonesia Traditional House

A traditional house refers to a residence that reflects the architectural and cultural norms, values, beliefs, lifestyle and technological advancement of the people, community or ethnic groups in a particular region. In Indonesia's history of traditional architecture, the majority of architectural expertise is transmitted verbally from generation to generation (Sardjono & Nugroho, 2015). They represent a vernacular response to the tropical climate, developed through trial and error. Recent scholar argues that vernacular architecture often posseses a higher content of sustainable design than the modern counterparts as they are put forward envoironmental harmony and resource efficiency (Cheong et al., 2020, as cited in Adib et al., 2025), thus, these houses are often built using locally available materials and construction techniques that have gone through trial and error and passed down through generations. A clear distinction exists between modern and traditional approaches to green living. As noted by Yu et al. (2020) and Abood et al. (2020), modern green houses typically rely on advanced active technologies, for example, the smart home automated systems to control energy consumption, or solar photovoltaic systems, whereas traditional green houses emphazise passive design strategies such as natural ventilation and locally sourced materials.

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When discussing traditional houses in East Java, there may be a lot of similarities with the other regions in Java Island because they are from the same tribe, Javanese. Various types of traditional houses in Java can be found in East Java as well, such as Joglo House (Zulkifli & Ika, 2020) Limasan House, "Kampung" House, Houses with Mosque shapes and "Tajug" or "Tarub", "Panggang Pe" House (Ismunandar, 2003 in Antonius et al., 2014), and the traditional house of the Osing people, an indigenous ethnic group in Banyuwangi city, East Java. (Wijaya & Purwanto, 2017; Suprijanto, 2002).

They exhibit similar ecological architecture principles, which is manifested in the high, pyramid-shaped roof, permeable woven bamboo walls or the use of clay which aligns with the sustainability frameworks in modern ways. Various designs of East Java traditional houses are derived from the philosophical and cultural aspects. These houses often reflect the beliefs and values of the community, such as harmony with nature (Prakoso & Willianto, 2020) and the social status differentiation which is visible from the roof (Wijaya and Purwanto, 2017; Idham, 2018; Prakoso & Willianto, 2020). The lower economy uses the Kampung roof, the medium economy uses the Limasan roof and the richer one uses the Joglo roof (Prakoso & Willianto, 2020; Idham, 2018) which is considered a perfect and sacred house in Java (Dakung, 1968, as cited in Sardjono & Nugroho, 2015; Prabasmara, 2020). In general, this study observes traditional Javanese homes in particular, in which the data are available in previous research studies and from the source persons' perspective.

This study adopts a conceptual framework (see Figure 1) that links traditional Javanese house elements with contemporary green building assessment criteria. Traditional architectural features are understood as passive environmental design strategies developed in response to the tropical climate. These elements contribute to passive mechanisms including natural ventilation, thermal comfort, heat reduction, and natural lighting. The framework further maps these passive strategies to the Green Building Council Indonesia's GREENSHIP categories. Through this mapping, the framework shows how vernacular architectural principles can be systematically translated into modern sustainability benchmarks, thereby supporting the adaptation of traditional design knowledge for contemporary housing development.

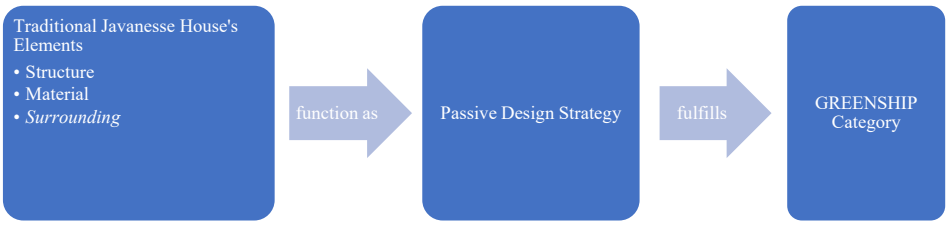


Figure 1. Conceptual Network
Source: Authors

RESEARCH METHODOLOGY

This study adopts qualitative approach through literature review and in-depth interviews to evaluate the alignment between traditional Javanese architectural design and Indonesia modern sustainability standards. The study follows these stages: Data Collection from literature and interviews; Data Analysis and Comparative analysis against the GREENSHIP Rating Tools as shown in Figure 2.

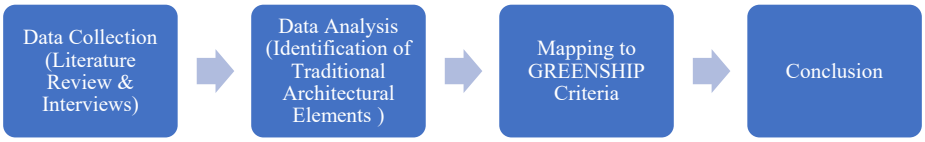


Figure 2. Reseach Stages
Source: Authors

1. Data Collection

Traditional Javanese houses have become commonly rare, especially in metropolitan areas. To observe traditional houses, most researchers need to step into the field and make direct observations. Meanwhile, many researchers have documented Traditional Houses Literature in their studies. Thus, due to the place and time limitations, this study mostly gathers and analyzes the data from previously available publications. This research was done through data collection from two primary methods:

1) Literature Review. A multifaceted process that entails interpreting a range of published and unpublished documents from different sources on a particular subject. The process ideally involves summarising, analysing, evaluating, and synthesising the documents (Onwuegbuzie et al., 2012, as cited in Antonius et al., 2014). The research data was used from various sources, 16 key articles were selected focusing on published Indonesian and International journals that

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explore the topic of traditional Javanese houses and sustainable construction practices.

2) In depth interviews. To ensure data triangulation and enhance credibility, the findings will further collaborate through in-depth interviews with two knowledgeable individuals possessing adequate knowledge about traditional Javanese houses. These individuals should have lived in East Java's traditional houses and directly experienced the transition from traditional to modern architectural styles. Two key informants were selected from the Greater Malang area in East Java: Mr. Moch Goeritno (60 years old) and Mr. Soeharwadi (85 years old). Both participants have inhabited traditional houses featuring "sirap" (ironwood) and clay roofs, providing first-hand insights into the passive cooling performance of these structures.

2. Data Analysis and Mapping to GREENSHIP Criteria

Initially, the collected data was identified to find its key architectural features found in the literature. Then we cross refference with the information from the in-depth interviews. To meet the objectives, the result then mapped against GREENSHIP Home (Version 1.0), a rating tool provided by the Green Building Council Indonesia (GBCI). The mapping process identifies specific credits that traditional features can naturally fulfill to understand how they align with green building aspects that can be applied in new housing.

RESULTS AND DISCUSSION

Traditional Javanese House Element and Passive Strategies

The analysis from literature reviews and in-depth interviews with senior residents (Mr. Moch Goeritno and Mr. Soeharwadi) reveals that traditional Javanese houses employ a set of architectural elements that function as passive environmental strategies. The key elements include high ceilings, permeable woven bamboo or wooden walls, large openings and ventilation, overstek (roof overhangs), clay or sirap roofing, extensive vegetation surrounding the house, and the use of local natural materials. These elements are contributing to each physical strategies used in the traditional houses in response of environmental conditions.

Java's climatic conditions are generally beyond the thermal comfort range, particularly during periods of elevated temperature and humidity between August and October (Idham, 2018). Under such conditions, achieving indoor comfort requires architectural responses that reduce solar heat gain while facilitating effective air movement. Traditional Javanese houses demonstrate a long-established climate-responsive design approach, developed through empirical knowledge and cultural practices, which integrates building

orientation, spatial configuration, roof form, material selection, and surrounding landscape to moderate indoor environmental conditions.

Building orientation is one of the fundamental strategies employed in traditional Javanese houses. In tropical climates, east- and west-facing façades receive the highest solar radiation due to the sun's daily movement (Wijaya et al., 2017). Traditional Javanese houses, however, commonly face north or south. While this orientation is closely associated with Javanese cosmological beliefs, such as the symbolic significance of Wisnu's residence in the north and the South Sea ruler (Nyi Roro Kidul) in the south, it also produces a climatic benefit by reducing direct exposure to intense solar radiation. As a result, indoor heat accumulation is indirectly minimised, contributing to a more thermally stable interior environment.

Vertical spatial configuration further enhances passive cooling performance. Traditional house types, particularly Joglo houses, are characterised by high ceilings, which significantly influence air movement within the interior space. High ceilings promote the stack effect, allowing warm air to rise and escape through upper openings, thereby lowering indoor air temperature (Idham, 2018). This mechanism is reinforced by the presence of large doors, wide windows, and dedicated ventilation openings, which ensure continuous airflow throughout the building (Antonius et al., 2014). In addition, the use of permeable bamboo or wooden walls allows air to pass through the building envelope, further enhancing cross-ventilation and indoor comfort.

Roof design constitutes another essential component of the traditional Javanese passive cooling system. Rather than employing flat roof forms, traditional houses utilise pyramid-shaped roofs with wide overstek that provide shading from both solar radiation and heavy rainfall (Maharani et al., 2021). The roof structure typically consists of a wooden frame combined with clay or terracotta roof tiles (Cahyani et al., 2015; Fajarwati et al., 2020). In many cases, the absence of a ceiling leaves the roof structure exposed, allowing warm air to accumulate and exit more effectively. Transparent or perforated roof tiles are sometimes incorporated to permit daylight penetration into interior spaces, reducing the need for artificial lighting. Material permeability, particularly in walls and roofing systems, therefore plays a critical role in facilitating air circulation and thermal regulation (Idham, 2018).

Natural lighting is another defining feature of traditional Javanese houses. Daylight penetration is optimised through the use of large openings, exposed roof structures, and translucent or permeable materials. Woven bamboo panels, commonly used for walls and partitions, not only serve decorative purposes but also allow natural light to penetrate deeper into interior spaces. This approach enhances visual comfort while maintaining airflow. Empirical evidence suggests that woven bamboo contributes positively to thermal comfort, air

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quality, and lighting conditions within interior spaces (Ababssi and Prihatmaji, 2024).

The literature findings are strongly supported by in-depth interviews with two senior residents of Greater Malang, East Java, Moch Goeritno (60 years old) and Soeharwadi (85 years old), both of whom have experienced living in traditional and modern houses. They confirmed that thermal comfort in traditional Javanese houses was achieved through a combination of high ceilings, clay or sirap roofs, extensive openings, and abundant vegetation surrounding the house. Both respondents emphasised that trees planted around the house provided natural shading and cooling, while open doors and windows during daytime allowed continuous air circulation. They also noted the presence of perforated roof tiles in some houses, which further enhanced ventilation.

Mapping Traditional Elements to GREENSHIP Criteria

Following the analysis approach, the architectural features identified from the literature and interviews were grouped and systematically mapped against the GREENSHIP for Home (Version 1.0). From the six GREENSHIP categories and 38 subcategories, the analysis indicates that seven subcategories can be naturally fulfilled through the application of traditional Javanese house features, particularly within the categories of Appropriate Site Development (ASD), Energy Efficiency and Conservation (EEC), Material Resources and Cycle (MRC), and Indoor Health and Comfort (IHC).

Energy Efficiency and Conservation (EEC) The primary contribution of traditional architecture lies in its passive cooling capabilities. The Javanese house achieves thermal comfort through structural geometry rather than mechanical systems. Specifically, the high-pitched Joglo roof and the absence of a ceiling board maximize the air volume and facilitate the stack effect, allowing hot air to rise and dissipate. This mechanism directly satisfies EEC 3 (Thermal Conditioning) by eliminating or significantly reducing the need for air conditioning. Furthermore, heat reduction is achieved through the building envelope design. The wide overstek (overhangs) effectively shade the walls from direct solar radiation, while the North-South orientation minimizes exposure on the east-west axis. These strategies collectively fulfill EEC 4 (Heat Reduction) by lowering the overall thermal transfer into the building.

Appropriate Site Development (ASD) Traditional land-use planning offers a blueprint for mitigating the Urban Heat Island effect. Javanese houses are integrally designed with a pekarangan (surrounding garden plot) dedicated to vegetation and tree planting. This zoning practice serves a functional climatic purpose: trees provide microclimate shading and evapotranspiration, which cools the surrounding air before it enters the house. In the context of the rating tool, this

practice directly aligns with ASD 1 (Green Area), addressing the modern challenge of maximizing permeable surfaces in residential developments.

Material Resources and Cycle (MRC) The material palette of the traditional house is inherently sustainable. The construction relies predominantly on locally sourced, renewable resources such as bamboo for walls, timber for frames, and clay or ironwood (sirap) for roofing. These materials possess low embodied energy and are non-toxic. Their usage directly supports MRC 3 (Environmentally Friendly Material Source) by reducing extraction impacts and MRC 7 (Local Material) by minimizing carbon emissions associated with transportation.

Indoor Health and Comfort (IHC) Finally, indoor environmental quality is optimized through envelope permeability. The extensive use of woven bamboo walls and large window openings ensures continuous cross-ventilation, a critical requirement for IHC 1 (Fresh Air Circulation). Unlike airtight modern structures, this breathable skin prevents moisture buildup and stagnation. Simultaneously, the design strategies for IHC 2 (Natural Lighting) are evident in the use of exposed roof frames (allowing for skylight integration) and wide apertures, which balance daylight penetration with glare control.

Table 2. GREENSHIP Categories

No.	GREENSHIP Category	Adaptable Javanese Traditional House Aspect
1.	ASD 1 Green Area	Has plot to gardening or planting trees
2.	EEC 3 Thermal Condition	Not using AC
3.	EEC 4 Heat Reduction	The use of woven bamboo in some of traditional Javanese House The usage of material that can block / prevent heat Overstek Trees to shade the house Large ventilation and opening Open space Direction of the house
4.	MRC 3 Environmental Friendly Material Source	The use of natural sources to be the house material
5.	MRC 7 Local Material	The use of natural sources for housing material, ranging from woods, woven bamboo, local clay, etc.
6.	IHC 1 Fresh Air Circulation	The use of woven bamboo in some of traditional Javanese House - Osing

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No.	GREENSHIP Category	Adaptable Javanese Traditional House Aspect
		The use of wide windows and openings.
7.	IHC 2 Natural Lighting	The use of exposed and holed roof The use of woven bamboo in some of traditional Javanese House - Osing The use of wide windows and openings

Comparative Analysis with Tropical Vernacular Context

To contextualise the research findings, this study compares the identified Javanese architectural features with recent scholarship on vernacular architecture across the tropical belt. This comparison illustrates that the alignment between Javanese traditional elements and green building standards reflects a broader set of architectural responses shared by heritage structures in similar climatic zones. The application of roof geometry and shading devices in Javanese houses follows a pattern consistent with other tropical vernacular typologies. Adib et al. (2025) report that traditional Malay houses employ similar elevated floors and open layouts to meet Green Building Index (GBI) requirements. Comparable strategies are documented by Berrak and Kapoor (2021) and Triarma et al. (2025), who observe that wide roof eaves and canopies are common vernacular solutions for reducing solar load. Specifically, Sari et al. (2024) note that expansive overhangs in Gayo Highland mosques serve a primary function in shading, which parallels the role of the Javanese overstek in addressing heat reduction criteria.

The use of permeable building envelopes for ventilation is also observed in broader regional contexts. Petrucci (2023) identifies passive ventilation principles in Indian Havelis and Turkish Ottoman architecture, utilizing windcatchers and porous screens to facilitate airflow. In the Southeast Asian context, Abdul Halim Choo et al. (2024) describe carved wood components in the Rumah Limas Bumbung Perak that function as ventilation panels, operating similarly to Javanese woven bamboo walls in supporting fresh air circulation. Regarding material selection, Ismail (2025) observes that contemporary adaptations of traditional houses in Johor integrate reclaimed wood. This approach aligns with the Javanese practice of utilising durable, local materials such as teak and ironwood, supporting principles of resource conservation and circularity.

The climatic function of the pekarangan (garden plot) corresponds with quantitative studies on microclimates. Michelle and Satwiko (2025) indicate that increasing private green spaces in residential areas can reduce ambient

temperatures by 1 to 2°C. Furthermore, Satwiko and Michelle (2018) found that tree canopies in urban corridors reduced solar radiation on surfaces by approximately 22%. These data suggest that the traditional practice of maintaining vegetated areas around the dwelling contributes effectively to modern Appropriate Site Development objectives.

CONCLUSION

This study establishes that traditional East Javanese architecture serves as a robust prototype for sustainable living, offering time-tested passive design strategies that remain highly relevant to modern environmental challenges. By mapping vernacular elements against the Green Building Council Indonesia's rating tool, this research confirms that traditional houses inherently satisfy seven specific GREENSHIP Homes (Version 1.0) subcategories without relying on complex modern technology.

The synthesis of literature and in-depth interviews reveals three primary architectural contributions to sustainability. First, regarding Energy Efficiency and Conservation (EEC), the structural geometry of the Joglo roof, high ceilings, and North-South orientation effectively facilitate the stack effect and reduce solar heat gain, thereby minimizing reliance on mechanical air conditioning. Second, in terms of Indoor Health and Materiality (IHC & MRC), the use of permeable woven bamboo walls and locally sourced materials (clay, teak, ironwood) ensures continuous cross-ventilation and lowers embodied carbon. Third, regarding Appropriate Site Development (ASD), the traditional pekarangan (garden plot) system serves as a critical ecological buffer, reducing micro-environmental temperatures through vegetation shading.

Implications for Practice The findings necessitate a shift in contemporary housing development practices. For architects and designers, the study suggests moving beyond aesthetic imitation of traditional forms toward a functional integration of passive strategies. For housing developers, adopting the pekarangan ratio concept can significantly mitigate Urban Heat Islands in dense residential clusters. Furthermore, policymakers are encouraged to integrate these vernacular principles into local building codes, incentivizing the use of low-carbon local materials and passive cooling designs as a standard for affordable housing projects.

Limitations and Future Research

While this study provides a comprehensive qualitative assessment based on literature and lived experiences, it relies on perceived thermal comfort rather than empirical data. Future research should focus on quantitative validation through field measurements, utilizing digital thermal sensors and energy simulation

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software (such as EDGE or EnergyPlus) to measure the exact temperature differentials and energy savings achieved by these traditional elements.

ACKNOWLEDGEMENT AND DISCLOSURE STATEMENT

This research received no grant from any funding agency. This research also has no conflict of interest that might influence the result and interpretation of the study.

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Received: 5th July 2025. Accepted: 15th November 2025

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Journal of the Malaysian Institute of Planners
VOLUME 23 ISSUE 3 (2025), Page 159 – 173

DETERMINATION OF A SPECIFIC RISK- ADJUSTMENT RATE FOR INTELLECTUAL PROPERTY VALUATION ACCORDING TO TECHNOLOGY READINESS LEVEL

Rohaya Abdul Jalil[1], Maimunah Sapri[2], Azlin Abd Jamil[3], Ng Wee Fern[4], Nadila Hamidi[5]

[1,2,4]*Fakulti Alam Bina & Ukur,*
UNIVERSITI TEKNOLOGI MALAYSIA
[3]*Fakulti Pengurusan,*
UNIVERSITI TEKNOLOGI MALAYSIA
[5]*Institut Penilaian Negara (INSPEN), Jabatan Penilaian Pengurusan Harta,*
KEMENTERIAN KEWANGAN MALAYSIA

Abstract

Intellectual property (IP) valuation is recognized as one of the knowledge that valuers need to explore as a new opportunity in diversifying valuation services. However, IP's intangible nature, unfamiliarity with specific risk allocations, unique IP characteristics and future uncertainty of IP growth make it challenging to allocate specific risks to ensure valuation reflects true economic fair value as IP risks differ by IP category and technology readiness level (TRL) level. Therefore, through relief from the royalty method, the study of the specific risk-adjustment rate (SRAR) framework to build a rubric that facilitates appraisers. The aim of the research is to determine the approach for establishing the element of potential and risk associated with the classification of IP. Through content analysis, this study successfully assesses associated risks by mapping methodology towards the assessment of the potential risk associated with the classification of IP and risk assessment according to the TRL level. Introducing this SRAR rubric will familiarize valuing IP among member firms and allow valuers to diversify their valuation service. IP is evaluated as a future backup collateral value for corporate financing.

[2] Corresponding author. Email: zuraini_mdali@um.edu.my

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Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 156 – 168

Keywords: Intellectual Properties, Technology Readiness Level, Specific Risk-Adjustment Rate, Weighted Average Cost of Capital

[1] Corresponding author. Email: rohaya@utm.my

INTRODUCTION

Since 2010, business models have become increasingly technology-driven, as reflected in online banking, e-commerce, and platform-based firms such as Airbnb and Grab, where intellectual property (IP) protection underpins competitive advantage (Schiavi et al., 2018; Miguez et al., 2018; Lindsay & Hopkin, 2010). Consequently, IP valuation has become critical for licensing, franchising, and mergers and acquisitions (M&A), influencing royalty determination, firm value, and financial performance. This is evident in major acquisitions and accounting practices that require intangible assets to be recognized separately from goodwill. Nevertheless, IP valuation remains challenging due to uncertainty in future economic benefits, limited asset life, and sensitivity to market and technological changes, a concern also reflected in Malaysian studies highlighting asset-specific risks beyond conventional tangible measures (Ramli et al., 2023; Mustaffa et al., 2023; Rohaizad et al., 2021).

To address these challenges, IP valuation commonly applies the income approach using discounted cash flows and the firm's Weighted Average Cost of Capital (WACC), although this often inadequately captures innovation-related risks (Wasserman, 2015). Technology Readiness Levels (TRLs) provide a structured framework for assessing technological maturity and associated risks across development stages. As risks vary by IP type and TRL, the formulation of a Specific Risk Adjustment Rate (SRAR) aligned with TRLs is essential to enhance valuation accuracy and reduce the risk of IP mispricing.

LITERATURE REVIEW

Associates Risk of Intellectual Property Valuation

University–industry collaboration plays a critical role in facilitating intellectual property (IP) commercialization and knowledge transfer; however, limitations in absorptive capacity, technology transfer office (TTO) capabilities, and market alignment continue to constrain effective valuation and commercialization outcomes, particularly in developing economies such as Malaysia. As intangible assets increasingly drive value creation, accurate IP valuation has become essential, although prior studies show that not all university-generated knowledge translates into improved firm innovation performance (Bekkers & Freitas, 2008; International Chamber of Commerce, 2019).

IP valuation is further complicated by uncertainties in forecasting future income and the frequent underestimation and underutilization of IP assets, particularly patents and trademarks (King, 2003; OECD, 2017). In Malaysia, many firms, especially SMEs, tend to undervalue their IP, reflecting weak absorptive capacity and limited ability to leverage external knowledge from universities (Chandran et al., 2014; The Star, 2008). Market misalignment further

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constrains commercialization, as innovations often fail to meet market needs due to insufficient demand-driven research (Raja, 2011; Bakar et al., 2022).

Moreover, structural constraints within TTOs—such as shortages of skilled personnel and financial resources—limit effective innovation management and commercialization support (Raja, 2011). Firms also face technological capability gaps that hinder the translation of research outputs into high-impact innovations (George et al., 2008). As firm value increasingly depends on the effective management of IP assets, strengthening absorptive capacity and improving IP evaluation mechanisms remain critical to overcoming commercialization challenges in Malaysia (Sandner & Block, 2011; Ramli et al., 2023; Mustaffa et al., 2023).

Uncertainty in Intellectual Properties Commercialization

The literature on commercialization support organizations—such as technology transfer offices (TTOs), science parks, and incubators—highlights the importance of efficient organizational practices in facilitating the transfer of knowledge from universities to industry (Bekkers & Freitas, 2008; Thursby & Thursby, 2001). Efficient IP commercialization generates economic value for universities and firms; however, valuation uncertainty arises when commercialization outcomes and future revenues are difficult to predict (Sharif et al., 2018). Empirical evidence from developed economies demonstrates the economic significance of IP commercialization, although such outcomes remain uncertain in valuation contexts. TTOs play a critical role in protecting and transferring IP through mechanisms such as patenting, licensing, spin-offs, and joint ventures, with licensing being the most common commercialization mechanism, while spin-offs may generate higher but more uncertain returns (Arundel & Geuna, 2004; Sveiby & Simons, 2002; Cohen & Munis, 2002; Ovortrup, 2006; Enache & Srivastava, 2018).

Despite these mechanisms, commercialization remains challenging due to the tacit nature of technological knowledge, which complicates effective transfer (Chew & Yun, 2007; Lee & Yun, 2007). Successful IP transfer therefore requires coordinated efforts among universities, industries, and students to support knowledge transmission (Nystén-Haarala et al., 2010). Trust further plays a crucial role in managing potential misunderstandings and protecting IP through contractual arrangements; however, inadequate valuation of IP may undermine the realization of its full economic potential (Bose & Thomas, 2007; Bishop, 2003; Smith & Parr, 2000).

The Complexity of Intellectual Property Commercialization Process

Commercialization of university IP starts with the disclosure of innovations by researchers to the TTO for an assessment of market potential and patentability (Sharif et al., 2018). When viable, TTO moves to arrange protection globally,

exploring further options for commercialization, including licensing or a spin-off. However, most researchers are not entrepreneurial, and that makes TTOs very significant in the knowledge transfer process (Brantnell & Baraldi, 2022).

Governments and industries also continue to play key roles in providing funding for university research and implementing supportive policies, such as faculty training and enhancing research markets. In Malaysia, the Centre for Research and Innovation Management helps professors seek funding and also monitors innovation progress. After an innovation is ready, the Technology Transfer Office-which commercializes the innovation through TTO-negotiates contracts and does all legal documentation (Debackere & Veugeler, 2005; Marshall, 2005; Kneller, 1999). Commercialization is faced with challenges such as bureaucratic delays, aversion to risk, and the difficulties inherent in the transfer of technology from academic to industry (Siegel & Wright, 2015; Mirowski & Nik-Khah, 2007). More often than not, inefficiencies and time-consuming approval processes discourage researchers from commercializing their work and hence limit the impacts of innovations (Chandran et al., 2014; Raja, 2011).

Poor Demand from Local Industrial in Commercializing Intellectual Property

Malaysia is transitioning into a technology-driven economy, inspired by Asia's Newly Industrializing Economies (NIEs). As the global shift towards a knowledge economy grows, businesses increasingly rely on intellectual property (IP) for competitive advantage (Chen et al., 2019). Malaysia's industry has expanded due to rising disposable incomes and consumer confidence, driving demand for top brands and IP licensing (IBISWorld, 2020). Ranked 37th in the Global Innovation Index (Cornell University et al., 2017), Malaysia is well-positioned to capitalize on Industry 4.0 advancements (WEF & A.T. Kearney, 2018).

Malaysia faces challenges in its innovation landscape, including low absorptive capacity for subcontracting commercialization (Motohashi & Yun, 2007) and poor IP management (King, 2003). Inexperienced companies struggle with pricing, marketing, and licensing decisions, hindering commercialization (Kodama, 2019; George et al., 2008). The country lags in innovation due to limited knowledge sharing and failure to capitalize on local expertise (Shah & Tripsas, 2016). To bridge this "commercialization gap," Malaysia needs to foster a culture of science, technology, and innovation, transforming scientific knowledge into socio-economic advancements (Akoum, 2016; Aman, 2020; Dyer & Hatch, 2006).

Intellectual Properties Protection Issued Does Not Meet Market Readiness

Technological and market readiness are critical factors in the adoption of new technologies; however, no standardized model fully captures market readiness. The Technology Readiness Level (TRL) framework, introduced by NASA,

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evaluates technological maturity but places greater emphasis on innovation push than market demand (Kirchberger & Pohl, 2016; Dent & Pettit, 2011). To address this limitation, complementary models such as innovation readiness and demand readiness have been developed to incorporate market-oriented considerations (Tao et al., 2009; Paun, 2012).

Despite achieving technological maturity and regulatory approval, market adoption remains a key challenge, as adoption depends on a technology's relative value, utility, and competitive positioning. As technologies transition from early adopters to broader markets, constraints related to market consensus, innovation support, and knowledge transfer often emerge. These uncertainties directly affect revenue forecasts and discount rate determination, requiring consideration of market, industry, and IP-specific risks. Consequently, successful IP commercialization relies on strong market demand, while weak market alignment and limited commitment to technology transfer continue to hinder the commercialization of local IP (Bakar et al., 2022; Trimi et al., 2012; Dent & Pettit, 2011; Sandner & Block, 2011).

Risk Associated with Intellectual Property Patents Valuation

IP valuation involves estimating intangible assets such as patents, trademarks, copyrights, and trade secrets while accounting for both diversifiable (unsystematic) and non-diversifiable (systematic) risks. Diversifiable risks include patent infringement, reputation risk arising from inaccurate valuation, and ownership risk related to legal ambiguities over IP rights, all of which can reduce asset value but may be mitigated through diversification strategies (Damodaran, 2020).

Non-diversifiable risks, including market, regulatory, geopolitical, and technology risks, stem from broader macroeconomic and industry-wide factors and directly influence discount rates used in valuation. Higher market volatility increases discount rates and lowers IP value, while technology obsolescence, regulatory uncertainty, market saturation, and litigation risks further shape valuation outcomes (Smith & Parr, 2000; Cockburn & MacGarvie, 2009; Dhingra, 2020). Accordingly, robust IP valuation frameworks must explicitly incorporate both diversifiable and non-diversifiable risks to ensure accurate valuation (Smith & Parr, 2000; Helfer & Austin, 2011).

Conceptual Idea on the Relationship of Patent Valuation According to Technology Readiness Level

Key risks include patent infringement, which may lead to costly litigation, reputation risk from inaccurate valuations that damage brand or investor trust, and ownership risk, involving legal disputes over IP rights that can reduce asset value. (Damodaran, 2020).

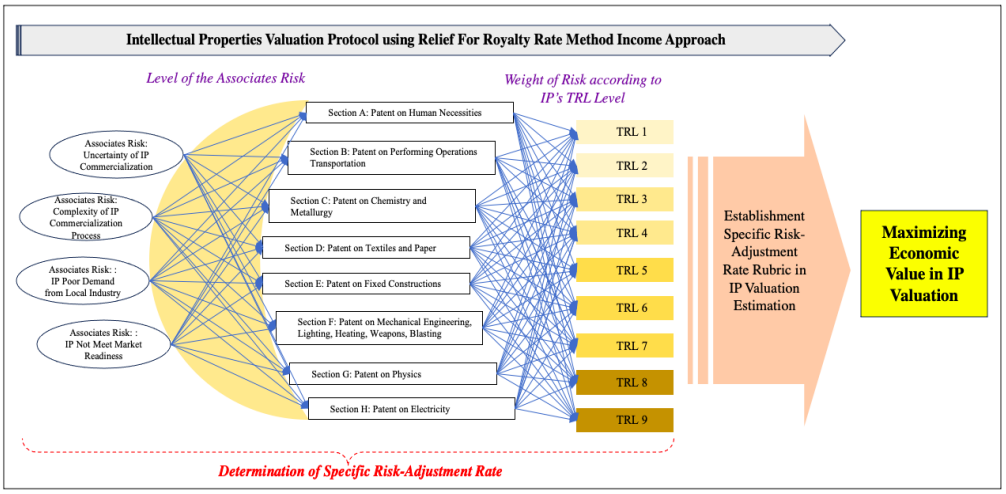


Figure 1: Conceptual framework illustrating the relationship between patent-specific risk-adjustment rate and Technology Readiness Level (TRL), incorporating diversifiable and non-diversifiable risk components.

As depicted in Figure 1, explain that non-diversifiable risks, such as market, geopolitical, regulatory, and technology risks, affect entire industries and influence IP valuations. Increased market volatility leads to higher discount rates and lower valuations. Technology risks include potential obsolescence due to innovation or competition, while geopolitical risks, like political instability or changes in IP laws, also impact IP value. Additional risks, such as market saturation and litigation, are critical considerations. Accurate IP valuation requires adjusting for both diversifiable and non-diversifiable risks to ensure reliable results (Smith & Parr, 2000; Damodaran, 2020; Cockburn & MacGarvie, 2009).

RESEARCH METHODOLOGY

The data collection was conducted through content analysis of prior literature to establish intellectual property (IP) valuation in relation to Technology Readiness Levels (TRLs). This analysis was further aligned with the intellectual property categorization framework outlined by the Intellectual Property Corporation of Malaysia (MyIPO), enabling systematic classification of IP types for subsequent risk and valuation assessment.

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Table 1: Intellectual Property Categorization Based on Patent Sections

Section A:	Patent on Human Necessities
Section B:	Patent on Performing Operations Transportation
Section C:	Patent on Chemistry and Metallurgy
Section D:	Patent on Textiles and Paper
Section E:	Patent on Fixed Construction
Section F:	Patent on Mechanical Engineering, Lighting, Heating, Weapons, Blasting
Section G:	Patent on Physics
Section H:	Patent on Electricity

Data collection involves content analysis of prior literature to establish the IP's Technological Readiness Level (TRL) and associated risk valuation based on IP categorization. A survey instrument is then developed to interview ITMA members, testing the reliability of this research. The data collection focuses on validating the related elements with ITMA members, following the rationale of the literature to establish IP valuation according to the TRL level. The elements of potential and risk associated with IP classification are identified through content analysis and tabulated.

ANALYSIS AND DISCUSSION

Table 2, materializes through Step 1 of Procedure 1 design in research methodology, which is the data collection from content analysis in Chapter 2 of the prior literature on potential and risk associated with IP commercialization. These risks have been considered in the estimation of specific risk-adjustment rates in IP valuation according to IP categorization.

Table 2: Associated risk in commercialization

Associated Risk in IP Commercialization			**Authors**
Uncertainty in Intellectual Properties Commercialization	(i)	Time speeding up the realization of knowledge transfer and commercialization	Arundel and Geuna (2004) Sveiby and Simons (2002) Cohen et al., (2002)
	(ii)	Innovation performance of the firm	Bekkers and Freitas (2008)
	(iii)	Innovation products have lower take-up rates for commercialization	Thursby and Thursby (2001); Sharif et al., (2018)
	(iv)	It is more complicated to transfer the technology or innovation when there are implicit elements in the innovation.	Teece (2010); Reily (2022)
	(v)	Immaturity of IP in developing innovative products reliable for the market	Paasi et al., (2010)

Associated Risk in IP Commercialization			Authors
	(vi)	Risk on commercialization collaboration engagement	Pisano and Teece (2007) Enkel et al., (2018); Lee (2019)
	(vii)	Capability of parties conducting commercialization	Blomqvist et al., (2008) Nystén-Haarala et al., (2010)
	(viii)	Future income is predicted, unreliable, and does not represent intellectual property assets' whole or fair value.	Smith and Parr, (2000) Bose & Thomas, (2007) Bishop, (2003)
The Complexity of Intellectual Property Commercialization Process	(i)	IP commercialization negotiation is difficult	Ellonen et al., (2008) Olander et al., (2010)
	(ii)	The long process of commercialization	Sharif et al., (2018)
	(iii)	Inexperience of TTO where it can help in assisting the knowledge transfer from creation to commercialization	Debackere and Veugeler (2005) Kneller (1999) Marshall (2005)
	(iv)	Require funding to adopt commercialization	Rasmussen (2008)
	(v)	Rigid procedure of commercialization	Mirowski and Nik-Khah (2007); Siegel et al., (2004); and Siegel & Wright (2015)
	(vi)	Inefficiency of exploitation in R&D by the university and linkages	Chandran et al., (2014); Raja (2011)
Poor Demand from Local Industrial in Commercializing Intellectual Property	(i)	Inexperience for commercialization	Kodama (2019); George et al., (2008)
	(ii)	Lowly managed or not fully utilised	King (2003)
	(iii)	Subcontract the commercialization to ^{third} parties and poor absorptive rate.	Motohashi and Yun (2007)
	(iv)	Less response on innovation commercialization	Rappert et al., (1999)
	(v)	Industry depends on financial assistance for commercialization	Shah and Tripsas (2016)
	(vi)	Deficiency in knowledge shared, interaction, and failure to adopt innovative knowledge and skill formation	Dyer and Hatch (2006) Riege (2005)
	(vii)	Industry requires an effective model to form a science-literate society	Akoum (2016)
	(viii)	Industry unaware of the capability of local IP creation	Aman (2020)
Intellectual Properties Protection Issued Does Not Meet Market Readiness	(i)	Enter the market at the right time	Bakar et al., (2022) Trimi et al., (2012)
	(ii)	Immaturity of IP entering the market	Mankins (1995)

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Associated Risk in IP Commercialization		Authors
(iii)	The local market lacks funds to commercialize IP	Dreyfuss (2010) Roessner et al., (2013) Paun (2012)
(iv)	Lack of consensus between the market and IP creator	Dent and Pettit (2011)
(v)	IP introduction requires a higher degree of market penetration	Kim et al., (2012); Lemley (2019)
(vi)	Lack of transforming the R&D into a valuable innovation product in the marketplace	Bakar et al., (2022) George et al., (2008)
(vii)	Inadequate for high-impact invention	Sandner and Block (2011)

Mapping of Associate Risk according to IP Categorization

These risks have been considered in estimating specific risk-adjustment rates in IP valuation according to IP categorization.

(i) Patent on Human Necessities
(ii) Patent on Performing Operations Transportation
(iii) Patent on Chemistry and Metallurgy
(iv) Patent on Textiles and Paper
(v) Patent on Fixed Construction
(vi) Patent on Mechanical Engineering, Lighting, Heating, Weapons, Blasting
(vii) Patent on Physics
(viii) Patent on Electricity

Evaluation of IP patents regards risks associated with the potential for commercialization and can be broken down based on the IP category. These risks associated with each category are evaluated using the Technology Readiness Level (TRL) and span from category 1 (where basic principles are observed) to category 9 (where the system has already been proven) (Lestari et al., 2022; Khan & Wu, 2020). Uniquely different risks associated with the different categories of IP (such as medical devices and industrialized building systems) pose differing threats to their prospects in terms of commercialization (Sharif et al., 2018).

Patent classifications influence risk exposure, with healthcare-related patents facing higher regulatory and approval risks, while engineering- and electricity-based patents encounter different commercialization challenges. As TRL increases, associated risks decline, reflecting greater technological maturity and market readiness.

From a broader planning and asset valuation perspective, prior studies in the Malaysian context emphasize that valuation accuracy improves when non-tangible risk attributes are systematically incorporated into assessment frameworks rather than treated implicitly. This aligns with findings in Planning Malaysia that highlight the importance of structured valuation approaches for

assets with complex, intangible, and technology-driven characteristics, particularly where future economic benefits are uncertain (Rohaizad et al., 2021; Jalil, 2023)

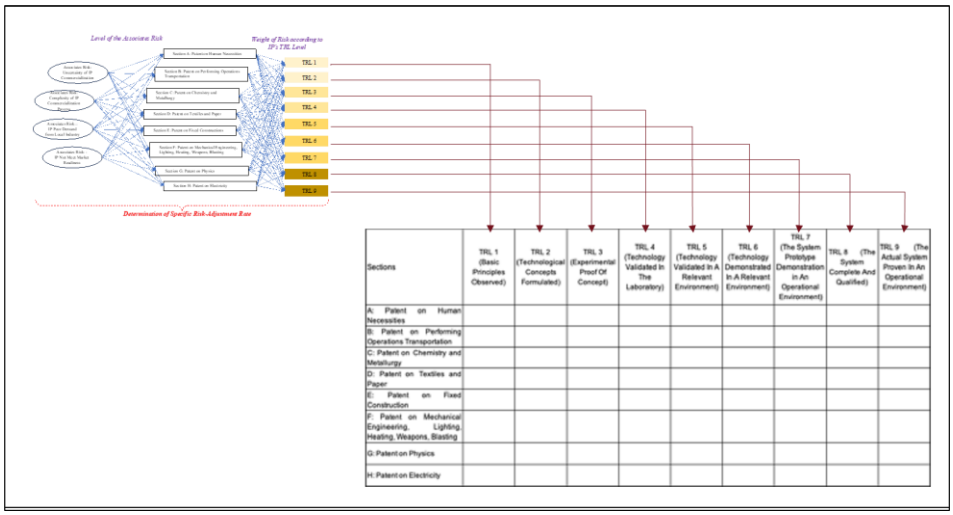


Figure 2: Mapping of associated commercialization risks across IP categories and corresponding Technology Readiness Levels (TRL), illustrating declining risk intensity as TRL increases.

CONCLUSION

This study maps the risks associated with IP categorization and its Technology Readiness Level (TRL), identifying four key risk sub-categories: (i) uncertainty in commercialization, (ii) commercialization complexity, (iii) poor demand from local industry, and (iv) market readiness. Risk levels vary across IP categories and are influenced by the patent lifecycle and TRL. Higher TRLs generally reduce risks, as mature technologies are easier to commercialize. The study introduces a Risk-Adjustment Rate (SRAR) to guide patent valuation, improving accuracy by incorporating both IP categorization and TRL level in the risk assessment.

ACKNOWLEDGEMENT

This is part of the research of the National Real Estate Research Coordinator (NAPREC), under the Allocation RMK-12 (Phase 2A), (INSPEN), Valuation and Property Services Department (JPPH), Ministry of Finance Malaysia

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Received: 9th March 2025. Accepted: 15th November 2025

PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 169 – 184

MEASURING THE IMPACT OF GREEN BUILDING ATTRIBUTES ON PROPERTY VALUE AND IMPLEMENTATION COST: A TWO-WAY APPROACH

Kamarulzaman Mat Salleh[1], Shazmin Shareena Ab. Azis[2], Nursyuhaida Aziz[3], Nur Hannani Ab Rahman[4], Muhammad Syahir Idrus[5]

[1,2,3,4]*Real Estate, Faculty of Built Environment and Surveying,*
UNIVERSITI TEKNOLOGI MALAYSIA
[5] DEWAN BANDARAYA KUALA LUMPUR

Abstract

Green valuation is one type of valuation methods used to estimate the value of property by taking consideration the effect of the green features. Previous studies agreed that green features should be considered in valuation due to its features that have added value to the building. However, many researchers have shown notable obstacle in implementing green buildings which is the cost of implementation. Therefore, it is important to determine green features that has positive effect on property value and the implementation cost of green features. Henceforth, this study is conducted to compare between the effect of green attributes in increasing property values and implementation costs to be used as a guidance for green building industry. The objectives of this study are to identify green attributes on building by systematic analysis, to analyse the effect of green attributes on property value via questionnaire survey, frequency analysis followed by regression analysis. Lastly, to measure the implementation cost for green attributes that increased property value via interview with stakeholders. Based on the five hedonic model performed, it resulted that green roof, green wall, solar photovoltaics, double skin façade glazing, and green shade coverage are recommended to be implemented on buildings, as it increases property value. However, the lowest implementation cost is the green shade coverage implementation as it provides lowest cost compared to other green component at RM370/sqm with high property value increment at 39%. Therefore, it is suggested to implement green shade coverage on property to harvest both benefits. Overall, this study is significant for building industry decision making in green building development.

Keywords: High-rise Residential, Strata Residential, Green Features, Green Valuation

[2] Corresponding author. Email: shazmin@utm.my

INTRODUCTION

Green valuation known as the process of estimating the value of a green property in monetary by taking consideration of its green features where its focus on increasing the efficiency of the usage of energy, water and material resources and reducing impacts on human health and environment (GBI, 2013). Green building has an impact on the property value due to its green features such as energy efficiency, water efficiency, indoor environmental quality, sustainable, green materials, and construction, certification and government incentives and regulatory compliance (Cole, 2003). Thus, the property valuers will consider all green building attributes that are associated with sustainable improvement towards the building and the environment. Green building attributes such as green roof, green wall, solar photovoltaics, roof skylight, external window shading, and light shelves has been designed to maintain a safe and comfortable indoor environment (Shazmin et al., 2017; He et al., 2017; Alaidroos & Krarti, 2015). Green buildings also consist of green attributes such as location, accessibility, and neighbourhood (Porumb et al., 2020; Houghton & Castillo-Salgado, 2020).

According to Meins et al. (2010), green attributes are expected to contribute to property value. Based on past research, green attributes such as green roofs and green walls positively impact building value by 3% to 20% (Tomalty et al., 2010; Chen et al., 2014). A hedonic price regression has been done on stratified green residential buildings in Johor Bahru shows that green roofs and green walls provide value increments at 13% and 43%, respectively (Zulkifli et al., 2019). Besides, solar photovoltaics is also positively affecting property value, where it increases property value by 3% to 5% (Dastrup et al., 2012). Property valuation these days needs to be incorporated with the green features as well to promote and sustain the eleventh sustainable development goals.

From these studies, there is evidence regarding the positive impacts of these green attributes towards the property valuation, but none of these studies have integrated the feasibility and viability of these attributes in term of its implementations costs towards the property. To date, no research has comprehensively compared between green attributes that increase property value and the implementation cost. Henceforth, this research aims to compare green attributes that have effects in increasing property value and the implementation cost to serve as a guidance for the building industry in making decisions for green building development.

LITERATURE REVIEW

Green Attributes

Literature studies have identified that green building components such as green roof, turbine ventilator, solar water heating, solar photovoltaic, roof skylight, light pipe, green wall, light shelf, window external shading, and double skin façade glazing have various effects on property value.

A green roof effectively reduces the need for air conditioning in summertime, thus contributing to energy-saving in buildings (Rumana & Hamdan, 2009). Besides, turbine ventilator has been proven to control high energy consumption and improve the indoor environment (Wang et al., 2021; Qin & Pan, 2020). Solar water heating system is efficient in the deployment of renewable energies by using solar thermal energy to produce hot water, while improves the energy efficiency of buildings through its simple technology and a fast payback period (Taher et al., 2021; Vengadesan & Senthil, 2020).

According to Bhatia (2014), solar photovoltaics is a component that uses semiconductors that exhibit the photovoltaic effect to generate electricity by converting solar power to current electricity. The implementation of building-integrated photovoltaics effectively promotes low-energy buildings (Zhang et al., 2017). Meanwhile, roof skylight gives benefits in terms of an adequate level of daylighting and annual energy-saving (Chel, 2014). The light pipe is helpful as the daylighting device that can replace the artificial lighting requirement, which eventually reduces the CO2 emissions in the environment and provides energy-saving (Sharma et al., 2018; Taengchum & Chirarattananon, 2018; Roccia et al., 2012).

Green walls have been proven to promote energy savings, reduce sound transmission into buildings, contribute to greywater treatment and increase the envelope's longevity (Ascione et al., 2020; Besir & Cuce, 2018; Pradhan et al., 2019). The light shelf improved the daylighting distribution throughout the room, reduced daylight glare problem, and reduced lighting energy consumption (Lim & Heng; 2016; Lee et al., 2018). Window shading is a suitable approach to managing unnecessary heat access and reducing indoor environmental temperature (Dutta et al., 2017; Bessoudo et al., 2010). Natural ventilation through double-skin façades reveals favorable impacts in building energy-saving and delivers efficient cooling (Tao et al., 2021; Kyritsi & Michael, 2020). The findings by Qahtan (2019) suggested that the double-skin façade is efficient in regulating the heat gain event due to the change of temperature between outdoor and indoor and the variations in surface temperatures especially under the tropical climate like Malaysia.

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Green Location

Green location attributes consist of attributes that are related to the location of the green residential and office buildings. The identified attributes are proximity to natural amenities, proximity to public transportation, and proximity to basic amenities. These factors are compared to the existing rating assessment tools developed by GBI, GreenRE, and Green Mark Scheme. The comparison between factors affecting residential and office value, and the existing assessment rating system can be seen in Table 1 below.

Green Neighbourhood

Green neighbourhood consist of attributes that are related to the site and neighbourhood of the property. The identified attributes are green space coverage, green shade coverage, and materials to prevent pollution. The difference in terms of the scales and policy is detailed in Table 1 below.

Effect of Green Attributes on Property Value

Numerous research has shown that green buildings have a higher property value than conventional building value based on Table 2 below which summarizes the literature review on the effects of green attributes on property value.

Table 2: Effects green features on property value

No.	Green attribute	Effect on value	Authors
1.	Green roof	Increase	Ibrahim et al. (2014), Ichihara & Cohen (2011), Tomalty et al. (2010)
		Decrease	Chen et al. (2014)
2.	Turbine ventilator	Increase	Ibrahim et al. (2014)
		No effect	Shazmin et al. (2017)
3.	Solar water heating	Increase	Ibrahim et al. (2014)
		No effect	Shazmin et al. (2017)
4.	Solar Photovoltaic	Increase	Hoen et al. (2011), Dastrup et al. (2012)
5.	Roof skylight	Increase	Sipan et al. (2014)
		No effect	Shazmin et al. (2017)
6.	Light pipe	Increase	Ibrahim et al. (2014)
		No effect	Shazmin et al. (2017)
7	Green wall	Increase	Manso et al. (2020), Perini & Rosasco (2013), Gao & Asami (2007)
8.	Double skin façade glazing	No effect	Shazmin et al. (2017)
9.	Window external shading	No effect	Shazmin et al. (2017)
10.	Light Shelf	Increase	Ibrahim et al. (2014)
		No effect	Shazmin et al. (2017)
11.	Green space coverage	Increase	Holt and Borsuk (2020)
12.	Green shade coverage	Increase	Nepal et al. (2017)
13.	Material to prevent pollution	Increase	Amaral et al. (2020)

Table 1: Green attributes for location and neighbourhood based on green rating tools.

Attribute		Green rating tools			Green Attribute
		Green Building Index (GBI)	Green Real Estate (GreenRE)	Green Mark Scheme	
Residential building					
Location	Proximity to natural amenities	**SM1** – SITE SELECTION AND PLANNING	Not stated.	Not stated.	No development building in agriculture land, habitat land with endangered species and **within 30 m** of any wetlands.
	Proximity to public transportation	**SM8** – PUBLIC TRANSPORTATION ACCESS	**RES 3-5** GREEN TRANSPORT	Not stated.	Public transport stops **within 500m.** Public transport interchange: - Same mode **within 750m** - Multiple mode **within 1 km** Walking distance to public transport **<800m**
	Proximity to basic amenities	**SM3** – COMMUNITY CONNECTIVITY	**RES 3-8** COMMUNITY CONNECTIVITY	Not stated.	Basic amenities **within 750m to 1km**
Office building					
Location	Proximity to public transportation	Not stated.	**ENRB 3-7** GREEN TRANSPORT	**SM1-10** GREEN TRANSPORT	Walking distance to public transport **<500m.**
Residential building					
Neighbourhood	Green space coverage	**SM11** – HEAT ISLAND EFFECT	**RES3-3** GREENERY PROVISION	**PART 1-2** URBAN HEAT ISLAND	Green space with native & adaptive plants and/or water body to **15% to 80% of land area**.

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	Green shade coverage	SM8 – PUBLIC TRANSPORTATION ACCESS	Not stated.	Not stated.	Covered walkway **at least 70%** of the pedestrian access.
	Quality of neighborhood and pollutions (Materials to prevent pollution)	**EQ6** – SOUND INSULATION **EQ2** – VOLATILE ORGANIC COMPOUNDS **SM6** – WORKERS' SITE AMENITIES	**RES3-4** ENV MGMT PRACTICE **RES4-1** NOISE LEVEL **RES4-2** INDOOR AIR POLLUTANTS	**PART 3-3** WASTE **PART 4-2** ACOUSTICS **PART 4-1** CONTAMINANTS **PART 1-2** SUSTAINABLE STORM WATER MANAGEMENT	**Reduce** the detrimental impact on occupants' health from finishes that emit air pollutants. **90%** of no paint and coating used. Provide **septic tank**. **Recycling bins** at each block **Noise level** **70 metres away** from building boundary. **Use of low VOC** emitting interior finishes **Treatment of at least 10% storm water run-off** from total site area
				Office building	
Neighbourhood	Green space coverage	**SM6** – GREENERY & ROOF Roof application:	**ENRB 3-5** GREENERY PROVISION	**SM 1-8** GREENERY	Vegetated roof and façade **at least 20%-50%** of the area.
	Green shade coverage	**SM6** – GREENERY & ROOF	**ENRB 3-7** GREEN TRANSPORT	**SM 1-10** GREEN TRANSPORT	**50% of covered walkways** to nearest public transport networks
	Quality of neighborhood and pollutions (Materials to prevent pollution)	**EQ4** – INDOOR AIR POLLUTANTS **EQ13** – INTERNAL NOISE LEVELS	**ENRB 3-3** WASTE MANAGEMENT **ENRB 4-2** INDOOR AIR POLLUTANTS **ENRB 4-5** INTERNAL NOISE LEVEL	**RS 3-8** RECYCLING FACILITIES **SHB 4-4** INDOOR CONTAMINANTS **SHB 4-6** ACOUSTICS	**No paint, coating, and adhesive**. **Ultraviolet Germicidal Irradiation (UVGI) system** Maintain **internal noise level at 90%** of the NLA. **Noise level** **Recycling bins** provision.

METHODOLOGY

Objective 1: To identify green attributes on building

The identification of green attributes for property is conducted through rigorous literature reviews. The literature review is conducted to determine green attributes that appropriate for green buildings in Malaysia. The green benefits of each green attribute are gathered from the literature to be matched with green criteria listed under the green building assessment tool. The results of data collection from literature review derived by using systematic analysis.

Objective 2: To analyse the effect of green attributes on property value

There are three stages involved to achieve objective 2, which are the distribution of the questionnaire, site inspection, and market transaction data collection. The first stage of the objective is the questionnaire survey. The questionnaires are constructed based on the findings of objective 1 and distributed among property valuers in Malaysia. This study has adopted probability sampling, which is simple random sampling. There is a total of 1684 property valuation practitioners in Malaysia and with a sampling error of ±10%, the number of minimum samplings required for this study is 94.The 5-point Likert scale is used in the questionnaire survey which ranges from increase value to decrease value. The second stage of objective 2 involves selected case studies of stratified green residential and special purpose green office buildings in Kuala Lumpur as it is the state with highest number of green building implementations. In terms of questionnaire survey, data reliability is assessed through Cronbach's alpha coefficient and data is analysed using frequency and descriptive analysis. Then, a total of 1165 data set of residential building that has been collected from NAPIC, JPPH KL and are used in the hedonic regression model. Data cleansing is conducted to identify and fix incomplete and incorrect data. The selected variables consist of basic factors, facilities factors, and green components. The Statistical Package for the Social Sciences (SPSS) tool is used to analyse the collected data.

Objective 3: To measure the implementation cost for green attributes that increased property value

Information regarding the cost of implementing green attributes on property that has positive effect is conducted by interviewing landscape contractors, building contractors, material suppliers, service providers, and other relevant stakeholder who have experience in cost of implementing green attributes. Thus, the guidance and advice from the professionals relating to the green attributes could enlighten the quotation for the implementation cost of green attributes. Costing analysis which comprises of direct costing where it is used to estimate the total cost of property increment for implementing green attributes. Cost is obtained based on the interview session conducted with relevant stakeholders.

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RESULTS AND DISCUSSION

Effects of Green Attributes on Property Value Based on Valuer Perceptions

In this study, the reliability of the Cronbach's alpha coefficient is 0.862. It shows that the Cronbach's alpha coefficient score is more than 0.8 where it indicates that the data gathered are good and reliable. This study proves that solar photovoltaics, solar water heating, roof skylight, double skin façade glazing, window external shading, green roof, and green wall increase property value. This finding is aligned with past research (Hoen et al., 2011; Dastrup et al., 2012; Ibrahim et al., 2014; Manso et al., 2020; Perini and Rosasco, 2013). Besides, proximity to public transportation, proximity to basic amenities, green space coverage, and green shade coverage for office resulted to increase property value. This study also supports past research on turbine ventilators, light pipes, and light shelves as green attributes that have no effect on property value (Azis et al., 2017; Chen et al., 2014). The provision of green space coverage, green shade coverage for residential, and material to prevent pollution also does not have any effect on property value. Furthermore, property value is expected to decrease if situated near natural amenities based on the valuer perspective. From this, Table 3 below presents the overall summary on effect of green attributes property value from valuer perspective.

Hedonic Price Regression Model on Effect of Green Attributes on Property Value

Table 4 below presents the comparison between the effect of green attributes on residential market value from valuer perspective and hedonic model percentages. Referring to the valuer perspective, there are ten green attributes that provide positive effect on residential market value which consists of five green component attributes, and five green location attributes. However, green neighbourhood attributes resulted in no effect on residential market value. Contrasting from the valuer perspective, hedonic model resulted that there are eight green attributes consist of four green component attributes, three green location attributes and one green neighbourhood attributes that provide positive effect on residential market value from 0.40% to 38.70%. Meanwhile, there are nine green attributes that provide negative effect on residential market value from 1.30% to 40.90%.

Table 3: Summary on effect of green attributes property value from valuer perspective

No.	Attribute	Effect on value					
		Residential			Office		
		Increase	No effect	Decrease	Increase	No effect	Decrease
Green component:							
1.	Green roof	/			/		
2.	Solar water heating	/			/		
3.	Solar photovoltaics	/			/		
4.	Roof skylight	/			/		
5.	Green wall	/			/		
6.	Double skin façade glazing	/			/		
7.	Window external shading	/			/		
8.	Turbine ventilator		/			/	
9.	Light pipe		/			/	
10.	Light shelf		/			/	
Green location:							
11.	Proximity to natural amenities:		More than 31m	Within 30m		-	
12.	Proximity to basic amenities	Within 1000m	More than 1000m			-	
13.	Proximity to public transportation:						
	1) Public transport stops	Within 1000m	More than 1000m		Within 30m	More than 751m	Between 31m - 750m
	2) Public transport interchange	Within 1000m	More than 1000m		Within 30m	More than 751m	Between 31m - 750m

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No.	Attribute	Effect on value					
		Residential			Office		
		Increase	No effect	Decrease	Increase	No effect	Decrease
Green neighbourhood:							
14.	Green space coverage: 1) Green space	21% - 80%		0% - 20%	61% - 80%	0% - 60%	
15.	Green shade coverage: 1) Green shade		0% - 80%		21% - 80%	0% - 20%	
16.	Materials to prevent pollution:						
	1) Low VOC paint		/			/	
	2) Sound transmission wall		/			-	
	3) Proper septic tank		/			-	
	4) Reduce finishes that emit air pollutants		/			-	
	5) Stormwater treatment		/			-	
	6) Recycle bin provision		/			/	
	7) UVGI air quality system		-			/	

Table 4: Effect of green attributes on residential market value

Variables	Valuer perspective	Hedonic model (%)	
		Positive	Negative
Green Components:			
1) Green roof	Increase value	0.40	
2) Solar photovoltaics	Increase value	33.30	
3) Green wall	Increase value	3.40	
4) Double skin façade glazing	Increase value	18.20	
5) Window external shading	Increase value		1.30
Green Location Attributes:			
Proximity to public transportation:			
1) Public transport stops – within 500m	Increase value	12.20	
2) Public transport interchange – within 1000m	Increase value	13.40	
Proximity to basic amenities:			
3) School – within 1000m	Increase value	9.80	
4) Supermarket – within 1000m	Increase value		22.50
5) Police and fire station – within 1000m	Increase value		40.90
Green Neighbourhood Attributes:			
Green shade coverage:			
1) Covered walkways – at least 70%	No effect on value	38.70	
Materials to prevent pollution:			
2) Low VOC paint	No effect on value		6.50
3) Sound transmission wall	No effect on value		9.90
4) Septic tank	No effect on value		40.60
5) Reduce finishes that emit air pollutants	No effect on value		5.90
6) Stormwater treatment	No effect on value		25.30
7) Recycle bin provision	No effect on value		26.50

Implementation Cost for Green Attributes

To derive the implementation cost, data is collected through interview among landscape contractors, building contractors, material suppliers, service providers, and other relevant and experience stakeholder. A total of nine service provider was interviewed at different dates to calculate the costings and the quotations is used as the costing data. The costing analysis only highlights the findings for implementation cost for green component attributes and green neighbourhood attributes that have positive effect on both residential market value and office rental value as these are the attributes that should be focused in the property valuation industry specifically by the valuers and the property owners. Hedonic model reveals several green attributes that have positive effect on residential market value and office rental value. There is only one green neighbourhood

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attributes to derive its implementation cost that has positive effect on residential and office building value which is green shade coverage. Table 5 presents the summary of green components implementation cost for residential and office building.

Table 5: Costing for green components attributes

Green components	Total cost (RM/sqm)	
	Min.	Max.
Green component attributes		
Green roof	3,770	5,060
Green wall	5,170	7,100
Solar photovoltaics	1,500	1,800
Double skin façade glazing	1,586	
Green neighbourhood attributes		
Green shade coverage	370	

Results found that green roof, green wall, solar photovoltaics, double skin façade glazing, and green shade coverage are recommended to be implemented on buildings, as it increases property value. However, the lowest implementation cost is the green shade coverage implementation. It provides the lowest cost compared to other green component at RM370/sqm with high property value increment at 39%.

CONCLUSION

In conclusions, this research has discovered that green roof, green wall, solar photovoltaics, double skin façade glazing and green shade coverage can increase property value via its existence on the valued properties. The developed models and the study results could be a guidance to the valuers, developers, and policymakers on promoting the implementation of green attributes on buildings. Apart from that, several limitations exist in this study such as the geographical focus of this study is only in Kuala Lumpur, small sample size and the costing were obtained only the for the attributes that have positive impacts. Future studies can explore the green attributes on buildings all over Malaysia together with considering larger sample size and deriving the costings for all the identified green attributes. Overall, this paper provides insights on the feasibility of green attributes implementation on buildings which provides benefits in terms of property value improvement and concurrently increasing sustainability.

ACKNOWLEDGEMENT

The research was supported by the Ministry of Finance, Malaysia through the National Real Property Research Coordinator (NAPREC) by National Institute of Valuation (INSPEN).

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Received: 9th March 2025. Accepted: 15th November 2025

PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 185 – 204

THE ECONOMICS OF AGRIVOLTAIC SYSTEMS: A MAPPING REVIEW

Mohd Iqbal Mohd Noor[1,2*], Izyan Hadirah[1], Amira Mas Ayu Amir Mustafa[3], Normah Abdul Latip[4], Muhammad Fuad Abdullah[2,5], Mohamad Pirdaus Yusoh[6]

[1]*Faculty of Business Management,*
UNIVERSITI TEKNOLOGI MARA, RAUB BRANCH
[2]*Institute for Biodiversity and Sustainable Development,*
UNIVERSITI TEKNOLOGI MARA, SHAH ALAM
[3]*School of Accounting and Finance, Faculty of Business and Law,*
TAYLOR'S UNIVERSITY, SELANGOR
[4]*Borneo Research Institute for Indigenous Studies (BorIIs),*
UNIVERSITI MALAYSIA SABAH (UMS)
[5]*Faculty of Business Management,*
UNIVERSITI TEKNOLOGI MARA, PUNCAK ALAM
[6]*Faculty of Hospitality, Tourism and Wellness,*
UNIVERSITI MALAYSIA KELANTAN

Abstract

Agrivoltaic systems (AVS) combine solar PV technology with agriculture, offering a dual-use solution to land-use conflicts and energy needs. While environmental and technical benefits are well-studied, economic viability remains less explored. This review analyzes 53 peer-reviewed studies using metrics like ROI, CBR, and IRR. Results show fixed tilt and bifacial systems offer strong economic potential, while elevated and tracking systems often need policy support. Key challenges include high upfront costs, inconsistent profitability, and limited long-term financial data. Standardized metrics and deeper economic analyses are needed to support AVS adoption and policy development.

Keywords: Agrivoltaic systems, economic impacts, profitability, renewable energy, agriculture

[2] Corresponding author. Email: sitiyuliandi@iium.edu.my

INTRODUCTION

Renewable energy, particularly solar photovoltaics (PV), presents a viable pathway to mitigate carbon emissions by reducing reliance on fossil fuels. Among renewable sources, solar PV has shown significant potential in lowering global greenhouse gas emissions and is expected to contribute substantially to the global energy mix. By 2026, renewable energy sources are projected to account for over one-third of total global electricity generation, with solar PV leading at an anticipated 37% growth (IEA, 2024). Solar energy's role in achieving net-zero emissions by 2050 is essential, as it reduces fossil fuel dependence and enhances energy production and storage capacity (Ali et al., 2024; Yusoh et al.,2023).

Despite its environmental benefits, the expansion of solar energy presents land-use challenges, as solar farms require large, open spaces often situated in agricultural areas to minimize development costs (Goh et al., 2024). This overlap creates competition for land, impacting local economies, food security, and biodiversity (Ahmad et al., 2024; Muhammad Nor et al.,2024; Yusoh et al.,2024). Projections suggest that global cropland may shrink by 50 to 650 million hectares by 2100 due to infrastructure expansion, urbanization, and environmental degradation, exacerbating the need for integrated solutions (Malu et al., 2017)

Agrivoltaic systems (AVS), which combine solar PV with agricultural activities on the same land, offer a promising dual-use solution, enhancing both energy production and agricultural yields. Research from the United States, Europe, and India indicates that AVS can diversify income, bolster economic resilience against weather-induced revenue fluctuations, and potentially increase farmers' net earnings (Cuppari et al., 2021). However, AVS adoption remains limited due to high initial costs and the complexities of adapting systems to varied climates, crop types, and market conditions (Jain et al., 2021)

While the current literature extensively addresses the technical, environmental, and socio-ecological benefits of agrivoltaics, there is a notable gap in assessing its economic feasibility and financial outcomes. Sirnik et al. (2023) and Mamun et al. (2022) provide reviews focusing on environmental sustainability, design, and landscape integration, while Favi et al. (2024) emphasize agrivoltaics' benefits across the water-energy-food-environment nexus in West Africa. Widmer et al. (2024) discuss AVS's potential for dual food and electricity production, and Zheng et al. (2024) explore the trade-offs between agricultural output and energy generation. However, these studies do not examine AVS's economic viability, including metrics like cost-effectiveness, return on investment, or regional financial scalability.

This review makes two unique contributions to the economic planning and renewable energy literature. First, it is the earliest systematic mapping review dedicated specifically to agrivoltaic economics, providing a structured synthesis

of financial feasibility across system configurations. Second, by consolidating global evidence into economic knowledge clusters, this review offers a foundation for planners and policymakers to evaluate agrivoltaics as a dual-use land strategy within national and regional development frameworks

Objective of the Review

The objective of this systematic map is to identify, catalogue, and explore the economic aspects of agrivoltaic systems, with a focus on evaluating their financial feasibility, profitability, cost structures, and the effectiveness of policy incentives. This review will consolidate existing knowledge on the economic impacts of agrivoltaic systems, focusing on cost-benefit analyses, financial performance, and economic implications across different regions and contexts. By highlighting promising research areas and identifying gaps in the literature, this review aims to provide a foundation for scientific, philanthropic, governmental, and non-governmental organizations to strategically allocate resources towards sustainable agrivoltaic initiatives. Through this synthesis, the review will also outline potential agrivoltaic interventions where economic research is currently limited, supporting informed investment in programs, policies, and research that contribute to the sustainability and scalability of agrivoltaics.

The systematic map aims to answer the following primary research question: "What evidence exists on the economic impacts of agrivoltaic implementation?" The components of this primary research question are summarized in Table 1.

Table 1: Components of primary research questions

Component	Description
Population	Global, with a focus on studies conducted across diverse geographical regions and agricultural contexts to understand the economic implications of agrivoltaic systems worldwide.
Intervention	Implementation of Agrivoltaic Systems (AVS), combining solar PV with agricultural practices to allow for dual land use, focusing on systems aimed at enhancing both energy and crop production.
Comparison	Not required; however, studies with comparisons to conventional farming, traditional solar farms, or other renewable energy methods will be included for additional insights.
Outcome	Economic impacts, including cost-effectiveness, return on investment (ROI), financial scalability, income diversification, cost-benefit analysis, and implications for local and regional economic resilience.

RESEARCH METHODOLOGY

The systematic map protocol has been developed in accordance with the PRISMA 2020 guidelines for systematic maps (Page et al., 2021) and follows the PRISMA 2020 reporting standards to ensure transparency and rigor in the synthesis process

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(see Supplementary Material 1). The flow of the study selection is shown in Figure 1.

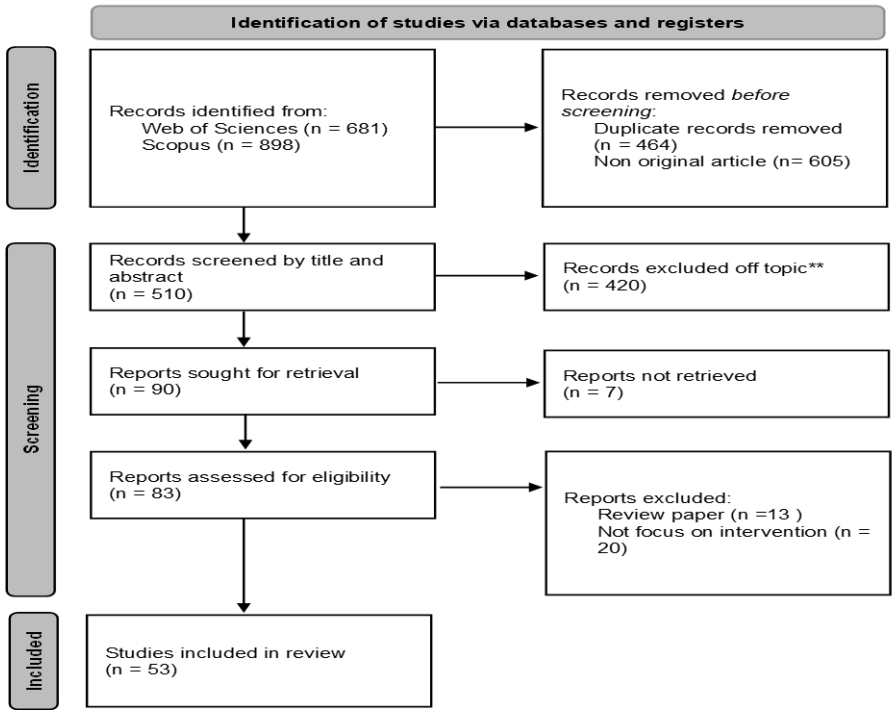


Figure 1: PRISMA flow diagram detailing the screening, eligibility, exclusion and inclusion criteria after a keyword search u

Bibliographic Databases

The literature search for this systematic map was conducted using two primary bibliographic databases: Web of Science and Scopus, both accessed through Universiti Teknologi MARA on 11th October 2024. In Web of Science, the Science Citation Index Expanded (SCI-EXPANDED) section of the Core Collection was searched, focusing on the "topic" (TS) field, which includes titles, abstracts, keywords, and "KeyWords Plus" (terms automatically generated from cited references). In Scopus, article titles, abstracts, and keywords were searched using the predefined search string detailed below, covering all available years.

Grey literature (non-peer-reviewed publications) was excluded from the review to maintain consistent scientific rigor and due to the lack of a systematic retrieval method for these sources. All searches were conducted in English, and only English-language publications were included, as English is the primary language of the reviewers. Search results were exported into an Excel spreadsheet

and reference management software, where duplicates were removed prior to analysis.

Search Terms

The search string "TS=((agrivoltai*) OR (agri-voltai*) OR (agriphotovoltai*) OR (agri-photovoltai*) OR (agrovoltai*) OR (agro-voltai*) OR (agrophotovoltai*) OR (agro-photovoltai*) OR (agrisolar) OR ("dual-use solar") OR ("solar farming") OR ("solar sharing*") OR ("PV agriculture*") OR ("dual land us*") OR ("photovoltaic greenhouse*") OR ("agriculture* photovoltaic*") OR ("greenhouse* photovoltaic*") OR ("flexible photovoltaic panel*"))" was developed specifically to encompass a broad range of terms associated with agrivoltaic systems. This inclusive search strategy was designed to capture the full scope of agrivoltaic studies, acknowledging that economic outcomes and impacts are not always directly stated in titles or abstracts. By avoiding restrictive filters, this approach maximizes the likelihood of identifying studies with relevant economic insights that might otherwise be overlooked.

Article Screening and Study Eligibility Criteria

Screening Process

The screening process for the systematic map was conducted in two stages: (i) title and abstract screening and (ii) full-text review following (Azzeri et al., 2020). At each stage, studies were evaluated against predefined eligibility criteria. The first stage involved reviewing titles and abstracts, with studies meeting the inclusion criteria proceeding to the second stage for full-text review. Articles with unclear relevance at the first stage were also included for further evaluation at the full-text level to ensure no potentially relevant studies were excluded prematurely. A detailed record of included and excluded articles was maintained at each stage, with reasons for exclusion at the full-text stage documented in an additional file.

To enhance consistency and accuracy, the screening process was conducted independently by two reviewers. A Kappa test was performed to assess inter-rater reliability. A random sample of 100 articles was screened independently by each reviewer, and the results were analyzed using Cohen's Kappa test (Cohen, 1960). Agreement levels were classified as "substantial" (K=0.61–0.80) or "almost perfect" (K=0.81–1.0). Discrepancies were resolved through discussion, ensuring consensus before the full screening process commenced. To maintain objectivity, assessments of publications authored or co-authored by review team members were referred to an independent reviewer.

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Eligibility Criteria

Relevant Types of Intervention: The review focused on studies investigating agrivoltaic systems, defined as interventions combining solar photovoltaic (PV) technology with agricultural practices on the same land to achieve dual land use. Only studies explicitly examining the implementation, design, or adaptation of agrivoltaic systems were included. Articles not directly related to agrivoltaic systems were excluded. Articles with a primary focus on environmental or social benefits without detailed economic analysis and lack primary economic data or do not address economic feasibility are excluded.

Relevant Types of Outcomes: The primary outcome of interest was the economic impact of agrivoltaic systems. Studies were included if they reported on economic outcomes such as cost-effectiveness, return on investment (ROI), income diversification, financial scalability, or contributions to economic resilience. Non-economic outcomes were excluded unless they provided supplemental insights into the financial viability of agrivoltaic systems.

Study Design: The review prioritized primary research articles and excluded opinion pieces, as they lacked primary data. Studies focusing on solar panel development, energy production, or social perception without economic analysis were also excluded. A total of 52 publications met the inclusion criteria and were included in the review.

Study Quality Assessment

A structured quality assessment checklist was applied to ensure the inclusion of high-quality studies. The checklist evaluated eight critical aspects, including study details, participant characteristics, interventions, data collection methods, and findings analysis. Articles were scored based on whether they met the criteria: 2 points for full compliance, 1 point for partial compliance, and 0 points for non-compliance. An aggregated quality score was calculated for each article, providing an overall assessment of its reliability and validity.

Data Coding Strategy

Metadata extraction and coding were performed on all studies passing the inclusion/exclusion criteria at the full-text screening stage. Two reviewers independently conducted the coding, with consistency verified through Kappa test analysis. A random sample of 10 articles was independently coded, and discrepancies were resolved until a substantial agreement (Kappa > 0.61) was reached. If data were insufficient or unclear, authors were contacted for clarification via email. Articles were excluded if authors did not respond or provide the necessary details.

Bibliographic Information
Each article was assigned a unique Study ID for easy reference, and each reviewer had a unique Coder ID to track individual assessments. Citation information was meticulously recorded to ensure accuracy and traceability.

Study Design
The systematic map aimed to comprehensively evaluate the economic implications of agrivoltaic systems. For each article, key details were recorded, including the study objectives, geographic focus, type of agrivoltaic system analyzed, and the economic methods employed. Findings were synthesized to highlight trends, gaps, and insights into the financial feasibility and market potential of agrivoltaic systems. This structured approach ensured transparency, reproducibility, and a comprehensive understanding of the economic dimensions of agrivoltaic systems. The key elements of the systematic map included the following:

- Citation Metrics: Citation counts and average citations per year were analyzed to identify influential studies and trends in agrivoltaic economic research.
- Geographic Distribution: The review identified leading countries contributing to agrivoltaic economic research.
- Economic Performance and Profitability: Financial metrics such as Net Present Value (NPV), Internal Rate of Return (IRR), Levelized Cost of Electricity (LCOE), Payback Period (PBP), and benefit-cost ratios were assessed to evaluate economic performance.
- System Configurations: Economic outcomes for various agrivoltaic configurations, including bifacial, fixed-tilt, elevated, and dynamic systems
- Knowledge Cluster Analysis: Studies were categorized into knowledge clusters focusing on economic viability, crop productivity, and environmental benefits, providing insights into the distribution of research within these areas.

Bibliographic Information
Each article in the review was assigned a unique Study ID, providing a numeric identifier for easy reference. Each reviewer involved in the coding process was assigned a unique Coder ID to track individual assessments. Citation information for each article was recorded to ensure accurate referencing and traceability within the systematic map.

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Study Review and Presentation

The final systematic map included summary figures and tables detailing the study characteristics of all identified evidence. Heat maps were generated to cross-tabulate two key variables, illustrating the volume of evidence (number of studies) within each cell. These heat maps highlighted various combinations of variables, specifically (i) knowledge clusters and (ii) key research focus areas, with knowledge clusters represented as columns and research focuses as rows. This approach effectively identified knowledge gaps—underrepresented subtopics requiring further primary research—and knowledge clusters, which are well-represented subtopics suitable for comprehensive synthesis. The analysis revealed key research focus areas, including standardized economic metrics, long-term financial performance, crop compatibility studies, impacts on soil and water resources, quantification of environmental impact, and adaptation to climate variability. Knowledge clusters encompassed themes such as economic viability, crop productivity, and environmental benefits. Based on these findings, recommendations were provided to guide future research priorities, advancing the field of agrivoltaics.

ANALYSIS AND DISCUSSION

Evolution of Published Studies

The search, as detailed in the methodology section, retrieved a total of 53 publications with an h-index of 18. These publications have accumulated 1,031 citations, resulting in an average citation rate of 19.45 citations per article.

Figure 2 illustrates the trajectory of economic research on agrivoltaic. The publication data on shows a clear upward trend, with low initial output (2 publications each in 2017 and 2020) rising to 7 in 2021, 11 in 2022, and peaking at 17 in 2023. The overall growth reflects increasing interest in the economic feasibility and market potential of agrivoltaic systems. This trend highlights agrivoltaics as an emerging focus in sustainable energy and agricultural economics, with researchers prioritizing its financial viability and dual benefits for energy and agriculture.

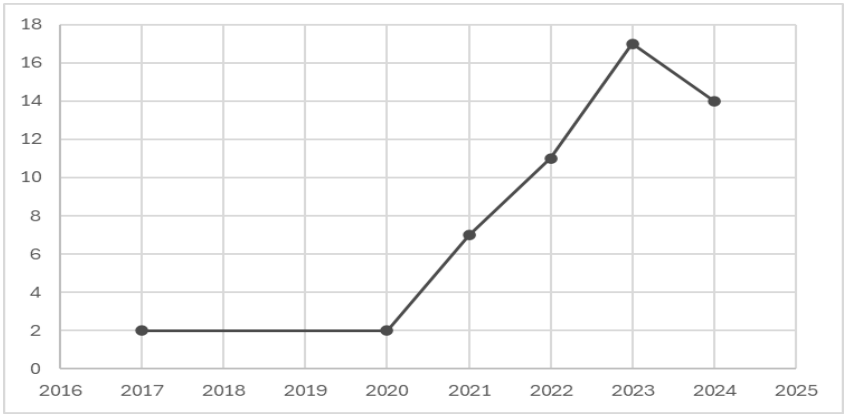


Figure 2: Number of research articles regarding economic research on agrivoltaic

The top five most-cited articles on the economic research of agrivoltaic systems reveal critical insights into the potential of this dual land-use approach. Schindele et al. (2020), (178 citations, 35.6 per year), demonstrate that agrophotovoltaic systems have higher levelized costs of electricity compared to ground-mounted PV systems but can yield favorable economic outcomes for specific crops like potatoes. Agostini et al. (2021) (125 citations, 31.25 per year), highlight Agrovoltaico® systems in Italy, which achieve comparable costs to conventional photovoltaics and provide additional benefits such as improved water efficiency and land-use optimization. Malu et al. (2017) (125 citations, 15.63 per year), show a 15-fold increase in the economic value of grape farms through agrivoltaic implementation, maintaining grape yields while generating significant electricity for rural electrification. Gonocruz et al. (2021) (46 citations, 11.5 per year), find that rice yields can sustain 80% of normal levels under optimal shading conditions, potentially meeting 29% of Japan's electricity demand. Feuerbacher et al. (2021) (35 citations, 8.75 per year), introduce the FEADPLUS framework, emphasizing that profitability is highly dependent on photovoltaic parameters and farm-specific trade-offs, such as shading effects reducing yields by up to 70%.

These studies collectively highlight the significant economic and environmental benefits of agrivoltaic systems, including improved land-use efficiency, enhanced crop protection, and renewable energy generation. However, they also emphasize challenges such as higher costs compared to traditional photovoltaic systems, the necessity of crop-specific suitability assessments, and the need for tailored policy interventions. The findings by Schindele et al. (2020) and Feuerbacher et al. (2021) suggest that profitability is often contingent on specific crop types, with low-value crops like cereals being more suitable for agrivoltaics than high-value crops such as vegetables. Meanwhile, the studies by

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Malu et al. (2017) and Gonocruz et al. (2021) underscore the viability of agrivoltaic systems in addressing energy and food security in land-scarce regions, particularly for staple crops like rice. Agostini et al. (2021), highlight the broader sustainability contributions of agrivoltaic systems, aligning with global climate and energy goals. Nonetheless, further research is needed to refine cost structures, optimize system designs, and evaluate long-term impacts to support broader adoption of this promising technology.

Table 2: Citation metrics of the top 5 most-cited articles in agrivoltaic economic research

Title	Author	Total Citations	Average/ Year
Implementation of agrophotovoltaics: Techno-economic analysis of the price-performance ratio and its policy implications	Schindele et al. (2020)	178	35.60
Innovative agrivoltaic systems to produce sustainable energy: An economic and environmental assessment	Agostini et al. (2021)	125	31.25
Agrivoltaic potential on grape farms in India	Malu et al. (2017)	125	15.63
Analysis of the Rice Yield under an Agrivoltaic System: A Case Study in Japan	Gonocruz et al. (2021	46	11.50
An analytical framework to estimate the economics and adoption potential of dual land-use systems: The case of agrivoltaics	Feuerbacher et al. (2021)	35	8.75

Economic Profitability

Figure 3 categorizes the profitability of agrivoltaic systems (AVS) into four levels: highly profitable, moderately profitable, moderately profitable with support, and not profitable without support. The evidence shows clear regional variations driven by crop type, solar resource availability, technology choice, and policy environments. In Germany, profitability is generally moderate and heavily dependent on subsidies, crop selection, and strong policy support (Trommsdorff et al., 2023; Jürkenbeck and Schulze, 2024). Although AVS can enhance electricity production and offset farm infrastructure costs such as hail nets, high capital expenditure remains a constraint. Studies such as Schindele et al. (2020) and Feuerbacher et al. (2022) show that profitability varies widely across crops, with high-value crops like strawberries benefiting more from shading than cereals such as winter wheat. Additional work by Feuerbacher et al. (2021) and Sponagel et al. (2023) indicates that potatoes can generate economic gains under AVS, although converting more than 10 percent of arable land may slightly reduce agricultural gross margins. Overall, AVS viability in Germany relies on economies of scale and targeted policy tools, including feed-in tariffs that compensate for yield reductions and higher structural costs.

By contrast, India demonstrates consistently strong economic potential, with most systems classified as highly or moderately profitable. Favourable climatic conditions, low Levelized Cost of Energy (0.039 USD/kWh), and payback periods ranging from 6 to 9.5 years contribute to this performance (Anusuya et al., 2024). Innovative models such as blockchain-enabled grapevoltaic farms generate significant revenues for both farmers and system operators (Kumar and Chopra, 2023). Studies by Giri et al. (2023) highlight high Land Equivalent Ratios (LER) of up to 1.73 and benefit-cost ratios of 1.71, particularly under the KUSUM programme. Poonia et al. (2022) further show that strategic crop selection and full-density PV designs can deliver strong internal rates of return. The findings align with earlier results by Malu et al. (2017), which emphasize the importance of tailored feed-in tariffs and crop-specific planning to achieve highly profitable outcomes.

Other countries also show promising economic potential. In Vietnam, AVS installed on rice farms can generate profits up to 115 times higher than traditional rice cultivation (Ahmed et al., 2022). Pakistan demonstrates strong feasibility for crops such as potatoes and wheat, supported by favourable feed-in tariffs and policies that offset installation costs, enabling high productivity and increased rural income (Alam et al., 2023).

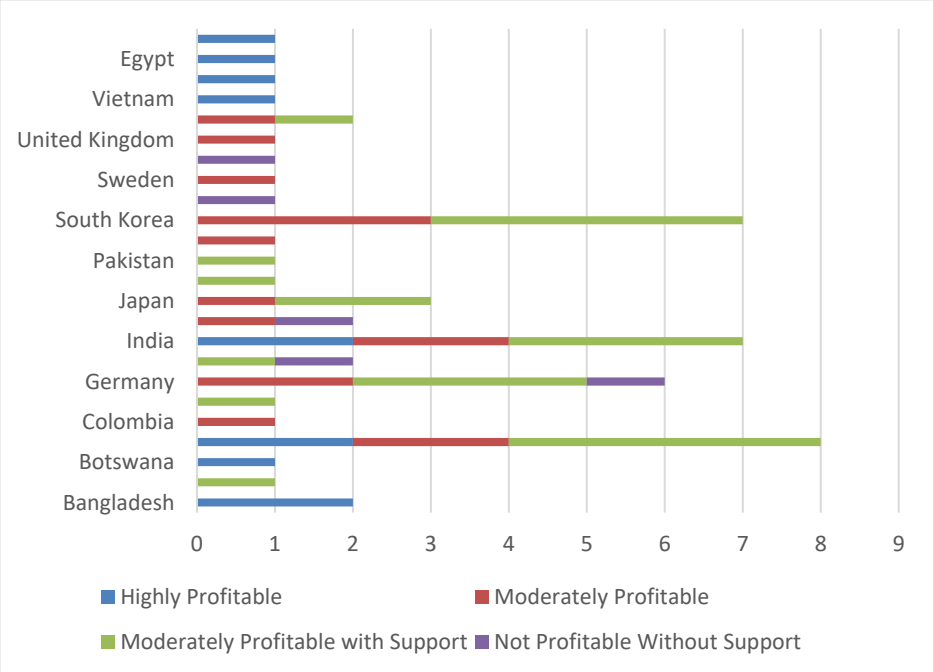


Figure 3: Profitability assessment of agrivoltaic systems across various countries

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Figure 4 illustrates the profitability assessment of various agrivoltaic system configurations, categorized into five types: bifacial systems, dynamic and tracking systems, elevated systems, fixed-tilt systems, and portable and modular systems. The results are presented across four profitability categories: highly profitable, moderately profitable, moderately profitable with support, and not profitable.

The literature identifies Fixed-Tilt Systems as a highly profitable agrivoltaic configuration. These systems optimize dual land use by balancing solar energy production and crop yields through effective shading and spacing management. Their simple design minimizes maintenance costs, enhancing economic viability. Moreda et al. (2021) and Gonocruz et al. (2021) demonstrated that Fixed-Tilt Systems sustain agricultural productivity while achieving high net present values. In contrast, Chalgynbayeva et al. (2022), Ji et al. (2024), and Xue (2017) reported that Vertical or Overhead-Tilt configurations exhibit limited profitability without substantial financial or policy support. While these configurations offer advantages such as increased land-use flexibility and enhanced energy output in specific conditions, their higher installation costs and operational complexity often undermine their economic feasibility.

Bifacial Systems display balanced profitability across diverse environmental and economic conditions. Ahmed et al. (2022) and Hwang and Lee (2024), found that bifacial systems enhance energy generation by 20–35% through dual-side sunlight capture, improving land-use efficiency and lowering the levelized cost of energy. Chae et al. (2022) and Kim et al. (2023), report successful application in rice and broccoli cultivation, maintaining over 80% of conventional rice yields under 32% shading while optimizing energy production. Anusuya et al. (2024) highlight that the payback period for bifacial systems can exceed seven years, though this is significantly reduced under favorable financial mechanisms, such as subsidies or feed-in tariffs. Hwang and Lee (2024) emphasize that profitability improves in regions with high solar irradiance or strong policy incentives.

Portable and Modular Systems are the least represented among agrivoltaic configurations, with most installations classified as "moderately profitable" or "not profitable." Giri and Mohanty (2022) note that these systems offer flexibility and adaptability to diverse settings, making them suitable for small-scale or experimental applications. However, Zhang et al. (2023) and Giri and Mohanty (2022) highlight scalability challenges due to higher per-unit costs and logistical complexities. For example, a 0.675 kWp portable system was reported to have a payback period of 9.49 years, making it less competitive than larger, fixed systems.

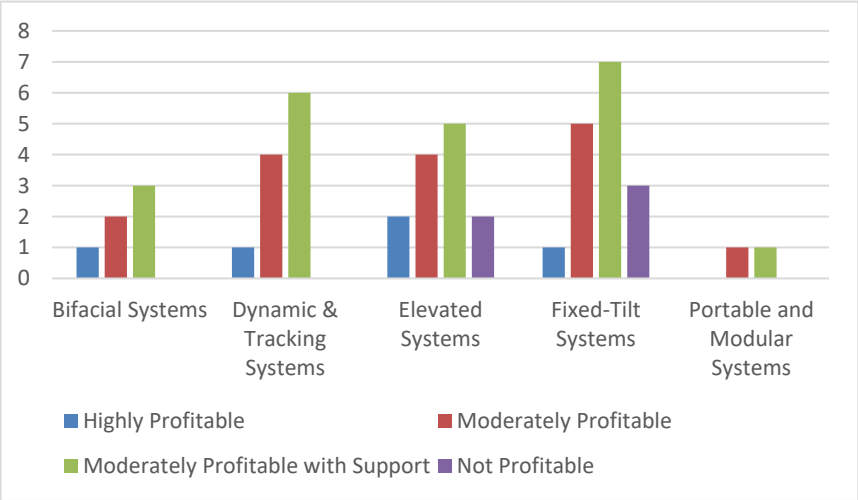


Figure 4: Profitability assessment of various agrivoltaic system configurations

The heatmap visualizes research distribution across three primary knowledge clusters: Economic Viability, Crop Productivity, and Environmental Benefits, with respective coverage of 92%, 79%, and 54%. Economic Viability is the most extensively explored, focusing on Standardized Economic Metrics and Long-Term Financial Performance, while Crop Compatibility Studies remain unaddressed in this cluster.

Under Economic Viability, researchers emphasize financial feasibility and sustainability. Cuppari et al. (2021) and Chalgynbayeva et al. (2022), used metrics such as cost-benefit ratios and revenue volatility to assess agrivoltaic systems. Feuerbacher et al. (2022) highlighted the importance of economies of scale, Campana et al. (2024) reported a 30-fold profitability increase in northern climates, and Willockx et al. (2023) demonstrated stable revenue generation through advanced system designs.

For Crop Productivity, the primary focus is on Crop Compatibility Studies, exploring how different crops adapt within agrivoltaic systems. Gonocruz et al. (2021) showed that shading levels of 27–39% maintained 80% of rice yields, meeting Japanese agricultural standards. Zheng et al. (2021) introduced the Even-lighting Agrivoltaic System (EAS), achieving a Land Equivalent Ratio (LER) of 1.64 and improving lettuce quality by increasing soluble sugars by 72%. Willockx et al. (2023) found that dynamic trackers outperformed fixed bifacial systems in sugar beet cultivation without affecting yields. Zhang et al. (2023) proposed spectral-splitting agrivoltaics, selectively transmitting light for crop growth and increasing biomass by 13%. However, limited research addresses Adaptation to Climate Variability within this cluster.

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In Environmental Benefits, key themes include Quantifying Environmental Impact and Adaptation to Climate Variability, emphasizing agrivoltaics' potential in mitigating climate change and enhancing ecosystem resilience. Sponagel et al. (2024) estimated that adopting agrivoltaic systems on 1–5% of arable land in Baden-Württemberg could reduce greenhouse gas emissions by up to 5.9 million metric tons of CO2 equivalent. Mo et al. (2023) showed that agrivoltaics optimized energy efficiency and supported climate-smart agriculture by reallocating sunlight to energy production while maintaining crop yields. Al-Amin et al. (2024) reported that agrivoltaics in Bangladesh reduced renewable energy payback periods and improved land-use efficiency.

CONCLUSION

In conclusion, while agrivoltaic systems demonstrate significant potential for economic and environmental benefits, their scalability and sustained financial viability require further exploration. By addressing the identified gaps and leveraging robust policy frameworks, AVS can contribute to a more sustainable and resilient energy-agriculture nexus.

The findings are directly relevant to Malaysia’s planning agenda, particularly the National Energy Transition Roadmap and Twelfth Malaysia Plan. Aligning agrivoltaics with existing solar schemes, land-use zoning, and rural electrification strategies can support balanced development and strengthen national food–energy security.”

This review is limited to peer reviewed English language publications, excluding grey literature and non-English sources. As systematic mapping emphasises breadth over depth, the review identifies patterns rather than performing meta-analytic comparisons. This review provides a foundation for future research, policy development, and investment strategies aimed at advancing the adoption and economic optimization of agrivoltaic systems.

ETHICAL CONSIDERATIONS

This study is based solely on published literature; no human subjects or primary data were involved. Ethical approval was not required

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ACKNOWLEDGEMENT

This study received funding from the FRGS-EC Grant with code project KPT: FRGS-EC/1/2024/SS06/UITM/02/13. This manuscript reflects only the authors' views and opinions and can be considered responsible for them.

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Received: 28th June 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 205 – 224

THE EFFECT OF DESTINATION QUALITY ON TOURIST SATISFACTION: A CASE OF CHINESE TOURISTS IN SABAH, MALAYSIA

Qi Qi[1], Rosazman Hussin[2], Md Sayed Uddin[3]

[1, 3] *Faculty of Social Sciences and Humanities,*
UNIVERSITI MALAYSIA SABAH
[2] *Borneo Institute for Indigenous Studies,*
UNIVERSITI MALAYSIA SABAH

Abstract

This study aims to find out what constitutes the quality of Sabah as a tourist destination and how destination quality affects the satisfaction of Chinese tourists. Influenced by COVID-19, an online self-administered questionnaire was used, and the questionnaire was distributed via prominent Chinese social media software (Douyin, Little Red Book, Weibo, WeChat, QQ, etc.). There were 374 valid questionnaires. Using IBM SPSS 26.0, an exploratory factor analysis (EFA) was conducted to determine the components of perceived destination quality. Additionally, the proposed hypotheses were tested. The results confirmed that destination quality comprises core tourism experience, accommodation and food, accessibility, amenities, information, and destination image. Meanwhile, Chinese tourists' satisfaction was influenced by core tourism experience, accommodation and food, information, and destination image. This suggests that there is no positive effect of accessibility and amenities on satisfaction for Chinese tourists in Sabah. The results of the study provide valuable suggestions for managers and related stakeholders of tourist destinations with marine resources to improve the level of service and increase tourist satisfaction.

Keywords: Destination Quality, Tourists' Satisfaction, Chinese Tourists

[2] Corresponding author. Email: azzs@ums.edu.my

INTRODUCTION

Research on tourist satisfaction is crucial to the development of tourism destinations and marketing strategies planning (Eusébio & Vieira, 2013). It has been proved that in the tourism industry, satisfied customers will lead to positive Word-of-mouth, recommend others, and repeat visits, which will increase the economic income of all sectors of the tourism industry (Žabkar, Brenčič & Dmitrović, 2010; Oviedo, Vega, Castellanos & Orgaz, 2019).

Tourists from different cultural backgrounds differ in the evaluation of service quality. Therefore, the cross-cultural perspective is also a hot spot of research (Bowen & Clarke, 2002; Crotts & Erdmann, 2000; Turner, Reisinger & McQuilken, 2001). Tourists from different countries emphasize all aspects of travel services. They may have different perceptions of the same service. Therefore, understanding the different cultural backgrounds of tourists will help managers and operators formulate more targeted marketing strategies.

According to the 2019 report of the China Tourism Association (2019), China's outbound tourism showed a continuous growth trend in 2018. Compared with the number of Chinese outbound tourists in 2017, there was a 14.7 percent increase. As of 2018 statistics, China has been the world's number one source country for outbound tourism for many consecutive years. The number of outbound Chinese tourists reached 150 million. Chinese tourist tends to choose Malaysia, Thailand, and other countries that have abundant marine resources and suitable travel prices (Jiang, 2017). With a growing number of Chinese outbound tourists and the considerable benefits brought by them, some researchers have begun to pay attention to the outbound travel of Chinese tourists. Chiu, Zeng and Cheng (2016) recommended that destination managers should have a better understanding of Chinese tourists' choice of destinations and their loyalty.

Sabah has a natural advantage in developing tourism. Due to the geographical advantage of having three seas facing the Sabah coastline, marine resources are abundant in Sabah. As a result, the west coast region of Sabah is home to many large freshwater wetlands. Among them, the Kota Kinabalu Wetland Centre is designated as a Ramsar Wetland. The Klias Peninsula in Sabah has large tracts of tidal wetlands. Moreover, Sabah's biodiversity provides the necessary conditions for Malaysia to be one of the world's 12 biodiversity centers (Sabah State Government, 2020). Sabah with its myriad of ethnic cultures offers diverse experiences for the culture-seeking traveller. Sabah is in the northeast corner of Borneo, with a strategic location. It is well-connected by air to major cities in the Asia-Pacific region. This determines that it is easy for tourists from numerous Asia-Pacific cities can visit Sabah (Corridor, S.D., 2009). Sabah’s tourism industry plays a vital role in Sabah’s economy. In 2018, a total of 3.9 million tourists arrived in Sabah, creating a gross domestic product (GDP) of 8.3

billion ringgit and the number of Chinese tourists is close to half of the total number of inbound tourists (Sabah Tourism Board, 2019).

Table 1: Sabah Tourist Arrival by Nationality 2017 and 2018

Nationality	**2017**	**2018**
China	431,026	593,623
South Korea	310,802	337,100
Indonesia	115,105	109,771
Brunei	94,797	56,259
Taiwan, China	62,121	49,771
Philippines	32,159	33,245
UK & Ireland	31,793	28,611
Singapore	23,016	25,102
Australia	24,010	21,482
Japan	22,079	19,357

Source : Sabah Tourism Board, 2019

LITERATURE REVIEW

In tourism research, quality is usually defined as the gap between tourists' expectations and their perception of actual performance. This is because definitions of quality are mainly based on service marketing theory. Using the gap between expected and actual performance to evaluate quality in tourism research can be problematic. As compared to frequently purchased services, tourism services may not be produced as frequently. Therefore, it seems doubtful that tourists will develop precise evaluation criteria for tourism services or destinations. It may also be difficult for tourists to distinguish between expected and actual performance during or after a vacation, possibly because tourists take longer vacations (Kozak, 2000; Meyer & Westerbarkey, 1996). Additionally, there is controversy over the use of the SERVQUAL model. The SERVQUAL model may not be universally applicable. It has been criticized for being too general and only partially applicable to some industries (Boulding, Kalra, Staelin, & Zeithaml, 1993; Bhat, 2012; Park, Yi, & Lee, 2021; Baharum, Haron, Ishak, & Mansor, 2019).

Destination Quality

Seakhoa, Augustyn and Mason (2020) attempted to define destination quality from a holistic analytical perspective. In their viewpoint, tourism destinations should be evaluated as a whole unit, and that destination quality is determined by the sum of the individual components and the degree to which each component

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contributes to the whole. However, the empirical evidence currently supporting this view is extremely limited. Le (2016) defines perceived destination quality as the experience, feelings, and overall evaluation of the destination by tourists. From a holistic perspective, Tosun, Dedeoğlu and Fyall (2015) suggest destination quality includes not only physical products but also services, and it can sub-divide further into destination service quality and destination natural quality.

Narayan, Rajendran, Sai and Gopalan (2009) identify dimensions of service quality (SQ) and their corresponding measurement variables in the tourism industry by focusing on India. They proposed service quality in tourism comprises 10 dimensions, namely core-tourism experience, information, hospitality, fairness of price, hygiene, amenities, value for money, logistics, food, and security. Tosun et al. (2015) proposed a two-dimensional destination quality. In other words, destination quality is composed of destination service quality and destination natural quality. Similarly, Dedeoğlu (2019) in his study subdivided destination quality into destination service quality and destination natural quality. The findings of Mukherjee, Adhikari and Datta (2018) confirmed that destination quality is composed of three sub-dimensions, namely quality of service (QSR), quality of destination feature (QDF) and quality of experience (QEX). Rajaratnam, Munikrishnan, Sharif and Nair (2014) proposal eight dimensions (Amenities, Accessibility and Logistics, Core Tourism Experience, Hygiene, Information, Security, Value for Money, and Hospitality) of service quality. Le (2016) conceptualizes destination quality as a formative construct consisting of five dimensions (transport, destination brand, attractions, hospitality, and entertainment). Seakhoa et al. (2020) reveal tourist destination quality should be authentic, safe, affordable, well-preserved, informative, relaxing, uncrowded, diverse, hospitable, all-weather, novel, and suitable for children.

Recent research, especially following 2020, has focused on both the changing nature of destination image and tourist expectations. Wang and Karl (2021), pointed to increasing concern about perceptions of safety and hygiene at destinations due to international health crises. Also, Albayrak et al. (2021) examined how a reduced density of tourism has meant 'quality of experience' is defined by how immersive and less crowded the experience is. All of this demonstrates that the need for destination-specific and updated models of satisfaction will continue, such as the one proposed for the case of Sabah.

Tourist Satisfaction

Tourist satisfaction can be defined as the cognitive-affective state resulting from a tourist's experience at a destination (San, Herrero & García, 2019). A growing number of studies have rejected the cognitive perspective and argued that customers' emotional states can represent tourist satisfaction (Brunner, Peters &

Strobl, 2012). That is, satisfaction can refer to a psychological outcome of a tourist's experience at a destination (Lee, Lee, & Park, 2014; Oviedo et al., 2019). Satisfaction is considered in some studies as a customer response to product or service satisfaction, emphasizing customer emotions and is a psychological concept (Chi & Qu, 2008). According to Phillips, Wolfe, Hodur and Leistritz, (2013, p. 95) tourist satisfaction is defined as "the overall contented feeling that a tourist felt from visiting a destination, which fulfilled his travel expectations and needs". Chiu et al. (2016) proposed that tourist satisfaction is the result of comparing tourists' expectations of a destination with their actual experience. Nam, Ekinci and Whyatt (2011) mentioned that there are two common expressions of satisfaction, the former is transient (transaction-specific) satisfaction, which refers to the evaluation of an activity or behaviour when a single service transaction occurs, and the satisfaction at this moment should be investigated immediately after each transaction activity occurs. Another term for overall satisfaction or what can be called cumulative satisfaction refers to the assessment of service encounters after all purchase behaviours have been completed.

Hypotheses

Narayan et al. (2009) defines core tourism experience (CTE) as the common benefits that most tourists may need to enjoy. Tourists can authentically experience the natural environment, life, culture and atmosphere of the destination, or visitors can explore nature in exciting ways, such as hiking, visiting waterfalls or forests, some visitors may have a keen interest in various landmarks, etc. Rajaratnam et al. (2015) confirmed that core tourism experience is an important factor influencing tourist satisfaction. Therefore, this study proposes:

H1. There is a positive impact of core tourism experience (CTE) on tourist satisfaction.

Accommodation services are one of the basic tourism activities. It is essential for a quality destination to be able to provide standard accommodation, particularly for out-of-country tourists. In study on tourism in Malaysia, Abdullah and Lui (2016) noted that the quality of accommodations is an important factor in determining the satisfaction of tourists. Tosun et al. (2015) argued that the quality of accommodation in a destination should be measured in terms of indicators such as cleanliness, safety situation, service level, staff service attitude, and speed of check-in and check-out. In perceived destination quality, accommodation is considered as one of the measurements. Accommodation is an important determinant of tourist satisfaction, and it has been tested in several

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studies (Tosun et al., 2015; Le & Dong, 2017; Chin et al., 2018). Cuisine enables tourists to experience the food culture of a destination and engage in pleasurable sensory experiences, all of which can contribute to the formation of unforgettable memories. As an essential aspect of attracting tourists to a destination, cuisine not only affects tourist satisfaction but is also a key factor in a destination's success (Babolian, 2016). Biswas, Deb, Hasan and Khandakar (2021) suggest that destination managers should pay attention to accommodation and food in the destination. Previous studies have confirmed that accommodation and food (AAF) services have a significant impact on satisfaction (Hui et la., 2007; Le & Dong, 2017; Biswas et al., 2021). Hence, this study proposes:

H2. There is a positive impact of accommodation and food (AAF) on tourist satisfaction.

Accessibility at the destination is important to tourists (Zabkar et al., 2010). Tourists are concerned about the transportation and logistics of their destinations (Kozak, 2001). Some researchers have used "transportation" instead of "accessibility" in measuring destination quality (Le & Dong, 2017; Tosun et al., 2015; Le, 2015), but in essence, both are measures of the accessibility of a destination. The accessibility of transportation, for example, the frequency of local transportation services, is also represented by assessing the accessibility of local transportation. Previous studies also highlight the important role of transport safety in their assessment (Le, 2015; Le & Dong, 2017). Hence, this study proposes:

H3. There is a positive effect of accessibility (ACC) on tourist satisfaction.

Amenities, used by some researchers as one of the measures of tourists' perceptions of the quality of the destination. In addition to food, accommodation, and transportation, there are some needs that are inevitable for tourists, especially for international tourists, such as telecommunications and Internet services, currency exchange in major locations, and some banking services, and tourists may also need to buy some medicines or daily necessities (Narayan et al., 2009). In addition, some essential public facilities, such as toilets, are also indispensable for travellers. Amenities or facilities are one of the elements of a tourist destination that can satisfy the temporary needs of tourists in the destination (Hermawan, Wijayanti & Nugroho 2019). Therefore, this study proposes:

H4. There is a positive effect of amenities (AME) on tourist satisfaction.

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Information on how to get to the destination, where to eat, and where to stay all has an impact on the visitor's experience. Seakhoa et al. (2020) identified information to mean that a quality tourism destination is a place that has tourist-friendly information and communication. In previous studies, it was found that a portion of the studies used information as a dimension of perceived quality (Narayan et al., 2009; Rajaratnam et al., 2014; 2015; Seakhoa et al., 2020; Mukherjee et al., 2018). Narayan et al. (2009) mentioned airports, places to stay, and attractions, which are relatively more important for tourists to get information. Also, most of the tourists expect the services of a guide to explain the landmarks and buildings. Seakhoa et al. (2020) mentioned that the signage of tourist attractions should be clear. Besides, language is the most direct and important way to get information. Narayan et al. (2009) and Seakhoa et al. (2020) both emphasize the importance of language when assessing the dimension of information. Tosun et al., (2015) used language as one of the dimensions of perceived service quality. Therefore, this study proposes:

H5. There is a positive effect of information (INF) on tourist satisfaction.

The destination image dimension represents the overall impression of a destination (cleanliness and safety) and the evaluation of the hospitality of the people at the destination. Hui, Wan, and Ho (2007) and Ragavan, Subramonian, and Sharif (2014) use image and local people as dimensions to measure perceived destination quality. Le (2015) assessed destination brand by detecting the hospitality, elegance, and friendliness of local people when measuring destination quality. Le and Dong (2017) found that at the destination level, the friendliness and hospitality of locals had the greatest impact on European tourists' satisfaction. Hui et al. (2007) also confirmed that cleanliness and safety of a destination have a positive impact on tourist satisfaction. Therefore, this study proposes:

H6. There is a positive effect of destination image (DIM) on tourist satisfaction.

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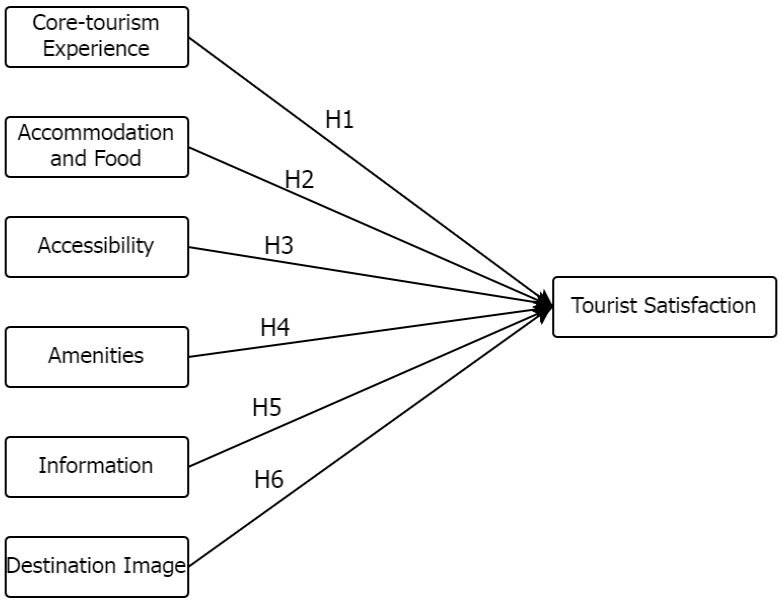


Figure 1: Conceptual Framework

RESEARCH METHODOLOGY

Sampling Procedure

This study focuses on Chinese tourists. Before COVID-19, the proportion of Chinese tourists was close to half of the total tourist arrivals in 2017 and 2018. This indicates that the Chinese market is an important submarket for the tourism industry in Sabah. Therefore, it is necessary to comprehend Chinese tourists' perceptions of tourism in Sabah and to assess the factors influencing the satisfaction of Chinese tourists. To test the proposed hypothesis, a sample of Chinese tourists who are over 18 years old and have visited Sabah at least once was surveyed. Due to the impact of COVID-19, we chose to distribute the questionnaire online, and the distribution period was from October 2022 to February 2023. Respondents of this study consisted of mainland Chinese tourists who visited Sabah in 2017 and were included in the study. A convenient sampling method was used, and the questionnaires were distributed on Chinese social media (Douyin, Little Red Book, Weibo, WeChat, QQ, etc.). Data were collected using a self-administered questionnaire to collect data. This study utilized a convenience sampling method to distribute a self-administered online questionnaire via major Chinese social media platforms. While this approach was pragmatic given the constraints of the COVID-19 pandemic, it presents certain

limitations. First, convenience sampling has implications for sample representativenes, which has implications for the generalization of the research findings exclusively to the overall target population of Chinese tourists who had visited Sabah. Secondly, the participants were mainland Chinese tourists who visited Sabah prior to the period of data collection of between October 2022 through to February 2023 (with some respondents, visiting as early as 2017). Accordingly, the answers can reflect the retrospective recall bias associated with the tourist's prior experience. The tourist's memory of their experience may have diminished or have subsequently been affected which would have an influence on their judgment of their perceived destination quality, and, satisfaction rationale.

In the present investigation, 450 questionnaires were distributed and 392 were returned, giving an 87.11% response rate. There were 374 valid questionnaires returned, with an effective return rate of 83.11%. All ethical standards related to academic research were strictly adhered to in this study. Informed consent was obtained from all participants before they completed the online self-administered questionnaire. Participants were assured that their participation was voluntary, and all data were anonymous, with confidentiality preserved. As the data collection was anonymous and online, institutional ethical clearance was not formally sought, as the data collected were non-sensitive and anonymous, compliant with norms for research of this nature.

Measure of the Constructs

Destination Quality

The present study proposes six dimensions of perceived destination quality adapted from previous studies (Zain, Zahari, Hanafiah & Zulkifly, 2016; Narayan et al., 2009; Le & Dong, 2017; Tosun et al., 2015; Seakhoa et al., 2020), namely core destination experience, food and accommodation, accessibility, amenities, information, and destination image. CTE is measured by eight items; AAF is measured by seven items; ACC is measured by four items; AME is measured by five items; INF is measured by five items; DIM is measured by four items. The study adopted a 5-point Likert scale (from completely disagree to agree) to measure perceived destination quality.

Tourist Satisfaction

In this study, satisfaction was measured using five question items mainly based on the understanding of satisfaction by Zabkar et al. (2010), Le (2016), and Eid (2015). These items are marked on how much the tourists agree with the following question items: “I feel delighted about this destination”, “I am satisfied with my decision to visit Sabah”, “Compared to my expectations, I was satisfied

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with my trip to Sabah", "This experience is exactly what I needed", "This was a pleasant visit".

Data Analysis

This study used descriptive statistics (both frequency and distribution) to present the demographic characteristics of the respondents. This study used exploratory factor analysis (EFA) to detect dimensional components of destination quality. Regression analysis used IBM SPSS 26.0 was conducted to test the research model and the hypotheses proposed.

RESULTS AND DISCUSSION

Descriptive Statistics

The results (Table 2) indicate that 154 males and 220 females were interviewed, accounting for 42.1% and 58.8% of the total number of interviewees, respectively. In terms of age, the number of Chinese tourists between 18 to 28 years old was the highest, totaling 193 and accounting for 51.6% of the total population; the number of Chinese tourists between 29 to 39 years old accounted for 40.1% of the total population; and the population over 40 years old accounted for the smallest proportion, 8.3%, of the total population. In terms of marital status, the number of unmarried individuals is considerable, constituting 64.4% of the population. In terms of education, the number of Chinese tourists with undergraduate and graduate degrees is higher, accounting for 44.1% and 43% respectively; the number of Junior College graduates accounts for 9.1%, and those with less than a high school diploma account for 3.5%.

Table 2: Demographic Information (n=374)

	Frequency	**Percentage (%)**
Gender		
Male	154	41.2
Female	220	58.8
Age		
18 to 28 years	193	51.6
29 to 39 years	150	40.1
40 to 50 years	31	8.3
Marital Status		
Unmarried	241	64.4
Married	133	35.6

	Frequency	Percentage (%)
Academic Qualifications		
Below high school	4	1.1
High school and Technical Secondary School	10	2.7
Junior College	34	9.1
Bachelor's Degree	165	44.1
Postgraduate and above	161	43

Source: Author's calculation

Factor Analysis and Validity and Reliability of Destination Quality

Before testing the relationship between perceived destination quality and tourist satisfaction, the dimensions of perceived destination quality need to be tested, Exploratory factor analysis was employed in this study. According to Kaiser (1974), KMO values less than 0.5 indicate unsuitable data for exploratory factor analysis. The KMO value of destination quality is 0.934, which indicates that the data are appropriate for exploratory factor analysis. The total variance explanation indicates that there are six characteristic roots extracted greater than 1; the cumulative variance explanation is 75.379, which is greater than 50%. The factor loading value of INF1 (Availability of tourist information center at place of stay) was less than 0.5. Other than that, all the question items were loaded on the proposed dimensions. The results of the exploratory factor analysis indicate good validity of the scale for measuring perceived destination quality.

The most prevalent method for measuring reliability is the Cronbach's reliability coefficient method. Cronbach's coefficient of reliability must be between 0 and 1, and a larger coefficient indicates greater reliability. In this study, the reliability of each variable of the formal research was examined using SPSS 26.0. The Cronbach's alpha coefficients for all six dimensions of destination quality are greater than 0.8, as shown in Table 3.

Table 3: Factor Analysis and Reliability Analysis for Destination Quality

Factors	Factor loading	Eigen value	cumulative explained variance	Cronbach (α) value
Factor 1: Core-tourism Experience		14.944	45.286	0.941
(CTE1) Natural and unique marine resources	0.897			
(CTE2) Comfortable weather and climate	0.747			
(CTE3) Marine activities	0.881			
(CTE4) Enjoy the marine activities	0.855			

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Factors	**Factor loading**	**Eigen value**	**cumulative explained variance**	**Cronbach (α) value**
(CTE5) Various landmarks	0.732			
(CTE6) Cultural heritage	0.689			
(CTE7) Get close to nature	0.871			
(CTE8) Opportunities for adventure activities	0.804			
Factor 2: Accommodation and Food		4.079	57.648	0.95
(AAF1) Accommodation is comfortable	0.797			
(AAF2) Accommodation is clean	0.767			
(AAF3) Attitude of the service staff	0.789			
(AAF4) Room safety	0.757			
(AAF5) Reasonable accommodation prices	0.733			
(AAF6) Food variety	0.718			
(AAF7) Reasonable food price	0.665			
Factor 3: Accessibility		2.002	63.715	0.928
(ACC1) Local transportation accessibility	0.826			
(ACC2) service attitude of drivers	0.809			
(ACC3) Transport safety	0.826			
(ACC4) Price worthiness of transport	0.736			
Factor 4: Amenities		1.504	68.383	0.888
(AME1) Internet connection is smooth	0.572			
(AME2) Bank facilities are easy to find	0.558			
(AME3) Toilet facilities are adequate	0.809			
(AME4) Cleanliness of toilets	0.731			
(AME5) Mobile payment	0.768			
Factor 5: Information		1.367	72.525	0.902
(INF1) Tourist information centre				
(INF2) Clear signs at attractions	0.706			
(INF3) Communicate in a common language (e.g. English)	0.742			

Factors	**Factor loading**	**Eigen value**	**cumulative explained variance**	**Cronbach (α) value**
(INF4) Service staff can speak Chinese	0.776			
(INF5) Tourist information can understand	0.799			
Factor 6: Destination Image		1.061	75.739	0.912
(DIM1) Safe place	0.651			
(DIM2) Clean place	0.65			
(DIM3) Friendly	0.809			
(DIM4) Hospitable	0.783			
Factor 4: Amenities		1.504	68.383	0.888
(AME1) Internet connection is smooth	0.572			
(AME2) Bank facilities are easy to find	0.558			
(AME3) Toilet facilities are adequate	0.809			
(AME4) Cleanliness of toilets	0.731			
(AME5) Mobile payment	0.768			
Factor 5: Information		1.367	72.525	0.902
(INF1) Tourist information centre				
(INF2) Clear signs at attractions	0.706			
(INF3) Communicate in a common language (e.g. English)	0.742			
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(INF5) Tourist information can understand	0.799			
Factor 6: Destination Image		1.061	75.739	0.912
(DIM1) Safe place	0.651			
(DIM2) Clean place	0.65			
(DIM3) Friendly	0.809			
(DIM4) Hospitable	0.783			

Note: KMO Measure of Sampling Adequacy .934.

Bartlett's test of sphericity (p<.001)

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Hypotheses Testing

Tables 4 and 5 demonstrate the results of the hypotheses of perceived destination quality on tourist satisfaction. The R^2 value of 0.535 in Table 4 indicates that the dimension of perceived destination quality explains 53.5% of tourist satisfaction, while the R^2 value after adjustment is 0.527. The model is significant ($p<0.001$), indicating that at least one of the six dimensions of perceived destination quality affects tourism satisfaction. The Durbin-Watson value of 1.628 is close to 2, indicating that the samples are independent. According to Lewis-Beck and Lewis-Beck (2015), a VIF less than three indicates the absence of multicollinearity. Table 5 reveals that all VIF values are less than three, indicating that there is no multicollinearity issue.

Table 4: Parametric Test

R	R^2	Adjusted R^2	Std. Error of the Estimate	DW	F	Sig.
0.731	0.535	0.527	0.56	1.628	70.306	0

Source: Author's calculation

Table 5 shows the results of the hypothesis. The dimensions of perceived destination quality, namely core tourism experience (CTE), accommodation and food (AF), information (INF), and image (IM), all passed the significance test at a significance level of 0.5, indicating that these dimensions have a significant influence on tourist satisfaction.

H1 of this study proposed that there is a positive influence of core tourism experience on tourist satisfaction. The results supported H1 ($\beta=0.149$, $p<0.05$), that is, the core tourism experience was confirmed to have a significant positive impact on tourist satisfaction (Rajaratnam et al., 2015). Accommodation and food have been shown to have a significant positive impact on tourist satisfaction (Hui et al., 2007; Le & Dong, 2017). The results support the H2 that there is a significant positive effect of accommodation and food on tourist satisfaction ($\beta=0.298$, $p<0.05$). In contrast to previous findings (Ozturk & Gogtas, 2016; Vareiro, Ribeiro, & Remoaldo, 2017; Biswas & Rashid, 2020), the result rejected H3. The result showed that there is no effect of accessibility on tourist satisfaction ($\beta=-0.04$, $p>0.05$). Hermawan et al. (2019) confirmed that there is a significant positive effect of amenities on tourist satisfaction. However, H4 was rejected. Thus, it was concluded that there is no positive effect of amenities on tourist satisfaction ($\beta=0.038$, $p>0.05$). The information dimension was confirmed to have a positive effect on tourist satisfaction ($\beta=0.179$, $p<0.05$) and therefore H5 was supported. H6 proposed that there is a positive effect of destination image on tourist satisfaction. The results support H6 ($\beta=0.264$, $p<0.05$), which suggests that there is a positive effect of destination image on tourist satisfaction (Hui et al., 2007; Chi & Qu, 2008; Le & Dong, 2017).

The rejection of H3 (Accessibility) and H4 (Amenities) provides important information regarding the planning of Sabah as a destination. There is no positive effect of these two factors on the satisfaction of Chinese tourists. This is the opposite of several past studies. It indicates that, for this market segment, these two factors are regarded as basic 'hygiene factors', or basic necessities and not satisfies. In other words, very poor accessibility or amenities would cause dissatisfaction, but simply meeting a minimum standard would provide no added value to overall satisfaction level. This conclusion leads to a few potential underlying explanations such as: (a) Considering that tourists travel to Sabah, a place known for one of its core tourism assets, i.e., natural marine environment resources, any assessments of accessibility and general public facility should have been muted as expectations towards local and public transport accessibility to core tourism experiences compared to developed urban tourist cities; (b) The travel experience for most Chinese tourists to destinations is organized group travel, with travel logistics (accessibility) and core destination facility augmentation (amenities) primarily organized in advance without being individually assessed. Thus, accessibility and amenities would be regarded as minimum tourist satisfaction variables. Tourists prioritize the Core Tourism Experience and Destination Image (DIM) of Sabah. If so, then destination managers should inform resource investment decisions to prioritize core uniqueness on enhancement of marine activities and friendliness image 18 of safety, rather than sinking excessive resources.

Table 5: Regression Model

	Unstandardized Coefficients		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity statistics**	
	B	**Std.Error**	**β**			**Tolerance**	**VIF**
(Constant)	0.543	0.199		2.726	0.007		
CTE	0.157	0.044	0.149	3.594	0.000	0.737	1.356
AAF	0.289	0.056	0.298	5.171	0.000	0.381	2.626
ACC	-0.035	0.043	-0.04	-0.812	0.417	0.517	1.936
AME	0.039	0.055	0.038	0.71	0.478	0.439	2.28
INF	0.194	0.057	0.179	3.407	0.001	0.459	2.178
DIM	0.288	0.059	0.264	4.911	0.000	0.438	2.283

Notes: CTE: Core Tourism Experience; AAF: Accommodation and Food; ACC: Accessibility; AME: Amenities; INF: Information; DIM: Destination Image
Source: Author's calculation

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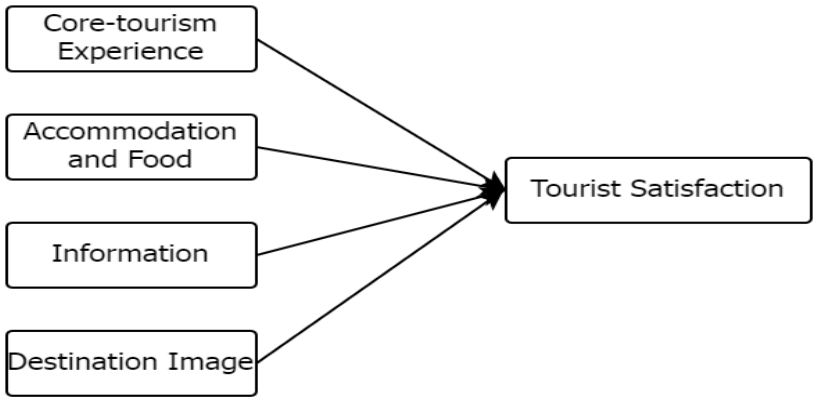


Figure 2: Revised Conceptual Framework

CONCLUSION

This study tested the components of perceived destination quality through exploratory factor analysis. The results found that perceived destination quality was composed of six dimensions (core tourism experience, accommodation and food, accessibility, amenities, information, and destination image). The measurement scale of Sabah as a tourist destination needs to highlight the uniqueness of Sabah's tourism resources and cannot be directly applied to the current measurement scale of perceived destination quality proposed by a particular scholar. Reviewing the literature related to perceived destination quality as well as the literature on tourism research in Malaysia, this study proposes a measurement scale for Sabah as a tourist destination. The second point is that the important role of perceived destination quality on destination tourism development is recognized and reconfirmed. The empirical results of this study reconfirm that the quality of a destination has a positive effect on tourist satisfaction, particularly for certain tourist destinations with marine resources. For these destination tourism managers and related stakeholders, it is more important in practice to explore the tourism characteristics of the destination, to improve the core tourism experience, to improve the quality of accommodation and the dissemination of food culture and the service capacity of related industries. Managers also need to improve the destination's ability to provide effective information and need to initiate positive interactions between citizens and tourists to improve and maintain a good image of the destination. Specifically, this can be done in the following ways. Using a sample of Chinese visitors in Sabah, this study examined the relationship between perceived destination quality and tourist satisfaction. Future research can be applied to additional marine resource-based destinations to evaluate the proposed

destination quality dimensions and to determine which factors influence the satisfaction of Chinese tourists.

This study offers a well-timed insight and distinctive contribution to the literature on tourism satisfaction, by creating and validating a six-dimensional perceived destination quality scale for a marine-based destination, Sabah. Significantly, this study's empirical results reveal the most important dimensions of satisfaction (core tourism experience, accommodation and food, information, and destination image) for the highly valued market of Chinese tourists. Considerably, this study's empirical results highlight the non-significance of accessibility and amenities for this unique market and provides actionable and targeted insights for the branding of the destination and the recovery of the destination after the pandemic. It assists managers in focusing resources on experiential, image and service-based dimensions rather than resource-heavy infrastructure or logistics which is vital for enhancing Chinese tourist satisfaction and ultimately achieving sustainable market recovery after COVID-19.

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Received: 28th June 2025. Accepted: 15th November 2025

PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 225 – 242

THE LOCAL COMMUNITY CHALLENGES TO DEVELOP THE HOMESTAY PROGRAMME IN GAYA ISLAND, KOTA KINABALU, SABAH, MALAYSIA

Harhamsah Hairal[1], Rosazman Hussin[2], Normah Abdul Latip[3], Jalihah Md Shah[4] & Andreas Pingking[5]

[1, 4,5]*Faculty of Social Sciences and Humanities,*
UNIVERSITI MALAYSIA SABAH
[2,3]*Borneo Institute for Indigenous Studies (BorIIS),*
UNIVERSITI MALAYSIA SABAH

Abstract

This study aims to identify the key challenges faced by the local community in developing a homestay program on Gaya Island, Kota Kinabalu, Sabah. The objective is to understand barriers that hinder effective community-based tourism development. This research applies quantitative approach using structured questionnaires administered to 150 respondents. The data analysis present in the table in statistic descriptive value such as frequency, percentage and mean. The findings reveal several significant challenges, including environmental pollution, lack of land ownership, inadequate financial capital, limited knowledge and skills, insufficient infrastructure, and weak cooperation both within the community and with tourism agencies. Despite these constraints, there is potential for homestay development if supported by structured financial aid, capacity-building programs, and collaborative efforts among stakeholders. These insights are vital for informing targeted policies and interventions that support rural tourism and sustainable community participation especially for homestay program as a unique marine based homestay development on the island in Sabah and Malaysia.

Keywords: Homestay program, rural tourism, community Participation, infrastructure, stakeholder collaboration

[2] Corresponding author. Email: azzs@ums.edu.my

INTRODUCTION

The homestay program is a form of rural tourism increasingly developing in Malaysia. It began as early as the 1970s in Kampung Cherating Lama, Pahang (MOTAC, 2019). It was officially introduced by the Ministry of Tourism Malaysia in 1988 as an alternative form of accommodation for tourists (Kalsom & Nor Ashikin, 2006). In Sabah, the program was introduced in the early 1990s through the efforts of both government and private agencies (Hussin et al., 2022). Among the popular homestays in Sabah are Tanak Nabalu, Tambunan Village, Bilit, Walai Tokou Kundasang, Miso Walai Kinabatangan, Misompuru Kudat, Kampung Pukak, Penampang, and Melangkap. Each of these homestays offers unique experiences through attractive tourism activities (Hussin & Kunjuraman, 2014). The unique case of the Pulau Gaya study is about an ethnic Bajau stilt village community and its culture. This stilt village, situated near the state capital of Kota Kinabalu, offers a unique marine-based homestay development on the island. In the same manner, this study highlights the distinct challenges faced by coastal squatter communities amidst urban development pressure and marine conservation issues in Malaysia.

The program has been well-received as it has the potential to improve the standard of living of rural residents and encourage their participation in tourism development (Hussin & Kunjuraman, 2014). It is also one of the government's strategies to diversify income sources for better socio-economic development. Several government policies have been implemented to support the development of the homestay program, including Government Policies Related to the Homestay Program such as Promoting rural areas as tourist attractions (Third Long-Term Plan Framework (2001–2010); Recognizing cultural diversity as a tourism asset and emphasizing the involvement of local communities (Sixth Malaysia Plan (1991–1995); Increasing community participation (Seventh Malaysia Plan (1996–2000), and Enhancing human resource development (Eighth & Ninth Malaysia Plans (2001–2010).

The program targets two main groups: rural communities and tourists. For rural communities, it creates opportunities to generate income and develop tourism entrepreneurship. For tourists, the program offers a unique experience to immerse themselves in the rural way of life, distinct from urban living, and provides rural hospitality tourism products at competitive prices and international standards.

LITERATURE REVIEW

Tourism Planning Approach by Inskeep (1991)

Inskeep (1991) outlines eight key approaches for effective tourism planning to ensure long-term benefits and sustainability but there are two approaches an important to community participation approach, first Comprehensive approach -

Involves institutions, environmental, and socio-economic factors holistically. Second, Community-Based approach – Emphasizes local involvement in decision-making and planning.

Tourism Planning Requirements (Inskeep, 1991)
Inskeep also identifies critical needs for successful tourism planning:

- Lack of expertise in new tourism areas.
- High sensitivity of tourism to environmental and socio-economic changes.
- Tourism must align with economic, social, and environmental goals.
- Limited existing resources to meet tourist demands.
- Infrastructure development must consider environmental impact.
- Long-term conservation of natural assets.
- Flexible planning for future destinations.
- A skilled workforce is essential.
- Need for organized institutions to ensure efficiency.
- Planning supports investment decisions.
- Enhances tourist satisfaction and destination reputation.
- Acts as a catalyst for rural development.
- Generates substantial returns, requiring solid policies and strategies.

Relevance and Challenges of Homestay Development in Kg Pulau Gaya
Inskeep's principles remain highly relevant today, especially in planning homestays like those proposed in Kg Pulau Gaya. His focus on sustainable development helps prevent harm to natural and cultural resources and ensures long-term community benefits. Community participation is crucial; without it, tourism projects risk failure. Involving local stakeholders not only enhances destination management but also boosts the socio-economic well-being of residents.

While studies by Nordin, D. et al. (2023), which study conducted in Kundasang, Sabah, offer valuable insights that are highly applicable to understanding the challenges faced by the local community in developing the homestay programme on Gaya Island, Kota Kinabalu. The post-MCO tourism recovery in Kundasang was hindered by several critical issues, including poor infrastructure, such as damaged roads and inadequate water supply systems, which directly impacted tourist accessibility and comfort. Financial limitations were another major obstacle, as homestay operators struggled to secure capital and experienced delays in receiving governmental financial aid.

Furthermore, the article by Rahmawaty et al. (2025) explores sustainable ecotourism development in Toba Regency, North Sumatra, Indonesia, emphasizing the crucial role of community perception and participation in

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planning and managing ecotourism initiatives. Using a mix of surveys, interviews, focus group discussions, and SWOT analysis, the study finds that while the local community generally supports ecotourism and shows moderate participation, significant challenges remain. These include limited engagement, insufficient training, inadequate infrastructure, and the need to balance economic development with environmental conservation.

The article by Hussin R. et al. (2022) investigates ecotourism and homestay recovery strategies in Kundasang, Sabah, following the COVID-19 pandemic. Their research identifies four key recovery components: infrastructure improvements, enhancement of tourist facilities, development of new ecotourism products, and effective promotion through various media channels. When applied to the challenges facing homestay programmes in Gaya Island, the findings reveal several parallel concerns, including infrastructure limitations specific to island settings, the need for specialized tourist facilities like jetties and coastal pathways, requirements for unique marine-based tourism products, potential digital marketing constraints due to connectivity issues, the importance of establishing formal community tourism organizations, and the necessity of developing disaster preparedness plans tailored to coastal environments. While Kundasang's recovery model provides valuable insights, any implementation in Gaya Island would require significant adaptation to address the distinctive challenges of island-based homestay programmes and the unique coastal and marine context.

Research Methodology: Mixed Method Approach

This study employs a mixed methods approach, combining qualitative and quantitative methodologies (Nur Hazirah & Ros Mahwati, 2020). The primary method is qualitative, focusing on in-depth insights to address the research questions and objectives, while the quantitative aspect supports the analysis through descriptive statistics such as frequencies and percentages. This quantitative data aids in understanding demographic distribution and community participation challenges in homestay programs using Likert scale measurements. The research is conducted in Pulau Gaya, Kota Kinabalu, Sabah, located just 10 minutes by boat from the city. Covering 1,465 hectares, the island is home to approximately 10,000 residents, primarily from the Bajau ethnic group, living in stilt houses along the coast. A significant portion of Pulau Gaya is part of the Tunku Abdul Rahman National Park, under the protection of Sabah Parks (DBKK, 2019).

The sampling of this study is a purposive method. Purposive sampling is a non-probability technique where researchers intentionally select participants for a study based on their specific characteristics and relevance to the research question (Creswell, 2014). Unlike random sampling, it does not aim for statistical

representativeness. Instead, it focuses on gathering in-depth, high-quality data from a deliberately selected subset of the population that yields the most informative insights. This method relies on the researcher's judgment and prior knowledge to identify "information-rich" cases to achieve specific study objectives (Ahmad & Wilkins, 2025). In this study, the purposive sampling method was applied because it is also relevant to the primary use of descriptive statistics (frequencies, percentages, means), and its reliance on a convenience sampling technique should be acknowledged. Ahmad & Wilkin (2025) mentioned that 'purposeful sampling is not just about the selection of cases. It's an interconnected puzzle of research questions. You select the design, and then the sampling is a by-product. So is the recruitment, so is the size, so is the data saturation, so is reflexivity, and thereby so is data verification; they must go together. Purposive sampling cannot stand alone. Consequently, the findings primarily offer localized insights specific to the Kampung Pulau Gaya community and are not intended for statistical inference or broad generalization to all homestay or stilt communities in Sabah.

Therefore, ethical clearance for this study was obtained from the supervisor and faculty. All participants provided informed consent before their involvement, and the study strictly adhered to institutional and national ethical standards for research involving human participants, ensuring participant anonymity and confidentiality throughout the research process.

RESEARCH LOCATION



Photo 1: Gaya Island's village area
Source: https://www.malaysia-traveller.com/sapi-island.html

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Photo 2: Gaya Island Community Village
Source: Kota Kinabalu City Hall

Photo 1. Kg Pulau Gaya is an unofficial village located under DUN N.17 Tanjung Aru, Parliament P.173, with its village gazettement still pending since the application in 2015 (see Photo 2). The village, led by Encik Haji Bantilan Bin Arkis, spans 10 acres and consists of approximately 180 stilt houses built along the coastline. As of 2015, it has a population of 1,079 residents from diverse ethnic backgrounds, including Bajau Ubian, Bajau Tuaran, Brunei, Iban, Buton, Dusun, Iranun, and Suluk (DBKK, 2015). The local economy is supported by self-employment, fishing, private sector work, and government service. Socially, the village is active through various community bodies such as the Residents' Committee, 1Malaysia Community Association, and Charitable Organizations. Kg Pulau Gaya is equipped with key infrastructure, including a public hall, mosque, kindergarten, electricity supply, public bridge, sepak takraw court, football field, and cemetery (Encik Haji Bantilan, 2019).

STUDY FINDINGS AND DISCUSSIONS

Community Members' Challenges in the Development of a Homestay Programme in Gaya Island, Kota Kinabalu, Sabah

1. Garbage Pollution

A long-standing issue in Kg Pulau Gaya is severe garbage pollution along the coastline and surrounding waters. Despite being under DBKK's jurisdiction, waste management remains unresolved. Community leaders and residents stress that this pollution negatively impacts the island's image, especially among

tourists, and must be addressed before implementing any tourism initiatives. While community clean-up efforts have been made, such as participation in the "Cleanest Village Competition," consistent cooperation and commitment are needed for long-term solutions.

2. Lack of Land Ownership

Table 1: Majority of Community Members Do Not Have Land Ownership Grants by Gender (N=150)

No	Land Ownership Grant	Likert Scale	Gender	Percentage (%)	Mean	Total
1	Land Ownership Grants that do not belong to villagers	Strongly Disagree	L = 0	0	3.92	3 (2%)
			P = 3	2		
		Disagree	L = 3	2		8 (5.33%)
			P = 5	3.33		
		Neither Agree nor Disagree	L = 22	14.67		42 (28%)
			P = 20	13.33		
		Agree	L = 22	14.67		42 (28%)
			P = 20	13.33		
		Strongly Agree	L = 24	16		55 (36.67%)
			P = 31	20.67		
		Total	150	100%		150 (100%)

Source: 2020 Field Study

The lack of formal land ownership among residents of Kampung Pulau Gaya presents a significant legal and administrative barrier to local tourism development. The village's status as a squatter settlement, stemming from the area being largely classified as government reserve and private land, severely complicates the formal establishment and expansion of homestay programs, requiring difficult-to-obtain consent from official landowners. This challenge is strongly validated by the survey data. Table 1 shows that the overall mean score of 3.92 for the statement "Land Ownership Grants that do not belong to villagers." This high mean, which approaches the 'Agree' category, indicates a widespread community acknowledgment of the issue. Specifically, the data shows that most respondents either Strongly Agree (36.67%, n=55) or Agree (28%, n=42) with the statement.

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3. Community Constraints in Providing Tourist Boats for Homestay Operations

Table 2: Some community members are less capable of owning tourism boat assets (N=150).

No	Asset	Likert scale	Genders	Percentage (%)	Mean	Total
1	A comfortable tour boat is expensive.	Strongly Disagree	L = 0	0	4.13	0 (0%)
			P = 0	0		
		Disagree	L = 2	1.33		10 (6.67%)
			P = 8	5.33		
		Neither Agree nor Disagree	L = 14	9.33		26 (17.33%)
			P = 12	8		
		Agree	L = 25	16.67		48 (32%)
			P = 23	15.33		
		Strongly Agree	L = 30	20		66 (44%)
			P = 36	24		
		Total	**150**	**100%**		**150 (100%)**

Source: 2020 Field Study

The high cost of acquiring essential tourism assets, particularly comfortable and well-equipped tour boats, represents a major financial barrier severely restricting community participation in developing the homestay program in Kampung Pulau Gaya. Table 2 shows that the financial limitation is strongly reflected in the survey results for the statement, "A comfortable tour boat is expensive," which yielded a high Mean score of 4.13. This means the average response is placed firmly in the 'Agree' category, indicating a clear consensus among residents regarding the financial challenge. The data shows overwhelming agreement: a total of 64% (n=96) of respondents either Strongly Agree (44%, n=66) or Agree (32%, n=48) that the boats are expensive. Conversely, almost no one disagreed, with only 6.67% (n=10) registering disapproval.

4. Lack of Cooperation Between the Community and Tourism Agencies

One of the key challenges in developing a homestay program in **Kg Pulau Gaya** is the **limited cooperation between community members and tourism-related government and private agencies**. Despite many locals particularly youth working in the tourism sector at nearby islands and Jesselton Point, the community remains largely **unexposed to tourism development knowledge**, especially concerning homestay programs.

Table 3: Lack of Collaboration Between Community Members and Government and Private Agencies by Gender (N=150)

No.	Relationship with Government Bodies	Likert scale	Gender	Percentage (%)	Mean	Total
1	Lack of collaboration between community members and government and private agencies	Strongly Disagree	L = 3	2	3.53	6 (4%)
			P = 3	2		
		Disagree	L = 14	9.33		25 (16.67%)
			P = 11	7.33		
		Medium	L = 19	12.67		40 (26.67%)
			P = 21	14		
		Agree	L = 15	10		42 (28%)
			P = 27	18		
		Strongly Agree	L = 20	13.33		37 (24.67%)
			P = 17	11.33		
		Total	**150**	**100%**		**150 (100%)**

Source: 2020 Field Study

The survey strongly indicates that a lack of collaboration between community members and government/private agencies is perceived as a critical impediment to local tourism development. Table 3 shows that the statement, "Lack of collaboration between community members and government and private agencies," yielded a Mean score of 3.53. This mean falls between 'Medium' and 'Agree,' showing a consensus toward acknowledging the lack of cooperation. In total, 52.67% of respondents (79 individuals) either Agreed (28%, n=42) or Strongly Agreed (24.67%, n=37) that this lack of collaboration constitutes a significant barrier. A breakdown by gender reveals a slight difference in perception: while male respondents (L) showed a combined 23.33% (10% Agreed + 13.33% Strongly Agreed) agreement, female respondents (P) showed a higher combined agreement of 29.33% (18% Agreed + 11.33% Strongly Agreed). Conversely, only 20.67% of respondents (31 individuals) disagreed or strongly disagreed.

5. Lack of Cooperation and Support Among Community Members in Kg Pulau Gaya

One of the key challenges facing the development of a homestay program in Kg Pulau Gaya is the lack of cooperation and support among community members. According to community leaders, participation in communal activities and village programs is consistently low. For example, when a cleaning program is organized, only a handful of residents-sometimes as few as three or four out of fifty-actively participate. This limited involvement makes it difficult to successfully implement community initiatives.

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Table 4: Lack of Cooperation and Support Between Community Members by Gender (N=150)

No.	Cooperation and Support between Community Members	Likert scale	Gender	Percentage (%)	Mean	Total
1	It is difficult to get cooperation from community members.	Strongly Disagree	L = 8	5.33	3.15	13 (8.67%)
			P = 5	3.33		
		Disagree	L = 21	14		41 (27.33%)
			P = 20	13.33		
		Medium	L = 14	9.33		29 (19.33%)
			P = 15	10		
		Agree	L = 19	12.67		45 (30%)
			P = 26	17.33		
		Strongly Agree	L = 9	6		22 (14.67%)
			P = 13	8.67		
		Total	**150**	**100%**		**150 (100%)**

Source: 2020 Field Study

The survey data reveals a significant but contested challenge regarding cooperation and support among community members in Kampung Pulau Gaya, which affects collective initiatives like the homestay program. Based on Table 4, the statement "It is difficult to get cooperation from community members" registered an overall Mean score of 3.15. This mean score sits slightly above the 'Medium' category (score 3), suggesting a marginal inclination toward acknowledging the difficulty in cooperation. In total, a substantial 44.67% (67 respondents) of the community recognized this issue, either agreeing (30%, n=45) or Strongly Agreeing (14.67%, n=22) with the statement. Conversely, a large opposing group, totaling 36% (54 respondents), did not perceive this lack of cooperation as a major issue, registering in the Disagree (27.33%, n=41) and Strongly Disagree (8.67%, n=13) categories.

Gender analysis shows that the perception of difficulty is slightly higher among female respondents, with a combined 26% (17.33% Agreed + 8.67% Strongly Agreed) agreement, compared to male respondents at 18.67% (12.67% Agreed + 6% Strongly Agreed).

6. Lack of Knowledge and Skills as a Barrier to Homestay Program Development in Kg Pulau Gaya

The development of the homestay program in Kg Pulau Gaya, initiated by MOTAC to enhance rural economies, is hindered by the community's limited knowledge and skills in tourism management. Many residents lack exposure to homestay operations, licensing procedures, and the economic benefits tourism can bring, which discourages their participation. Community leaders emphasize the need for organized training and guidance to raise awareness and build

capacity. Despite some families having members employed in nearby tourism sectors, specific knowledge about homestay management remains scarce.

Table 5: Having Knowledge and Skills in Developing a Homestay in Kg Pulau Gaya by Gender (N=150)

No.	Barrier Factors	Likert scale	Gender	Percentage (%)	Mean	Total
1	Have knowledge and skills in developing Kampung Pulau Gaya homestays	Strongly Disagree	L = 12	8	2.73	25 (16.67%)
			P = 13	8.66		
		Disagree	L = 19	12.67		53 (35.33%)
			P = 34	22.67		
		Medium	L = 11	7.33		25 (16.67%)
			P = 14	9.33		
		Agree	L = 18	12		32 (21.33%)
			P = 14	9.33		
		Strongly Agree	L = 11	7.33		15 (10%)
			P = 4	2.67		
		Total	**150**	**100%**		**150 (100%)**

Source: 2020 Field Study

The survey data presents a divided community perception regarding the presence of adequate knowledge and skills necessary for developing Kampung Pulau Gaya homestays, with a slight majority not identifying it as a major barrier. Table 5 shows that the statement, "Have knowledge and skills in developing Kampung Pulau Gaya homestays," registered a Mean score of 2.73. This mean falls between the 'Disagree' (score 2) and 'Medium' (score 3) categories, indicating a leaning toward disagreement with the implied barrier. The majority of respondents, totaling 52% (n=78), disagreed or strongly disagreed with the statement, suggesting they believe they possess sufficient knowledge and skills. Specifically, 35.33% (n=53) Disagreed and 16.67% (n=25) Strongly Disagreed. Female respondents (P) showed the highest level of disagreement, with 22.67% (n=34) disagreeing. Conversely, a significant minority of 31.33% (n=47) acknowledged the issue, either agreeing (21.33%, n=32) or Strongly Agreeing (10%, n=15). These results suggest that while a significant portion of the community feels adequately prepared or views other factors as more pressing challenges, a substantial segment recognizes the need for greater awareness and training to successfully implement and scale the homestay program.

7. Financial Capital Constraints Limiting Homestay Program Development in Kg Pulau Gaya

Financial limitations represent a significant barrier to community participation in developing homestay programs in Kampung Pulau Gaya. Community members lack sufficient financial resources to independently develop these facilities, necessitating support from government agencies or private organizations.

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Table 6: Having Capital and Financial Preparations in Developing a Homestay in Kg Pulau Gaya by Gender (N=150)

No.	Barrier Factors	Likert scale	Gender	Percentage (%)	Mean	Total
1	Have capital and financial preparations in developing a homestay in Kampung Pulau Gaya	Strongly Disagree	L = 11	7.33	2.67	25 (16.67%)
			P = 14	9.33		
		Disagree	L = 24	16		60 (40%)
			P = 36	24		
		Medium	L = 11	7.33		21 (14%)
			P = 10	6.67		
		Agree	L = 14	9.33		27 (18%)
			P = 13	8.67		
		Strongly Agree	L = 11	7.33		17 (11.33)
			P = 6	4		
		Total	**150**	**100%**		**150 (100%)**

Source: 2020 Field Study

The survey data strongly confirms that a lack of capital and financial preparation represents a major economic barrier to developing homestays in Kampung Pulau Gaya. Statement about "Have capital and financial preparations in developing a homestay in Kampung Pulau Gaya," in Table 6 shows the Mean score of 2.67. This means score sits between the 'Disagree' (score 2) and 'Medium' (score 3) categories, indicating that the average respondent disagrees with the notion that they possess adequate financial resources. Most of the community, totaling 56.67% (n=85), reported significant financial constraints, combining those who Disagreed (40%, n=60) and Strongly Disagreed (16.67%, n=25). This constraint was particularly acute among female respondents (P), where a combined 33.33% (24% Disagreed + 9.33% Strongly Disagreed) indicated a lack of financial readiness, compared to male respondents (L) at a combined 23.33% (16% Disagreed + 7.33% Strongly Disagreed). Conversely, only a minority, 29.33% (n=44), indicated having adequate financial resources. This substantial 27.34 percentage point gap between those reporting financial constraints (56.67%) and those reporting readiness (29.33%) underscores that financial insecurity is the single most dominant impediment preventing broader community participation in the homestay tourism development.

8. Inadequate Housing Infrastructure for Homestay Development

A significant barrier to implementing homestay programs in Kg Pulau Gaya is the unsuitable condition of the existing housing infrastructure. To qualify as official homestays under MOTAC (Ministry of Tourism, Arts and Culture) regulations, homes must meet specific safety and comfort standards that many local residences currently fail to satisfy.

Table 7: Having a comfortable home infrastructure to be used as a homestay in Kg Pulau Gaya by Gender (N=150)

No.	Barrier Factors	Likert scale	Gender	Percentage (%)	Mean	Total
1	Have a comfortable home infrastructure to be used as a homestay.	Strongly Disagree	L = 4	2.67	2.99	17 (11.33%)
			P = 13	8.67		
		Disagree	L = 22	14.66		45 (30%)
			P = 23	15.33		
		Medium	L = 14	9.33		31 (20.67%)
			P = 17	11.33		
		Agree	L = 19	12.67		37 (24.67%)
			P = 18	12		
		Strongly Agree	L = 12	8		20 (13.33%)
			P = 8	5.33		
		Total	**150**	**100%**		**150 (100%)**

Source: 2020 Field Study

The survey results highlight that the suitability of existing housing infrastructure is a significant, though not universal, barrier to homestay development in Kampung Pulau Gaya. "Have a comfortable home infrastructure to be used as a homestay" statement in Table 7 shows a Mean score of 2.99. This mean sits just below the 'Medium' category (score 3), suggesting a slight overall tendency towards disagreement that current homes are suitable. A total of 41.33% (n=62) of respondents indicated their homes were unsuitable, combining those who Disagreed (30%, n=45) and Strongly Disagreed (11.33%, n=17). The perception of inadequacy was marginally higher among female respondents (P), with a combined 24% (15.33% Disagreed + 8.67% Strongly Disagreed), indicating unsuitability, compared to male respondents (L) at a combined 17.33% (14.66% Disagreed + 2.67% Strongly Disagreed). Conversely, a substantial minority of 38% (n=57) felt their housing infrastructure was adequate, with 24.67% (n=37) agreeing and 13.33% (n=20) Strongly Agreeing. This finding suggests that while infrastructure challenges are indeed significant for a large segment of the community, there remains a potential foundation of existing properties that are considered suitable, providing a starting point for initiating homestay development with targeted support and necessary upgrades.

CONCLUSION

This study reveals that Kg Pulau Gaya community members face significant challenges that must be addressed to establish a sustainable tourism center capable of delivering substantial benefits to both the local community and the broader economy. The identified barriers, particularly financial constraints and inadequate housing infrastructure, represent formidable obstacles to homestay program implementation.

Despite these challenges, the research demonstrates clear community support for homestay development, provided appropriate assistance is made

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available. Community members are receptive to participating in tourism initiatives when supported by targeted interventions from relevant authorities, specifically in three critical areas: financial capital provision, skills development through training programs and courses, and ongoing professional guidance throughout the implementation process.

The findings underscore the importance of collaborative approaches between government agencies, private organizations, and the local community to overcome existing limitations and harness the community's potential for tourism development. With structured support mechanisms addressing the identified needs, Kg Pulau Gaya could transform its current challenges into opportunities for sustainable economic growth and community empowerment through tourism.

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Received: 28th June 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 243 – 264

AWARENESS TO UNDERSTANDING OF GREEN INFRASTRUCTURE IN ISKANDAR MALAYSIA

Mohammad Qasim Noorzai[1], Nafisa Binti Hosni[2], Numan Pashton[3]

[1,3]*Department of Architecture, Faculty of Engineering,*
KANDAHAR UNIVERSITY AFGHANISTAN
[2]*Department of Urban and Regional Planning,*
Faculty of Built Environment and Surveying,
UNIVERSITI TEKNOLOGI MALAYSIA

Abstract

Strategic development of green infrastructure, including blue and green networks in developing and urbanizing neighbourhoods, is becoming more prevalent. The goal of these initiatives is to establish an ecological network to promote social, economic, and environmental well-being in Malaysia. For this purpose, seven public and private sector professionals were polled using questionnaires in a recent research study. Eight green infrastructures, which include parks, bodies of water, and bioswales, were determined to exist in Iskandar Malaysia initially according to the study. On the other hand, visible vegetation loss along city corridors signifies the urgent necessity for replanting and reforestation programs. Besides, the study identified ten key green infrastructure elements such as electric vehicle charging stations, rainwater harvesting systems, and street furniture that are relevant to the development of Iskandar Malaysia. Despite this, the development process in most developing countries unconsciously neglects the advantages and significance of green infrastructure. The main objective of the study was to investigate the various applications and benefits of green infrastructure in Iskandar Malaysia, dividing the benefits into the environmental, economic, and social categories. It also aimed to assess the level of awareness and knowledge of green infrastructure concepts in the area. The development of green infrastructure is hindered by various factors, including cultural barriers, technical difficulties, contextual limitations, structural problems, and regulatory constraints. Key challenges also include budget limitations, maintenance expenses, debates on agency responsibility, and excessive start-up expenses. Recommendations therefore encompass stimulating group efforts, implementing reforestation policies, and strengthening public-private sector partnerships. Both community and expert engagement are essential to advancing sustainable urban planning and enabling green infrastructure.

Keywords: Green, Infrastructures, Types, Values, Barriers, Sustainability, Reforestation and Biodiversity

[1] Corresponding author. Email: noorzai@kdru.edu.af

INTRODUCTION

To commence, intentional green and blue space construction, or "green infrastructure" (GI), gains greater prominence internationally due to proposals like the European Commission "green infrastructure strategy." In response to stresses owing to urbanization, GI initially emerged in the United States during the 1990s, proliferated there, and diffused further across other countries, including Australia, as well as the United Kingdom. Global ecosystem (GI), crucial to maintaining biodiversity, well-being of ecosystems, as well as functioning ecosystems, includes patches of seminatural patches, as well as patches of natural patches.

Green infrastructure (GI) necessitates intentional efforts, including tracing out green patches, modernizing them to modern standards, as well as creating green patches where necessary. Green infrastructure (GI) is crucial, this holistic approach, to maintaining biodiversity, human living, as well as addressing pressing concerns, including pollution, land erosions. By facilitating the incorporation of nature in the city, green infrastructure (GI) maintains green infrastructure (GI)-sustainable urbanization, balancing advancing social equity across neighbourhoods, advancing economic progress, while also maintaining the environment.

The biodiversity of GI maintains several functions of ecosystems, including climate change mitigation, water purification, and carbon sequestration. Not only does it provide social cohesion, but also quality of living, leisure, and cultural opportunities also get promoted. Well-designed green spaces attract massive crowds, boost cultural values, and boost both physical and emotional well-being. Besides, it drives economic development by advancing property values, funding, and green infrastructure projects. By reducing noises, creating spots of calm, as seen in spots like the National Park of Athens, it proves worth enhancing living quality areas while stimulating living standards. Sustainable development demands, for urban development, support by way of green infrastructure strategies. Environmental preservation demands green spaces' restoration, especially as land gets turned into land cover by way of urbanization, further causing climate change symptoms, flooding, and the heat island effect. Green infrastructure (GI) provides an inclusive way out of issues facing the environment, economy, and society. Waste generation, biodiversity decline, water use, and emissions result from the construction industry. Green building, one form, must be practiced, especially due to these issues. Green infrastructure (GI) provides an opportunity, irrespective of economic losses, especially in developing economies, like that of Malaysia. Green infrastructure, including mangroves, plays an essential role in Iskandar, Malaysia, enhancing biodiversity, climate change management, and carbon sequestration. Deforestation, land use changes, and threats facing these ecosystems necessitate

efforts aimed toward conservation. In Iskandar Malaysia, this demands efforts aimed toward preservation.

LITERATURE REVIEW

Theoretical Contexts of Green Infrastructure

Urbanization has significantly impacted biodiversity, natural habitats, as well as functions of ecosystems across Asia, Latin America, as well as Sub-Saharan Africa (McDonald, 2013). It has produced uneven distribution of green cover as well as lost land both outside as well as within the city. Besides, unless green as well as blue spaces are included in city development as advocated by Green Infrastructure (GI), future issues are bound to aggravate (UN, 2019). Besides, particular green areas categories, including city parks, gardens, as well as woodlands, have gained extensive study as well as utilization across the globe, still, especially across Asia.

Lack of full acquaintance by the planners toward the conception of the GI serves as an obstacle toward successful utilization (Cilliers, 2019). Larger, well-developed metropolises, including Kuala Lumpur, Johannesburg, Durban, as well as Bogota, have proved utilizing strategic means toward developing green as well as blue spaces across the city due to efficient management plans. Smaller metropolises, however, lack data as well as plans toward green city development, further elevating the need toward greater plans there.

Categories of Green Infrastructure

In Latin America, there has also been a focus, specifically, on Green Infrastructure (GI) study, practical application, green areas, parks, and forest, city. While there are studies specifically focusing on GI, there are those focusing on cognate concepts not utilizing the term. Specific emphasis has also been placed, specifically, on green infrastructure elements that are publicly accessible, parks, plazas, and streetside trees. Bogota's vast tree surveying has established the significance of green areas (Escobedo et al., 2015). Santiago, Chile, has only has only 43% of the trees planted on publicly accessible land, leaving it facing problems that show the significance of managing the forestry of the city differently (Reyes and Figueroa, 2010).

Other than publicly accessible green areas, the semi-natural, and natural areas found outside the periphery of the city are also essential components of Green Infrastructure (GI) network elements that perform fundamental ecological functions. In Latin American cities, by way of an example, wetlands, alongside patches of forest, are fundamental components of Green Infrastructure (GI) (Doobs et al., 2019). Not only are these areas responsible for biodiversity preservation, but also provide fundamental ecosystem functions, including regulation of floods, purification of water, as well as habitats for various species. Green Infrastructure (GI) greatly enhances the quality of the environment, by

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various kinds, well established, specifically, in developed economies, including the United Kingdom, as well as Germany. These, by Feng et al. (2019), are green rooftops, green parks, green streets, SUDs, et al. Through minimization of the effect of the urban heat island, air, as well as water quality, purification, as well as biodiversity, these elements of Green Infrastructure (GI) enhance the beauty of the city, while also advancing the environment toward greater sustained.

Benefits, Significances and Purposes of Green Infrastructure

Food production, hazard minimization, and biodiversity preservation are highest prioritized by Los Angeles's Urban Green Infrastructure (UGI) study projects. Garcia et al. (2014) highlight how UGI serves as an environment and lessens flooding hazard threats, as well as coast line erosions. Besides, Vásquez et al. (2019) tackle climate change adaptation in Latin American cities wherein master plans, as well as people's policies, involve UGI approaches, although it has been noted by Reynolds et al. (2017) that there are concerns, including air quality, as well as environmental injustice, not prioritized. Just 38% of Sub-Saharan Africa (SSA) nations have conducted studies on UGI, whereby it has been noted that it is leadership by South Africa, by Du Toit et al. (2018). In the case of UGI, whereby it mostly seeks to address issues in the urban environment, including climate change, as well as flooding, temperature management plays a crucial role (Ngulani and Shackleton, 2019). Urban farms located in UGI provide food security, while urban agriculture serves as an insurance cover against poverty decline (Abo-El-Wafa et al., 2018). In 2018, Shackleton et al. Urban agriculture, as well as gathering, both play an essential role in food provisioning in SSA (Titz and Chiotha, 2019).

Among the functions of managing UGI includes creating opportunities for leisure, as well as people's spaces' enhancement (du Toit et al., 2018). However, an overconcentration on beauty could result in camouflage of the myriads of ecosystem services (ES) that UGI has to provide, silencing local innovations (Schäffler and Swilling, 2013). It is crucial, therefore, to comprehend the greater benefits of UGI, especially biodiversity preservation, so as to boost people's resilience, as well as well-being, especially those living below poverty.

Shackleton and Blair (2013) also lay emphasis on generating work opportunities in poor neighbourhoods, while King and Shackleton (2020) anticipate generation of 17,000 work opportunities by the UGI with reasonable scales of pay per annum in the minor towns of South Africa. Schäffler and Swilling (2013) discover there exists an extension observed by the green industry of Johannesburg. The majority of studies focusing on the decision-making by the UGI, particularly those by China, account for the master objective of city sustainability (Wei et al., 2018). China and India ventured significantly toward the three general gains by environmentalism, consisting of biodiversity

strengthening, reducing pollution, temperature management (Kotharker et al., 2019).

Foremost Hindrances and Enabling Factors of Green Infrastructure

Green infrastructure (GI) studies in Latin America focus primarily on quantitative estimations of spatial planning, provision of ecosystem services, and integration into urban design, with less attention given to planning and management operations (Vásquez et al., 2019). Lack of consensus among stakeholders and indicators of performance is hindering progress in this direction. Insufficient use of the word "GI" in management and planning literature constrains its possible benefits and makes it impossible to incorporate into urban development (Vásquez et al., 2019). Moreover, construction of multifunctional solutions is impeded by the inclination of public-sector GI plans to be insufficient when taking into consideration the various ecosystem services (Doobs et al., 2019).

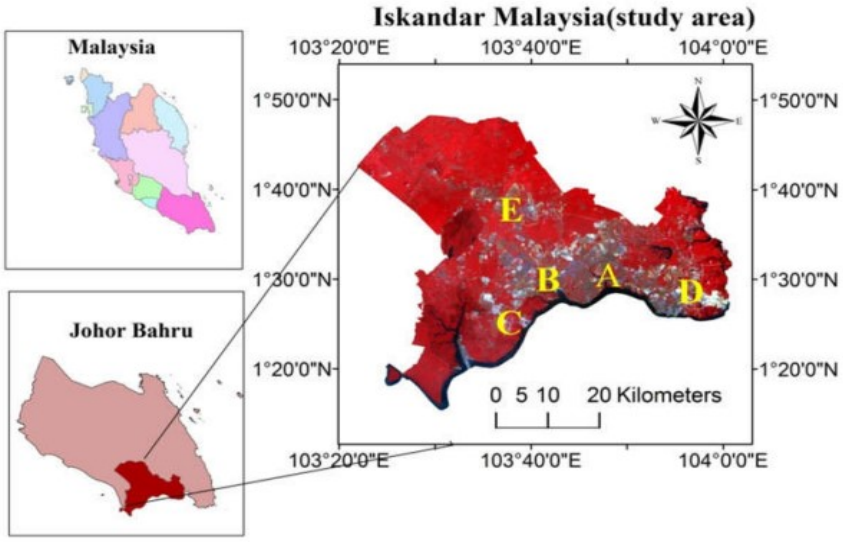


Figure 1: Iskandar Malaysia and the Right Panel Five Flagship Zones are Denoted as A-E. ***Source:*** *Lo and Yeung, 1996; Ho et al., 2013*

In spite of these challenges, NGOs and social organizations are emerging social actors involved in the development and sustenance of GI (Vásquez et al., 2017). However, scientific research pays no attention to these efforts, and there is a need for more profound scientific understanding of their goals. Neoliberal policies in Latin America restrict the application of urban planning mechanisms, which discourage the evolution of GI (Andrade et al., 2013, 2014). Vulnerable communities may be displaced by the deployment of the

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UGI, and informal settlements most so because of issues like the UGI having a limited ability to enforce planning controls (Anguelovski et al., 2016).

Green Infrastructure Course of Action in Iskandar Malaysia

As part of its effort to fight climate change and global warming, Iskandar Malaysia has implemented policies aimed at green infrastructure with the intention of reducing carbon footprints and enhancing a green economy (Ho & Fong, 2007). This strategic approach aligns with the principles of sustainable growth whose core intention is to emphasize how important environmental conservation is. The conservation of Iskandar Malaysia's blue and green infrastructure has also been more of a focus in an attempt to enhance the overall well-being of the region (Azian & Mubaraq, 2012). Such policies help reduce energy usage and greenhouse gas emissions while also encouraging environmental conservation through the utilization of the advantages of green infrastructure, such as temperature regulation and carbon storage (Daniel et al., 2011). Moreover, Hamdann (2012) emphasizes the importance of incorporating blue and green infrastructure for Iskandar Malaysia as well as the overall Malaysian urban environment.

RESEARCH METHODOLOGY

Study Area

Since its initiation in 2006, Iskandar Malaysia has remained to remain to be one of the country's biggest and ambitious developments significantly transforming land use pattern throughout the country. Measuring at vast tract of land of 2216.3 km² in size, Iskandar Malaysia sits between latitudes of 1.4833° to 1.6667° north to between longitudes of 103.4500° to 103.9094° east as presented in (Figure 1). To put that in context, Iskandar Malaysia is twice that of that of that of Hong Kong Island or more than three times that of that of that of Singapore, thus presenting its vast potential for developments as well as presenting its strategic importance in region (Yunos and Johar, 2015).

In future outlooks, Iskandar Malaysia or simply known as "IM" is going to take on front-runner of contender of notable East Asia cities in ranks of notable cities like that of that of Singapore and that of that of that of Hong Kong. As that, it is going to make it leading region in influencing economic dynamics of greater region. As part of measures to induce planned investments in all infrastructure aspects in all aspects of economy, Iskandar Regional Development Authority (IRDA) was at centre of Iskandar Malaysia in its initiation in 2006. Iskandar Malaysia has general objective of causing inclusive and lasting regional developments in region. Iskandar Malaysia has model of governing through concerted actions of five regional governmental agencies in working towards implementation of strategy and policies set in (Table 1), which divide five flagship economic developments corridors or zones.

To attract planned investments in various infrastructure and economic sectors, the Iskandar Regional Development Authority (IRDA) launched Iskandar Malaysia in 2006 through strategic planning. The ultimate objective of this program is to create balanced and sustainable regional development. The synergy of five local government agencies renders the governance of Iskandar Malaysia distinctive. In addition to that, they collaborate to implement the policies and strategies enumerated in (Table. 1), which identifies five development plan flagship zones. In the long run, these zones serve a crucial function in consolidating already established economic clusters.

Table 1: Five Flagship Zones in Iskandar Malaysia

Flagship Zones	Area Covered	Development
A	City Centre of Johor Bahru	Includes the Malaysia-Singapore Causeway, a newly developed financial hub, the Central Business District, Danga Bay's waterfront city, and diverse projects in Tebrau Plentong.
B	Nusajaya	Features Medini Iskandar Malaysia, a healthcare hub, an educational city, an international tourist destination, an industrial logistics cluster, and a planned residential community.
C	Western Gate Construction	Comprises the Ramsar World Heritage Park, Tanjung Piai, a designated free trade zone, and the Port of Tanjung Pelepas (PTP), serving as an additional Malaysia-Singapore transport link.
D	Eastern Gate Construction	Includes Tanjung Langsat Port, Pasir Gudang Port and its industrial area, Tanjung Langsat Technology Park, and the Kim Regional Distribution Centre.
E	Senai-Skudai	Hosts a multimodal hub, the MSC Cyberport city, Senai International Airport, and centres for information technology and freight operations.

Methodology

This section presented a description of the methodology of research and procedures followed for conducting the study. This chapter also discussed how the data collection, handling, and analysis processes are carried out. This chapter also explains the demography of the research participants who took part in completing the questionnaire survey and how data was used to attain the study purpose. This chapter provides a descriptive explanation of the location, population, areas, and boundaries of the case study area. This research includes an overview, literature review, data collection and analysis, findings and results, conclusion, and recommendations. The settlements' green infrastructure history is established in the first phase of understanding the research. Then the problem statement was formulated, and its applicability to the study was established. Lastly, the purpose, scope, and aim of the research were established for effective

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data collection and analysis. The literature review, which encompasses all the information and data collected from a variety of textual sources, is the second component of this study.

The objective of carrying out the review of literature was to determine the body of work in context to research topics at stake, alongside discovering how other researchers have tackled similar topics. Review captures the concept of green infrastructure, its manifestations, people living in these areas' benefits to them, challenges that it poses to them, alongside why it must be embraced. Gathering of data was step three in research where approach used was quantitative from primary data. Expert opinions have served as method of getting the primary data. At step four in getting the data and drawing inferences from the questionnaire, inferences from these have been interpreted through utilizing the program of Excel. To make easy to go through, results and inferences have been put in tables through utilizing the Likert Scale score of mean. Last part of research gives concluding remarks alongside suggestions on how green infrastructure in Iskandar Malaysia may improve from research results. There is clear presentation of research objectives, data sources, alongside methodology in Table 2.

The first step of research entails having clear understanding whereupon research title is set forth and analysed to establish relevance. Initial understanding is employed to set statement of the problem by providing context to research. Through utilization of accumulated wisdom, green infrastructure context of settlement is set to verify by providing context to research statement of research statement. Aside from that, to establish relevance as well as applicability of future research, initial data is employed to set research scope in scope. Aside from that, in step of research work in this step, research objectives as well as research purposes are set forth. The second step entails literature review whereupon insight of research work on green infrastructure in all green infrastructure aspects of green infrastructure in all green infrastructure from Latin America to developed countries like United Kingdom and Germany to countries of Asia like Bangladesh, Malaysia, China, India, Sub-Saharan Africa countries is synthesized.

Table 2: Links Between Research Objectives and The Method Employed

Research Objectives	Nature of Information Needed and Source	Research Methods Used
Investigate the existing green infrastructure types in Iskandar Malaysia.	Primary data collected through expert interviews.	Expert interviews, Descriptive analysis.
Assess the significance and advantages of green infrastructure in Iskandar Malaysia.	Primary data obtained from discussions with experts.	Expert interviews, Descriptive analysis.
Determine the key challenges and supporting factors	Primary data gathered from expert consultations.	Expert interviews, Descriptive analysis.

Research Objectives	Nature of Information Needed and Source	Research Methods Used
influencing green infrastructure in Iskandar Malaysia.		

Above paragraphs provide context to general objectives, precepts, as well as missions of green infrastructure in developed countries as well as countries of Asia as well as Africa. Aside from that, review provides context to ecosystem benefits of benefits in these situations. Overall challenges as well as driving factors of green infrastructure in countries like Asia, Latin America, developed countries like United Kingdom and Germany to Sub-Saharan Africa countries are analysed. Study of article diversity has helped to set green infrastructure context in the settlement in scope of its kind, benefits, benefits, as well as limitations therewith associated to it. Aside from that, research centres on green infrastructure enabling factors as well as hindrances from research work. Quantitative research approach to research is employed to obtain data in third step of research work.

The primary method of generation of data is through perceptions of experts where interviews through questionnaire have used as chief method of extracting of data. Experts have requested to provide their perceptions of green infrastructure categories, their potentialities, benefits, and contribution in Iskandar Malaysia, their obstacles and facilitators that they believe in. Questionnaire designing has done by research objectives while structure of it has decided by literature review. Value, availability, and facilitation have measured on Likert scale. Azila (2015) elucidate that Likert scale is psychometric instrument used in questionnaire to identify how much of agree or disagree on statement by respondents would agree or not agree on that statement. Through that ordinal measurement instrument that measures feelings of people on given statement by how much agree or disagree on that statement (Azila, 2015).

The most commonly employed is the five-point Likert scale, shown in (Table. 3). The scale points include strongly disagree, agree, neutral, and disagree. The 7- and 9-point Likert scale and 3-point scale are employed by a few researchers in order to verify the validity and reliability of the study. The study's objective is pertinent to the variable Likert scale. However, Azila (2015) suggests that the 5-point Likert scale is a commonly used rating scale, therefore was used in this study. Likert Scale and questionnaire were used in this study.

Primary data were employed while making the data of the study. Questionnaire survey was employed for gathering primary data for the research. Since a questionnaire is a versatile instrument from which a large number of types of answers could be extracted out of the respondents, it constitutes a significant portion of the process of collecting data. It is a well-crafted series of questions aimed at unscrambling the intricate web of public opinion, attitude, and response associated with a given subject. Bird (2009) states that the questionnaire is an

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example of a systematic exercise that goes beyond questioning for a deep understanding of what drives human behaviours, beliefs, and tastes to function. The start of any questionnaire is determined by how well it is defined and closely coupled with the entire research purpose. For this study, the development of the questionnaire represents a milestone indicating the transition from theoretical basis to empirical research. The information gained by conducting a vast literature review forms the basis, assisting researchers to set up the field, form questions, and refine the survey instrument to mirror the study's nature more appropriately.

Table 3: Likert Scale

Likert Scale Description	Likert Scale	Likert Scale Range	
Strongly Disagree	1	1- 1.80	Very Low
Disagree	2	1.90-2.60	Low
Neutral	3	2.70-3.40	Moderately High
Agree	4	3.50-4.20	High
Strongly Agree	5	4.30-5	Very High

There are four distinct areas in which the research questionnaire is utilized, and each is distinct in purpose and implication. Part A sets the context in which the demographic surroundings and condition of the respondents are examined prior to transitioning into more focused analyses, similar to how an introductory prelude serves to transition into the primary composition. Section B explores expert opinions through which their opinions and assessments of the different forms of green infrastructure along Iskandar Malaysia are exposed. Section C explores perception and how these skilled witnesses balance the value and perceived value added by green infrastructure. Section D explores the functional dimensions with an eye to exposing the intricate interactions between green infrastructure and the Iskandar Malaysia ecosystem. Finally, Part E discusses the challenges, detailing the impediments that cloud the progress achieved in enhancing the green infrastructure of the region. This kind of form provides a comprehensive description of the questionnaire used in this empirical adventure, acting as a descriptive visual support to accompany the written account.

Further, research introduces a new phase marked by systematic scrutiny and rigorous scrutiny after data have been gathered. Analysis of data is the process of converting raw data into meaningful implications which involves a sophisticated balancing act between interpretive subtlety and methodological elaboration. In essence, by mapping the intricate tapestry of numbers and figures, quantitative data analysis is the navigator that guides researchers to the illusive shores of knowledge and understanding. As Azila (2015) theorizes, this analysis journey is undertaken through a myriad of statistical techniques, all of which seek

to reveal the hidden patterns, trends, and relationships that lie beneath the surface of empirical reality.

RESULTS AND FINDINGS

The scholarly study presents the findings and conclusions drawn from a rigorous process of data collection and analysis. It incorporates questionnaires using the Likert Scale with insights obtained through a literature review from global methods utilized.

Participants' Background

The intricate mosaic of traits that make up a participant's demographic background presents key information on the composition of survey respondents. It contains numerous factors such as the years of work experience, job title, age, gender, marital status, and education level. Both genders are equally represented in the sample of respondents of this research, which comprises seven experts and a gender distribution of 57 percent female and 43 percent male.

The age distribution of the respondents reveals that they constitute different generations if analysed in finer detail. Six age ranges were utilized to place the participants in groups: 18–24, 25–34, 35–44, 45–54, 55–64, and over 65. Strikingly, 57% of the participants fall in the age range 35–44, which translates to considerable middle-aged representation within the sample. In addition, 43 percent of the sample is in the 45-54 age group, which means that a significant portion of the population is at the end of their working life. The sample's occupations add another dimension to the demographic profile. There was a move to introduce diversity from a work sector perspective, with 57% being from the public sector and 43% from the private sector. It is a conscious intention on the part of public sector as well as private sector professionals to make contributions towards the dataset in order to arrive at an informed understanding of insights emanating from disparate organizational settings.

Table 4: Experts' Profiles

Experts' Profiles			
Gender	Male (%)	Female (%)	
	43%	57%	
Age	35-44(%)	45-54(%)	
	57%	43%	
Agency	Public (%)	Private (%)	
	57%	43%	
Year of Experience	Less than 10 years (%)	10-20 years (%)	20-30%
	14%	43%	43%

The need to document the diversity of professional experience among participants is also highlighted by the research. The respondents in (Table. 4) to

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have a heterogeneity of positions and levels of experience, therefore marking the heterogeneity of the respondent samples. The research participants include novice and experienced practitioners up to veteran to provide diversity in the perspectives and opinion on the issue. The population characteristics of the study participants mark a keen consideration to accommodate representation in terms of diversity across diverse contexts. By including diversity in age, gender, occupation, and experience, the research seeks to provide strong findings commensurate with the intricate nature of the research question. Through this participative approach, topic development of the investigation is eased while making the study credible and reliable.

Green Infrastructure

The following describes chief results and inferences from results of the survey employed to obtain the data from specialists. Specialists in public organizations' green infrastructure and in organizations' green infrastructure offer their own perceptions through these results. There are four divisions in this chapter. To start with, demographical profile of survey respondents is presented. The next part consists of detailed discussion of results on green infrastructure specialists in Iskandar Malaysia. There is further explanation of these results through three sub-segments that align to specific research objectives. The section finally captures general discussion of research that captures all of its aspects.

Existing Typologies of Green Infrastructure

Opinions from specialists identify Iskandar Malaysia to have eight specific green infrastructure that have their ranks in decreasing order from their mean scores as considered vital for their community by their mean scores from expert opinions. They include sports field, parks, pocket space, water bodies, community space, residential garden, rooftop garden, courtyard, bioswales, permeable paver, hill forest, and flexible space that have their ranks in decreasing order from their mean scores. Sports field and parks ended up ranking as greatest of all these of interest that topped with their average score of 4.29 (see Table 5).

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Table 5: Available Types of Green Infrastructure in Iskandar Malaysia

Available Type of GI	Number of Experts							Mean Score
	1	2	3	4	5	6	7	
Parks and Playing Fields	**4**	**4**	**4**	**4**	**5**	**4**	**5**	**4.29**
Bodies of Water	**4**	**4**	**4**	**3**	**5**	**4**	**4**	**4.00**
Hill Forests	**4**	**3**	**3**	**2**	**5**	**4**	**3**	**3.43**
Pocket Spaces	**4**	**4**	**4**	**4**	**5**	**4**	**4**	**4.14**
Courtyards	**4**	**4**	**3**	**4**	**3**	**4**	**4**	**3.71**
Loose-Fit Places	**4**	**4**	**3**	**3**	**3**	**3**	**4**	**3.43**
Neighbourhood Open Spaces, Home Gardens, and Roof Top Gardens	**4**	**4**	**4**	**4**	**4**	**3**	**4**	**3.86**
Bioswales and Permeable Pavement	**4**	**4**	**4**	**3**	**3**	**3**	**4**	**3.57**

Parks and Playgrounds: They are the most ubiquitous types of green infrastructure (GI) in Iskandar. They are recreational facilities, providing space for exercising, recreation, and socializing with others. Playgrounds and parks have a median value of 4.14, thus making them worth so much that they help boost residents' living conditions. And lastly, stash spaces hold a massive portion of all the GI. Those small patches of green amidst the concrete city give moments of respite and an injection of nature. Unjustly enough, they mostly have a numeric score of 4.00. Besides, Iskandar Malaysia has its water system of bodies that fit in with surrounding green cover. With a mean callous rating of 4.00, these water bodies provided biological benefits as well as adding beauty. They maintain biodiversity, manage microclimates, and improve general environmental health.

Another benefit is that open areas in the neighbourhood, home gardens, and rooftops gardens are easily accessible. Experts verified their proximity in Iskandar Malaysia, determining a mean standard score of 3.86. They are supportive of well-being, enable urban farming, and promote a sense of community. In addition, backyards conventionally positioned in open structures or house complexes obtain a mean score of 3.71. These comparatively hidden areas are serene and add to indoor living areas. Their development has significant effects on overall urban participation. Last but not least, pervious asphalt and bioswales receive an average score of 3.57 for their contribution to more affordable stormwater management. They capture moderate floods, filter out contaminants, and reroute groundwater.

Hillside open land and woodland have high scores of 3.43, but there are complications attached. One scientist does not know what to expect, although most experts do not either. We need to exert out-of-the-ordinary effort in preserving and defending nature in the face of uncertainty. Iskandar, Malaysia's mangrove forest is losing trees in accordance with other trends in the same direction throughout the region. Peninsular Malaysia lost approximately 19% of its mangrove cover between 1990 and 2010, and Johor lost approximately 20%

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of its mangrove cover (Hamdan, 2012). In general, Iskandar Malaysia's green and blue infrastructure is caught in the middle of all this. Therefore, towards a sustainable future, however, something has to be done in order to plant more trees, sequester carbon, and reduce greenhouse gas emissions.

Table 6: Values and Benefits of Green Infrastructure in Iskandar Malaysia

Category	Value and Benefit of GI	Number of Experts							Mean Score
		1	2	3	4	5	6	7	
Social Value	Provide Goods and Products	4	4	4	2	4	4	4	3.71
	Improvements to People's Physical Health	5	4	5	4	5	4	4	4.43
	Improvements to People's Mental Health	4	4	5	1	5	4	4	3.86
	Encouraging Active Travel	4	4	5	4	4	4	3	4
	Improving Social Cohesion	4	4	5	4	3	4	4	4
	Increasing Connectivity for People and Nature	4	4	5	4	4	4	4	4.14
Environmental Value	Reducing Overheating in Urban Areas	5	4	5	2	5	5	4	4.29
	Increasing Biodiversity	4	4	5	4	4	4	4	4.14
	Improving Local Air Quality	5	4	5	4	5	4	5	4.57
	Protecting The Environment	5	4	5	4	4	3	4	4.14
	Flood Mitigation and Storm Water Management	4	4	5	5	4	5	4	4.43
Economic Value	Attracting Investment into The Area	4	4	5	5	4	5	4	4.43
	Private And Public Cost Savings	5	4	4	4	4	4	3	4
	Attracting Skilled Workers to The Area	4	4	3	3	3	4	3	3.43
	Increasing or Sustaining Tourism	4	4	5	4	4	3	4	4

The Importance and Benefits of Green Infrastructure in Iskandar Malaysia

The fifteen of these have been established by seven experts on basis of their scores' averages of mean that reflect upon how much significance or advantage green infrastructure (GI) has in Iskandar Malaysia from Table 6. Attraction of skilled workers to Iskandar was found to have lowest significance or advantage in regard to GI with average score of 3.43. At other extreme was improvement of locality air quality that was found to have greatest significance or advantage of GI with average score of 4.57. Through analysis of scores' averages of mean, improvement of locality air quality, good condition of body of people, mitigation of flooding, regulation of stormwater, attraction of investment, mitigation of overheating, and protection of environment have greater significance or advantage to GI in Iskandar Malaysia than other of these with scores of 4.57, 4.43, 4.43, 4.29, and 4.29 on average, respectively.

These findings demonstrate that all these specialists agree on aspects that contribute immensely to Iskandar Malaysia in GI benefits as well as GI

values. As in accordance to Iskandar Malaysia policy that states that qualities of lake, large trees, as well as waterways contribute immensely to cooling off of high temperature as well as greenhouses by acting as carbon sinks by absorbing CO2 in abundance while maintaining terrestrial as well as aquatic biodiversity, these aspects have importance to their plan by Hamdan (2012), where he concluded that mangrove tree population in Johor dropped by 20% from 1990 to 2010 in order to further take account of how much it is needed to preserve as well as further GI in Iskandar Malaysia. Aside from that, with score of 4.14 on average, all these specialists concluded that Iskandar Malaysia is benefited from green infrastructure in biodiversity, connectedness to nature, as well as environmental protection.

This aligns with Iskandar Malaysia's policy to preserve mangrove forests as natural buffers to guard against intense gusts of wind, waves, and tsunamis, as well as to mitigate erosion of land and flooding. Because of these outcomes, these results have influenced Iskandar Malaysia's policy formation. Aside from that, these professionals have cited GI in Iskandar Malaysia in promoting tourism so that for transport to actively take place, community bonding is established, as well as cost savings by publics and privately—these all having mean scores of 4.00. All these results concur with Iskandar Malaysia's GI strategic plan to synchronize environmental, societal, and economic facets to create smart cities. There are six smart city elements to smart cities that include (1) smart people; (2) smart living; (3) smart mobility; (4) smart environment; (5) smart economy; and (6) smart governance. Because of these results, GI not only makes Iskandar Malaysia inviting to investors but is used to mitigate flooding in that region on a recurring basis.

Challenges Hindering the Enhancement of Green Infrastructure

As indicated in Table 7, professionals differed in their perceptions of greatest hindrance to green infrastructure promoting in Iskandar Malaysia. Regulation hindrance was initially quoted as greatest hindrance with maximum score of 3.29. Technical hindrance was followed by scores of 3.14 while that of context hindrance was 3.00 in that order. Surprisingly enough, differentiation was not achieved in structural hindrance and that of cultural/behavioural hindrance where these achieved on average score of 2.86. Thus, it would thus seem that professionals in general agree that greatest challenges in demarcating and practicing GI in Iskandar Malaysia include context, technical, and regulation hindrance.

Table 7: Barriers to Green Infrastructure in Iskandar Malaysia

Barriers	Number of Experts							Mean
	1	2	3	4	5	6	7	Score
Structural Barriers	4	2	3	4	3	3	1	2.86
Regulatory Barriers	4	2	4	5	4	3	1	3.29

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Barriers	Number of Experts							Mean Score
	1	2	3	4	5	6	7	
Cultural/Behavioural Barriers	4	2	4	4	2	3	1	2.86
Contextual Barriers	3	2	3	4	3	3	3	3
Technical Barriers	4	2	2	4	4	3	3	3.14

Additionally, the findings indicate that GI in IM will be significantly impeded by regulations related to policies that are ill-defined. Thus, this finding is consistent with Iskandar Malaysia's goal of instituting laws and regulations for green space in IM. Additionally, it was found that professionals strongly acknowledge technical implementation problems and contextual factors as obstacles to developing green infrastructure. Last but not least, behavioural, cultural, and structural barriers were classified as average barriers to GI in Iskandar Malaysia. Needless to say, in cities such as Iskandar, Malaysia, culture plays a part in sustaining GI. The various types of barriers are summarized below:

Structural Barriers: Barriers that come as a result of the specific arrangements and work processes of organizations and institutions. Therefore, by altering how these organizations work and set and attain their goals, these practices can have an impact on new programs.

- Regulatory Barriers: Challenges arising from the manner in which the activities of the citizens are monitored and regulated by a government or an organization and the laws to which they are subject.
- Cultural and behavioral barriers: The impact of the attitudes, traditions, beliefs, and mentality of individuals holding pivotal positions in an organization.
- Contextual Barriers: Problems and priorities brought about by external sources which call for an institution's or state's attention.
- Technical Barriers: Functional or structural obstacles which deter or postpone the development of green infrastructure.

Insights from Specialists Regarding Additional Barriers and Supporting Factors

The expert analysis identified a range of other barriers to the growth of green infrastructure in Iskandar Malaysia. The funding cap is an issue because insufficient funding limits the capacity to implement sustainable actions and slows development. The major barrier is the cost of maintenance, which stretches available resources and is a source of concern for stakeholders. The complicated administrative structure, with its creation of conflict regarding the departments or the lead agencies charged with maintenance and enforcement, is an added source of complexity. This lack of clarity makes efficient stewardship cumbersome and

makes it difficult to maintain accountability in the infrastructure development process.

In addition, the resource allocation issue further exacerbates existing challenges by pitting organizations against each other for limited resources while they strive towards competing goals. Since it often leads to prohibitive expenses for developers who want to adopt green solutions, this shortage also hinders progress. A holistic approach through stakeholder cooperation, streamlined governance structures, and strategic fiscal planning is needed to overcome these challenges. By promoting collaboration and innovation, achieving the potential of its green infrastructure initiatives, and spearheading green growth and sustainable development in the area, Iskandar Malaysia can excel in these challenges. Additionally, the experts presented an all-encompassing strategy for incorporating green infrastructure in Iskandar Malaysia to excel in the challenges they encountered. The method outlined in this plan is multi-dimensional and begins with the promotion of the public and private sectors' collaboration. By collaborating and partnering to leverage the strengths and resources of both sectors, the realization of sustainable infrastructure projects can be expedited. This method can bypass the issue of finance, streamline processes, and energize imagination.

DISCUSSIONS

In the first place, taking Chinese studies as an example, "ecological security" studies typically apply concepts such as continuity and multi-functionality alongside the precepts of landscape ecology like the patch-corridor-matrix (Wang et al. 2018). Furthermore, Asian studies have suggested that sacred sites like temples and cemeteries, and urban green spaces like parks, gardens, campuses, and greenways need to be preserved to ensure biodiversity (Qiao et al. 2019). Some examples of how GI studies in Asia exhibit positive health impacts are the utilization of leftover forests for environmental variables (Foo, 2016), a decrease in stress induced by visits to parks (Paul and Nagendra, 2017), and increased physical activity and social bonding through local greenspace (Paul and Nagendra 2017).

To begin, based on Iskandar Malaysia, this study determines eight various forms of green infrastructure. These include a range of features, including courtyards, bioswales, hill forests, parks, pocket spaces, water features, and loose-fit areas (Zhang et al., 2019). These are ordered according to their mean scores, demonstrating how the parks, sports fields, pocket spaces, and water bodies in the area are all connected. The study also sheds light on how green corridors will help increase the sequestration of carbon as well as reducing the impacts of greenhouse gas emission in urban environments. Green corridors include permeable pavement, bioswales, home and roof gardens, as well as community open spaces. It does acknowledge the loss of vegetation along the

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corridors of a city and proposes replanting and reforesting policies for reversing this tendency. The study finds many of the infrastructure components required for the development of Iskandar Malaysia, which are compared with green infrastructure requirements set in the UK and Germany. Permeable pavements, green roofs and walls, play spaces, greening of infrastructure, street trees, and urban parks are just a few of them (Foo, 2016).

The report also analyses ten other green infrastructure components that are essential for Iskandar Malaysia in mitigating successfully environmental issues like climate change and global warming. These include garbage bins, recycle bins, EV charging stations, rainwater collection systems, bike lanes, building complex fountains, covered pedestrians' walkways, retention ponds, and electric buses. Ngulani and Shackleton (2019) found that despite the potential advantages, Iskandar Malaysia's green infrastructure development is restrained by structural and cultural barriers. These barriers include financial limitations, maintenance expenses, jurisdictional disputes, and high implementation costs for developers.

It was the second instance for this study to enumerate fifteen green infrastructure values and benefits in Iskandar Malaysia. The 15 green infrastructures found are ranked from the highest to the lowest benefit and value, and some of these are (1) enabling physical health; (2) flood and stormwater management mitigation; (3) local air quality enhancement; and (5) investment attraction to the area. Reducing overheating, improving biodiversity, creating connectivity with nature and humans, sustaining tourism, facilitating active transport, fostering social cohesion, saving private and public funds, improving mental health of people, providing goods and products, and attracting skilled employees are just some of the benefits.

Urban green infrastructure offers the advantage of regulatory environmental governance to city dwellers. The presence of green spaces in Bangalore, for instance, lowers the temperature of the city by 3 to 5 degrees Celsius through the minimization of pollutants and suspended particulate matter, thereby improving the city's air quality, as stated by Gopal (2011). A further example of microclimatic control is provided by the Addis Ababa residential urban morphological types (UMT) mapping project through the regulatory services in addition to the context (Cavan et al., 2014).

CONCLUSION

There was a careful analysis of fifteen values and advantages of green infrastructure in the Iskandar Malaysia research. These are the material advantages, such as improvements to local air quality, which directly add to the physical well-being of people. And, in an area with these kinds of natural hazards, green infrastructure is essential for flood control and stormwater management. Along with this, it also brings in investment and maintains economic programs

of growth and sustainability. Less overheating and the stimulation of biodiversity, green infrastructure also enhances environmental resilience and the quality of life for residents overall. Connectivity is another significant benefit that encourages community spirit and awareness of the environment alongside making tangible connections between humans and nature. By ensuring an infrastructure that supports active travel, it reduces dependence on motorized transport and the ensuing environmental impacts. In addition to social cohesion and recreational aspects, green infrastructure enhances the psychological well-being of individuals in the community. Furthermore, in offering solutions for all natural causes of an array of concerns, including erosion prevention and minimizing the urban heat island effect to further improve performance, it enhances public and private savings.

Furthermore, a critical scrutiny of the topography of Iskandar Malaysia revealed an intricately intertwined tapestry of green infrastructures throughout the area. On examination, eight different types of these infrastructures were found, each of which made a distinct contribution to the ecological resilience and sociocultural vitality of the area. At the top of this hierarchy are beautifully groomed parks and large playing fields that are great centres for recreation and socialization, encouraging physical health and social integration in the midst of the city's bustle. With further investigation, the understated elegance of neighbourhood parks, rooftop gardens, and home gardens is uncovered. Each is a testament to its elegance and promotes a deep connection with nature amidst urbanization. Despite the above evident benefits, the study indicates a number of constraints to the construction of green infrastructure in Iskandar Malaysia. These include cultural and behavioural factors, technology factors, contextual limitations, structural limitations, and regulatory barriers. These barriers need to be established for green infrastructure projects to be properly implemented and maintained.

ACKNOWLEDGMENTS

This is a culmination of an academic exercise that is part of a research project whose purpose is to culminate in the field of Architecture.

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Received: 1st September 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 265 – 274

THE IMPACT OF ROOF SIZE ON THE DIMENSIONS AND EFFICIENCY OF RAINWATER COLLECTION TANKS USING TANGKI NAHRIM 2.0

Naim Shauqi Mohd Noor[1,2*], Faridahanim Ahmad[1,3*], Rozana Zakaria[1], Ahmad Farhan Hamzah[2]

[1]* *Faculty of Civil Engineering,*
UNIVERSITI TEKNOLOGI MALAYSIA
[2]*National Water Research Institute of Malaysia (NAHRIM),*
UTM CONSTRUCTION RESEARCH CENTER (CRC), BLOK C09, FACULTY OF CIVIL ENGINEERING, 81310 UNIVERSITI TEKNOLOGI MALAYSIA, JOHOR DARUL TAKZIM, MALAYSIA

Abstract

The phenomenon of global warming, coupled with the growing global population, has a direct and significant influence on the demand for water worldwide. In Malaysia, the use of drinkable water is significantly higher compared to other nations, and the primary supply of drinkable water is predominantly surface water. Rainwater harvesting is a widely adopted alternative for water resources globally. Despite Malaysia's copious rainfall, rainwater collection remains unpopular in the country. Houses of varying sizes have corresponding variations in roof sizes, which in turn necessitate variable sizes of rainwater tanks. This study employed the use of Tangki NAHRIM 2.0 (TN2), a web tool, to calculate the most suitable tank capacity for a rainwater collecting system. The analysis was conducted for five distinct roof sizes, with the focus on meeting non-potable water requirements. The TN2 simulation employs a daily water balance model that utilizes rainfall data from an integrated database, following the yield-after-spillage (YAS) protocol. The ideal capacities for rainwater tanks for five distinct roof sizes range from 2.6 m3 to 3.8 m3. These tanks exhibit water-saving efficiency values ranging from 59% to 76.2% and storage efficiency values ranging from 30.9% to 53.9%. A larger tank capacity provides greater water-saving efficiency, but at the expense of reduced storage efficiency. The product will be valuable for the implementation of RWHS in residential buildings.

***Keywords**:* Rainwater harvesting, Water, Storage, Efficiency, Residential

[1] Corresponding author. Email: naimshauqi.mohdnoor@gmail.com

INTRODUCTION

The global population growth has led to a rise in the demand for water across all areas of production. Furthermore, climate change is amplifying the occurrence and severity of both droughts and storms worldwide. Currently, the increasing problem of river contamination is causing disruptions to water supplies in Malaysia, as the country relies on rivers as a primary source of water. The pollution of rivers poses a significant threat to the long-term viability of water resources. Malaysia's per capita household water usage is from 209 to 228 liters per day, which is considered excessive when compared to the World Health Organization's recommended level of only 165 liters per day(Zabidi et al., 2020). Moreover, Stec et al. (2019) found that more than 50% of water used in households is for non-potable purposes(Stec & Zeleňáková, 2019). One method to attain a sustainable infrastructure is by implementing Rainwater Harvesting Systems (RWHS). RWHS, or Rainwater Harvesting Systems, enhance the water supply and mitigate flooding by reducing the amount of surface runoff that enters drains and rivers. They also assist alleviate combined sewer overflows (CSOs) and minimize the long-term withdrawal of water from surface sources (Gold et al., 2010).

Rainwater harvesting is a widely adopted alternative for water resources globally. Malaysia is a nation that experiences a significant amount of precipitation. Nevertheless, the utilization of rainwater harvesting in Malaysia remains rather limited. The research, analysis, and implementation of Rainwater Harvesting Systems (RWHS) for residential residences are currently not as extensive as those for government buildings (Lani et al., 2018). For instance, Hashim et al. (2013) conducted a simulation of a model representing a large-scale Rainwater Harvesting System (RWHS) (Hashim et al., 2013). Their findings indicate that the ideal capacity for the storage tank is 160 m3 with a dependability of 60%, given a roof area of 20,000 m2. In their study, Hamid et al. (2011) discovered that by using a storage tank with dimensions of 40m × 35m and a depth of 5m, a student hostel with a roof area of 3000m^2 could save 6500m^3 of treated water annually (Abd Hamid & Nordin, 2011). This leads to a yearly reduction in water expenses of around RM10460. A study on RWHS for institutional application at the Infrastructure University Kuala Lumpur (IUKL) Bangi Campus (Al-Saffar et al., 2016). They used Tangki Nahrim 1.0 (TN) for their research. The chosen tank sizes for the two academic blocks are 75 m3. These tanks provide water saving efficiencies of 81% and 93% respectively. In a study conducted by Kuok Kuok et al. (2020), it was determined that Rainwater Harvesting Systems (RWHS) can be used for non-potable purposes in residential buildings in Kuching, Sarawak (Kuok Kuok et al., 2020). The study found that the ideal size for the RWHS tank in double-story residences in Kuching is 2m^3. In a recent study conducted by Goh et al. (2021), it was shown that the ideal size

for a rainwater harvesting system (RWHS) tank for a $100m^2$ roof area in Kuala Lumpur is $3m^3$ (Goh & Ideris, 2021). This tank size is capable of meeting 90% of the non-potable water demand using rainwater.

The size of the roof or catchment area is a crucial element of RWHS. However, the varying sizes of houses necessitate different roof sizes, which in turn require variable quantities of rainwater tanks. Gurung (2012) found that tanks make up 30% of the total expenses over the lifespan of the RWHS and are the most expensive individual component (Gurung & Sharma, 2012). Therefore, choosing the wrong size of rainwater tank will result in resource wastage if it is too large, and poor system efficiency if it is too small. Therefore, this study aims to identify the most suitable rainwater harvesting tank capacities for different sizes of residential roofs. The output will be valuable for the implementation of Residential Water Harvesting Systems (RWHS) in residential.

RESEARCH METHODOLOGY

TN2.0 is an enhanced iteration of a web application created by the National Hydraulic Research Institute of Malaysia (NAHRIM). The system is specifically created and developed to determine the most suitable tank capacity for Rainwater Harvesting Systems (RWHS) in Malaysia, taking into account the available rainfall data. TN2.0 utilizes an R-based water balance model. There are two categories of water balance models, namely Yield Before Storage (YBS) and Yield After Storage (YAS). The YBS model employs a strategic methodology, wherein the collected rainwater is utilized for daily purposes, while the remaining amount is kept in a reservoir for future usage. The YAS concept follows a conservative strategy by initially collecting rainwater and directing it to the tank, while any surplus rainfall is then discharged through overflow. The tank will be utilized to measure the daily usage.

YAS and YBS were two models created by Jenkins et al. (1978) to analyze the temporal and volumetric performance (Jenkins & Pearson, 1978). YAS stands for the utilization of rainwater that occurs after the release of excess rainwater, whereas YBS refers to the utilization of rainwater that occurs before the release of excess rainwater. According to Fewkes et al., YAS was determined to offer a cautious estimation, whereas YBS yielded the opposite result. Therefore, YAS was suggested as a better choice compared to YBS (Fewkes&dagger et al., n.d.).

Study Area

The study situated in Putrajaya, Malaysia. This study examined five distinct categories of houses. The dimensions of the houses range from 6m by 21m, 7m by 21m, 9m by 21m, 10m by 21m, to 13m by 21m. The sizes of the houses are deemed equivalent to the sizes of the roofs. The closest rainfall station is station

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ID: 2916001 Puncak Niaga Putrajaya, situated approximately 10km radius from the research area.



Figure 1: Study area rainfall station is station ID: 2916001 Puncak Niaga Putrajaya

Figure 2 illustrates the annual variations of rainfall from 1997 to 2017, with an average rainfall amount of 2067 mm. Figure 3 illustrates the monthly variation in rainfall. The biggest quantity of rainfall occurs in November due to the North-East Monsoon, while there is a smaller peak in June during the inter-monsoon season. The significant annual and monthly precipitation levels indicate that the region is suitable for rainwater harvesting (Goh & Ideris, 2021). Therefore, the effectiveness of the rainwater harvesting tank is directly influenced by the intensity of rainfall in the area.

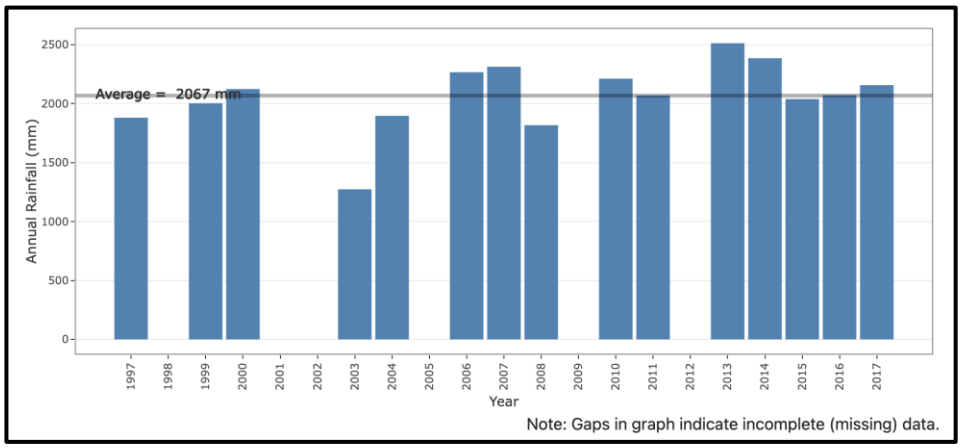


Figure 2: Annual rainfall pattern at Putrajaya Station from 1997 until 2017 with an average of 2067mm

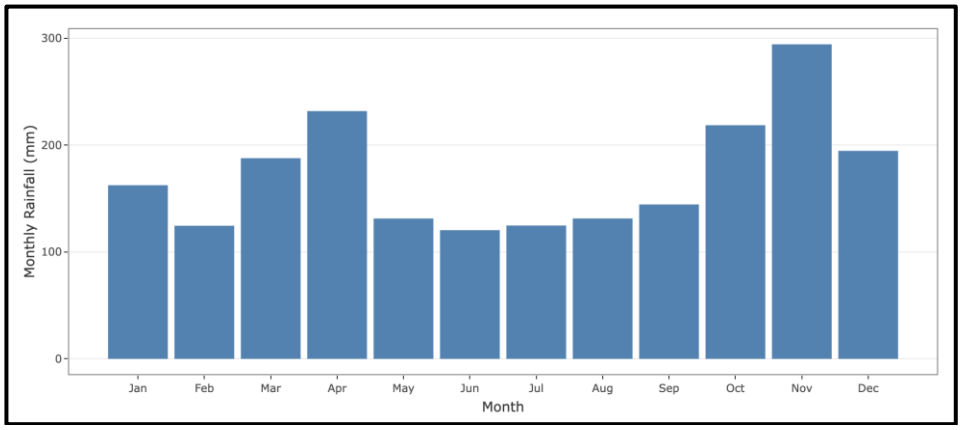


Figure 3: Average monthly rainfall pattern at Putrajaya Station

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RESULT AND DISCUSSION

The simulation results for the five different sizes of housing are depicted in Figures 4 to Figure 7. These figures display the curves representing water-saving and storage efficiency in relation to the range of tank capacities, supposing a consistent daily non-potable demand. The graph exhibits a linear growth pattern, indicating that as the size of the tank increases, the amount of water that may be collected also increases, contingent upon the desired level of water conservation.

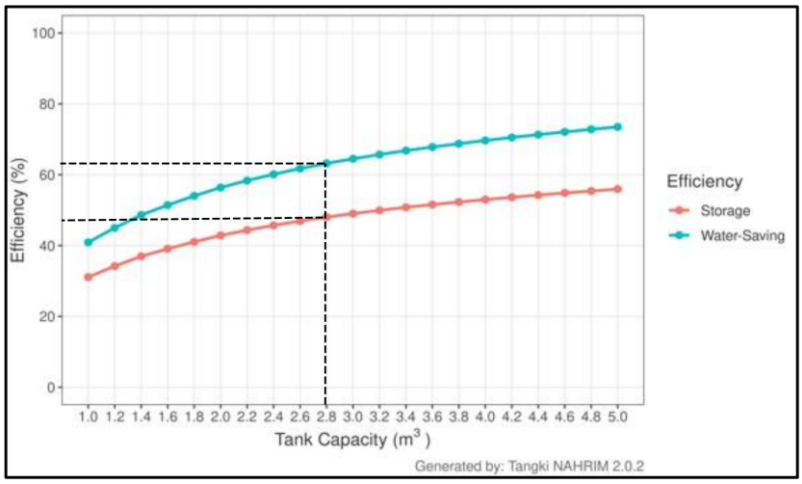


Figure 4: Roof size area 156m^2

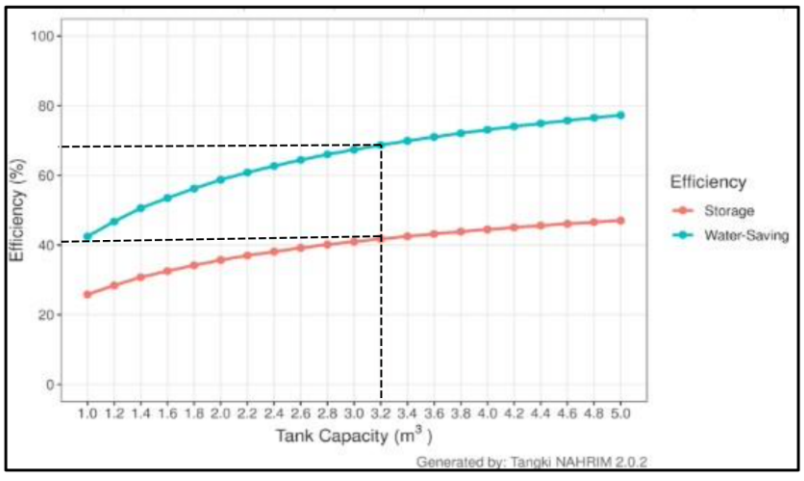


Figure 5: Roof size area 195m^2

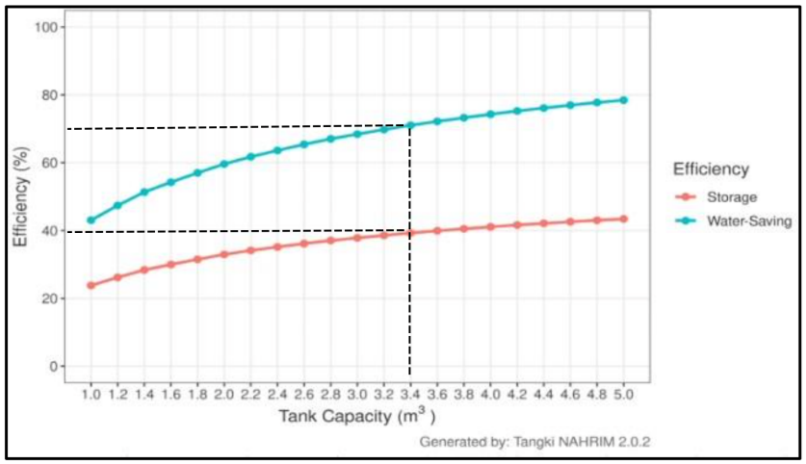


Figure 6: Roof size area 215m^2

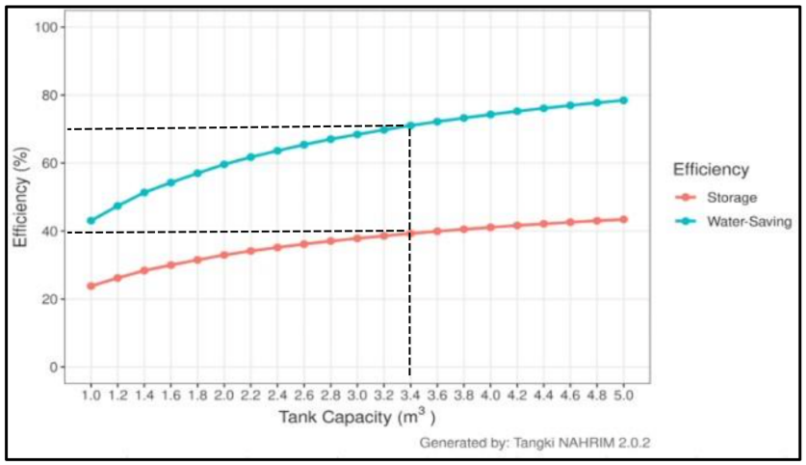


Figure 7: Roof size area 292m^2

Figure 4 to Figure 7 show the comparing water-saving and storage efficiency for different roof sizes: a) 130m^2, b) 156m^2, c) 195m^2, d) 215m^2, and e) 292m^2.

The determination of the ideal tank size for each housing mostly relied on the analysis of water-saving and storage-efficiency curves. An increase in tank sizes leads to an improvement in efficiencies until the percentage of efficiency gains becomes less significant as the tank size increases (Goh & Ideris, 2021). The point at when the graphs began to level out is observable. Through careful

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observation, it was determined that the ideal tank sizes for each dwelling are 2.6m^3, 2.8m^3, 3.2m^3, 3.4m^3, and 3.8m^3. These tanks have water-saving efficiency values ranging from 59% to 76.2% and storage efficiency values ranging from 30.9% to 53.9%. A water-saving efficiency of 59% means that 390.8 litres of rainwater can be used out of a total daily non-potable demand of 662.3 litres.

The water-saving efficiency is directly proportional to the increase in roof area. The water-saving effectiveness of a tank with a size of 2.6 m^3 is just 59%, which is the lowest among all options. The largest roof size provides a greater water-saving efficiency of 76.2% for the same daily water demand. Figure 8 shows the relationship between tank size and water-saving and storage efficiencies.

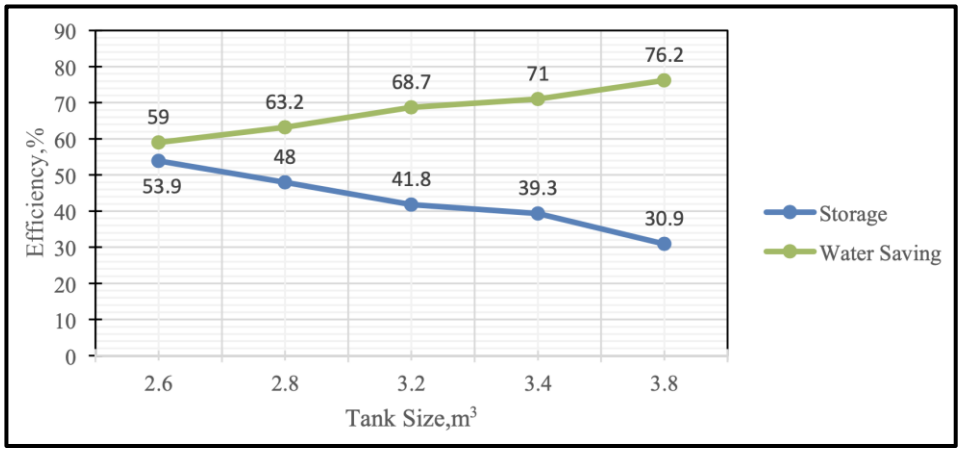


Figure 8: Comparison of tank sizes in relation to storage capacity and water-saving effectiveness

A reduced roof surface area can only collect a limited amount of rainwater. By expanding the roof area, the inflow of water into the tank will rise, hence enhancing the tank's volume reliability. According to reference (Khan et al., 2017), the reliability of a tank increases as the catchment area increases, given a specific tank size. However, the efficiency of storage has an inverse correlation with the efficiency of water conservation. Using a larger rainwater tank will result in decreased storage efficiency. The storage efficiency declined from 53.9% to 30.9% with an increase in tank size from 2.6m^3 to 3.8m^3. Storage efficiency is determined by the combined factors of spillage and roof runoff volume. When the spillage volume decreases, the storage efficiency improves. Low storage efficiency indicates that a significant proportion of the rainfall collected by the roof is lost through drainage. Due to the low water demand and high rainfall volume, there will be an increase in spillage, resulting in a decrease in storage

efficiency (Goh & Ideris, 2021). This aligns with the precipitation pattern in the western region of Peninsular Malaysia, which is impacted by the inter-monsoon periods and marked by intense convective storms.

CONCLUSION

This study utilized TN2.0, a web-based application, to calculate the ideal tank capacity for five distinct roof sizes of a residential dwelling in Selangor, while maintaining consistent daily water consumption. TN2.0 utilizes a decade's worth of daily precipitation data for its simulation. The ideal sizes for rainwater (RW) tanks for non-potable use in residences with roof sizes of $130m^2$, $156m^2$, $195m^2$, $215m^2$, and $292m^2$ are determined to be $2.6m^3$, $2.8m^3$, $3.2m^3$, $3.4m^3$, and $3.8m^3$, respectively. A larger roof size necessitates a larger optimal tank size. The ideal capacities for rainwater tanks for five distinct roof sizes range from $2.6m^3$ to $3.8m^3$. These tanks exhibit water-saving efficiencies ranging from 59% to 76.2% and storage efficiencies ranging from 30.9% to 53.9%. As the capacity of the tank increases, the water-saving efficiency will also improve for the same level of demand. However, when faced with similar demand, the storage efficiency of a larger rainwater tank decreases.

This study specifically examines the implementation of TN2.0 in residential dwellings. However, it is recommended that TN2.0 be extended to include commercial and industrial structures in future applications. It is advisable to further investigate the impact of geographical rainfall patterns on the size and performance of rainwater tanks. Subsequent studies might examine the impact of different roof technologies on the efficiency of tanks. Elevated temperatures on the rooftop will inevitably impact the gathering of rainfall. Another aspect that should be investigated is how the tank performs when there are changes in water demand. The demand fluctuation can occur on a daily, weekly, or user count basis.

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Received: 17th January 2025. Accepted: 10th March 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 275 – 289

KEY INDICATORS INFLUENCING THE MAINTENANCE PLANNING OF MASJID KARIAH'S FRAMEWORK IN KELANTAN, MALAYSIA

Azhar Yusof[1], Mohamad Ridzuan Yahya[2], Faridah Ismail[3], Siti Fatimah Hashim[4]

[1,2,3,4]*College of Built Environment,*
UNIVERSITI TEKNOLOGI MARA

Abstract

Effective maintenance is crucial for preserving mosques as sacred spaces and community hubs, requiring coordination and commitment to meet the needs of worshippers. In Malaysia, there are 6,351 Masjid Kariah, the highest among mosque types, yet most maintenance planning studies focus on Masjid Negeri. Additionally, no formal measurement criteria exist for Masjid Kariah maintenance, creating a significant research gap. This study examines maintenance planning in 59 Masjid Kariah across 10 districts in Kelantan, representing 10% of the total in the state. The research evaluates the relationship between seven Maintenance Performance Measurement indicators (organization management, planning and scheduling, financial provision, service quality, assessment, resource allocation, and safety and health) and three Maintenance Strategy Criteria (Planned Preventive, Planned Corrective, and Unplanned Maintenance). A total of 354 questionnaires were distributed to key committee members, including nazir, deputy nazir, secretary, deputy secretary, treasurer, and the bureau of development, using systematic and stratified sampling. Findings reveal that four indicators: planning and scheduling, service quality, assessment, and resource allocation were positively influence the maintenance planning. However, organization management, financial provision, and safety and health did not show significant effects. These findings provide practical insights to improve maintenance strategies for Masjid Kariah in Kelantan, addressing the less impactful indicators for better overall maintenance planning.

Keywords: Masjid Kariah, Maintenance Strategy Criteria, Maintenance Performance Measurement, Malaysia

[1] Corresponding author. Email: azharbinyusof@gmail.com

INTRODUCTION

According to Johnson & Crossing (2020), the global Muslim population increased from about 570 million in the 1970s to 1.9 billion in 2020, with the most substantial growth occurring in Asia; within this trend, Malaysia has emerged as Southeast Asia's second-largest Muslim nation (Latief et al., 2021). For Muslims, the mosque (Masjid) functions as the primary place of prayer and is commonly defined as "a place for prostration" (Sofii & Pertiwi, 2021; Hassan et al., 2021; Shoemaker, 2021). In Malaysia, where the Muslim population exceeds 19 million and the number of mosques surpasses 6,000, mosques are classified into four levels: Masjid Negara, Masjid Negeri, Masjid Daerah, and Masjid Kariah (Department of Islamic Development Malaysia, 2021). Masjid Kariah is the most prevalent typology and is established across districts nationwide; however, maintenance research and planning have largely prioritised State and District Mosques, leaving Masjid Kariah underexplored, often due to resource constraints. In practice, mosques face persistent maintenance challenges such as limited funding, shortages of skilled labour, and the need to reconcile traditional architectural elements with modern construction techniques (Hamdan et al., 2023). Since buildings, including mosques, inevitably require maintenance throughout their life cycle to remain functional (Ali et al., 2013), this study addresses the gap by examining Masjid Kariah maintenance planning and evaluating the relationships between seven Maintenance Performance Measurement indicators and Maintenance Planning (Maintenance Strategy Criteria).

MAINTENANCE PLANNING IN MASJID KARIAH'S PERSPECTIVE

The British Standard 3811 (BS3811) provides a key framework for building maintenance in sectors such as offices, hospitals, and apartments. Maintenance includes technical and administrative actions to keep facilities functional, while maintenance planning focuses on timely replacement of worn components to reduce cost and extend service life (Laham & Dalalah, 2020). As important religious facilities, Masjid institutions require structured maintenance planning to support daily worship and community programs. Masjids are classified into five levels, with Masjid Kariah at the community level under State Islamic Religious Councils (e.g., MAIS, MAINS). However, limited funding and weak institutional focus often cause deterioration (Kalumbu et al., 2016; Mohamad, 2019b). This gap highlights the need for a formal framework using maintenance strategies and performance indicators, supported by evidence that proactive maintenance improves outcomes (Swanson, 2001).

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Maintenance Planning (Maintenance Strategy Criteria) Indicator

Maintenance planning is effective only when supported by an appropriate strategy that guides organisations toward their objectives (Ding & Kamaruddin, 2015; Waeyenbergh & Pintelon, 2002). Strategy evaluation also helps detect weaknesses and refine actions for better results (David, 1986). Guided by British Standard 3811 (BS3811), this study focuses on three maintenance strategies for Masjid Kariah: planned preventive, planned corrective, and unplanned maintenance. Planned preventive maintenance consists of scheduled or condition-based activities to prevent defects, reduce failures, and minimise emergency repairs (Izobo-Martins, 2014). Planned corrective maintenance restores function after failure and is widely practised (Waeyenbergh & Pintelon, 2002). Unplanned maintenance is triggered by unexpected damage requiring immediate response (Ing, 2008; Rani et al., 2015). These strategies collectively aim to improve the overall maintenance planning and performance of Masjid Kariah. Figure 1 shows the overview of maintenance strategy in buildings based on British Standard BS3811.

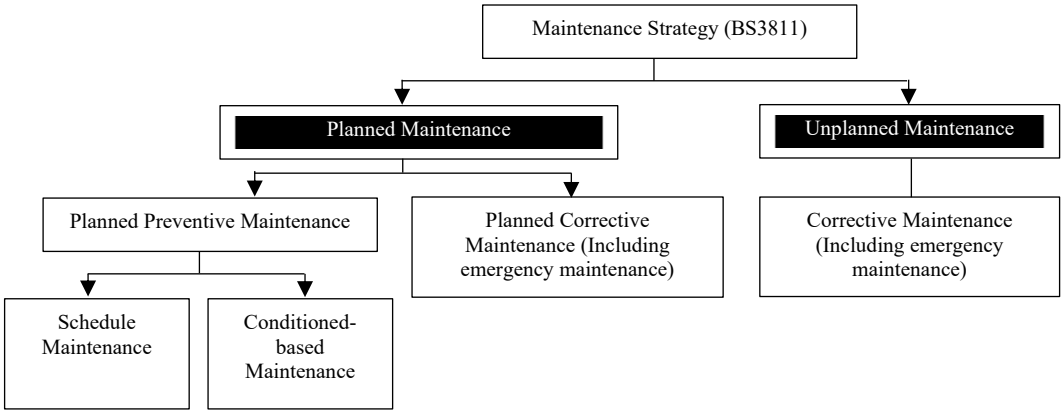


Figure 1: The Overview of Maintenance Strategy in Buildings based on British Standard BS3811 (the shaded box shows maintenance strategy criteria that has been employed in this study)

Source: BS3811 (1993); Chanter and Swallow (2008); Leong (2004); Mohammed and Wan Mat (1991); Seeley (1987); Wireman (2013)

Maintenance Performance Measurement Indicator

Maintenance performance measurement, as defined by Amaratunga (2001), quantifies the efficiency and effectiveness of maintenance activities, helping to assess strengths and weaknesses in planning (Amaratunga & Baldry, 2002a). These measurements evaluate the success of maintenance strategies and have

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been adapted to fit Masjid Kariah maintenance planning in Malaysia based on models like the General Maintenance Management Model (Tsang et al., 1999) and Performance Measurement Model (Cholasuke et al., 2004), alongside other studies. Seven key indicators have been identified: organization management, planning and scheduling, financial provision, service quality, assessment, resources allocation, and safety and health. Organization management covers policy deployment, human resource management, and continuous improvement. Planning and scheduling focus on arranging and optimizing maintenance work within a set timeframe through approaches such as record management and communication. Financial provision involves budgeting and fund allocation to ensure cost efficiency. Service quality ensures user satisfaction by emphasizing reliability, assurance, and responsiveness. Assessment addresses the sustainability of building assets through evaluations of structural and service conditions. Resource allocation involves managing contracts, spare parts, and equipment to support maintenance goals. Safety and health focus on creating a safe and comfortable environment for users. These indicators provide a structured framework for enhancing Masjid Kariah maintenance performance.

Relationship between Maintenance Planning (Maintenance Strategy Criteria) and Maintenance Performance Measurement

What are the key indicators in the relationship between seven indicators of Maintenance Performance Measurement (organisation management, planning and scheduling, financial provision, service quality, assessment, resources allocation and safety and health) towards the Maintenance Planning (maintenance strategy criteria: Planned Preventive Maintenance, Planned Corrective Maintenance and Unplanned Maintenance) of the Masjid Kariah? The PLS-SEM model assessment has been used to verified the hypothesis of this study:

H1: Organization Management (OM) has significantly positive influence on Masjid Kariah Maintenance Planning (MKMP)
H2: Planning and Scheduling (PS) has significantly positive influence on Masjid Kariah Maintenance Planning (MKMP)
H3: Financial Provision (FP) has significantly positive influence on Masjid Kariah Maintenance Planning (MKMP)
H4: Service Quality (SQ) has significantly positive influence on Masjid Kariah Maintenance Planning (MKMP)
H5: Assessment (AS) has significantly positive influence on Masjid Kariah Maintenance Planning (MKMP)
H6: Resource Allocation (RA) has significantly positive influence on Masjid Kariah Maintenance Planning (MKMP)

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H7: Safety and Health (SH) has significantly positive influence on Masjid Kariah Maintenance Planning (MKMP)

RESEARCH METHODOLOGY

The aim of this study is to evaluate the key indicators in the relationship between seven indicators of Maintenance Performance Measurement (organisation management, planning and scheduling, financial provision, service quality, assessment, resources allocation and safety and health) towards the Maintenance Planning (maintenance strategy criteria) which includes three main indicators i.e. Planned Preventive Maintenance, Planned Corrective Maintenance and Unplanned Maintenance. The study utilized probability sampling methods, specifically systematic and stratified sampling. In total, there are 584 Masjid Kariah from 10 districts have been situated in the Kelantan State. By considering 10% of the total numbers of Masjid Kariah from each district, 59 Masjid Kariah have been chosen as a case study area in this study.

This study employed an empirical questionnaire survey. Sample adequacy was determined using the Raosoft Sample Size Calculator, which recommended 385 respondents based on Kelantan's population of 1,857,600, a 95% confidence level, and a 5% margin of error (Department of Statistics Malaysia, 2023). The planned sample was distributed across 59 Masjid Kariah located in ten districts: Kota Bharu, Pasir Puteh, Jeli, Machang, Gua Musang, Tanah Merah, Pasir Mas, Tumpat, Kuala Krai, and Bachok. Due to limited participation from committee members, 354 usable responses were collected. Respondents targeted key Masjid Kariah committee roles, including nazir, deputy nazir, secretary, deputy secretary, treasurer, and development bureau members. Table 1 summarises distribution details.

Table 1: Positions Held at the Masjid Kariah

No.	District	Frequency	Percentage (%)	10% of Total Masjid Kariah (Unit)	Empirical questionnaire survey Distribution	Target Group
1.	Kota Bharu	130	22	13	85	Nazir, deputy Nazir, Secretary, Deputy secretary, Treasurer and Bureau of development
2.	Pasir Puteh	65	11	7	46	
3.	Jeli	21	4	2	13	
4.	Machang	43	7	4	26	
5.	Gua Musang	39	7	4	26	
6.	Tanah Merah	44	8	4	26	
7.	Pasir Mas	91	16	9	59	
8.	Tumpat	45	8	5	32	
9.	Kuala Krai	50	9	5	32	
10.	Bachok	56	10	6	40	
	Total	**584**	**100**	**59**	**385**	

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The reliability and validity of the model measure were assessed through partial least squares-structural equation modeling (PLS-SEM) analysis using the SmartPLS software application. This study evaluated both reliability, ensuring the measurement instruments are free of random errors, and validity, assessing the dimensions' capacity to distinguish real differences related to the characteristic being measured (Hashim et al., 2023). Additionally, the PLS-SEM analysis was performed to assess two main aspects: firstly, to test the measurement model, which aimed to validate the instruments used in the study; and secondly, to examine the structural model, which aimed to test the hypotheses formulated in the research. Figure 4 shows the two stages of PLS-SEM and assessments.

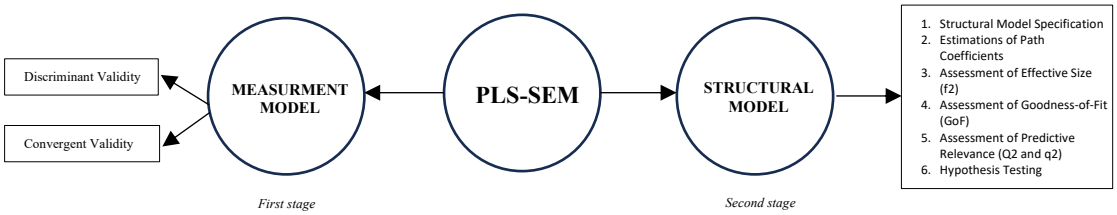


Figure 2: The two stages of PLS-SEM and assessments
(adopted from Hashim et al., 2023)

For statistical analysis in this study, SmartPLS 4.1.0.0 software was utilized, employing the partial least squares structural equation modeling (PLS-SEM) approach. For statistical analysis in this study, SmartPLS 4.1.0.0 software was utilized, employing the partial least squares structural equation modeling (PLS-SEM) approach. PLS-SEM employs variance-based partial least squares techniques to estimate causal models rooted in established theory. It adopts an iterative approach akin to multiple regression analysis (Sakip et al., 2023). The main objective of PLS-SEM is to maximize the explained variance of endogenous constructs (Fornell & Bookstein, 1982). Selecting PLS-SEM aligns with the study's objective of extending established theory, as recommended by Hair et al. (2019).

RESEARCH FINDINGS

The findings and discussion initiates with descriptive findings elucidating the profile of the study participants. Subsequently, the measurement model findings for each variable are presented to assess convergent validity. Following this, discriminant validity is checked to ensure that correlations between constructs are lower than correlation estimates between factors. The analysis then proceeds to

the examination of the structural model to address the formulated research hypotheses.

Descriptive Analysis

The study respondents comprised 354 Masjid Kariah committee members, including nazir, deputy nazir, secretary, deputy secretary, treasurer, and bureau of development members, with each role representing 16.7% of the total. All respondents were male, with 41.0% aged 51 and above, another 41.0% aged 41-50, and 0.8% aged 31-40. They all served as contract workers and had academic qualifications evenly distributed among SPM, Diploma, and Degree certificates at 33.3% each. Regarding the Masjid Kariah's general characteristics, all studied mosques were government-owned, with 93.2% being over 15 years old, followed by 5.1% aged 6-10 years, and 1.7% aged 11-15 years. These mosques were fully registered under the Department of Agama Islam dan Adat Istiadat Melayu Kelantan (JAHEAIK). Concerning maintenance strategy implementation, all Masjid Kariah had a written maintenance policy, with 66.1% practicing planned corrective maintenance and 33.9% relying on unplanned maintenance. Maintenance responsibilities were fulfilled regularly, with 42.4% performed monthly, 39.0% every six months, and 18.6% every three months.

Assessment of the Measurement Model

Following the recommendation of Hashim et al. (2023), Abu et al, (2021), Jayasingam, et al. (2018), and Kashif et al. (2018), the convergent validity (CV) was assessed using factor loadings, average variance extracted (AVE) and composite reliability (CR) – the recommended values for loadings were set at >0.5, AVE at >0.5 and CR at >0.7. From Table 2, the results showed that the measurement models' results surpassed the proposed values hence suggesting adequate convergent validity and all of the reflectively measured constructs were above the threshold of 0.5. However, 84 lower loading items were dropped to obtained better reliability and discriminant validity. The CR are varied between 0 and 1. Hair et al. (2019) and Abu et al. (2021) stated that, CR values of above 0.7 were still considered satisfactory. Besides, all the AVE assessed were higher than the critical value of 0.5. This indicates that the main construct captures more construct-related variance than error variance.

Table 2: Convergent Validity

No.	Model Construct	Measurement Item	Loadings	AVE	CR
1.	Masjid Kariah Maintenance Planning (MKMP)	D_PPT	0.776	0.674	0.861
		D_PBT	0.847		
		D_PTT	0.838		
2.		C1_PD_01_PPT	0.872	0.579	0.803

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No.	Model Construct	Measurement Item	Loadings	AVE	CR
	Organization Management (OM)	C1_PD_01_PTT	0.649		
		C1_PD_02_PPT	0.745		
3.	Planning and Scheduling (PS)	C2_RM_02_PTT	0.715	0.526	0.768
		C2_Com_02_PPT	0.647		
		C2_Com_02_PTT	0.805		
4.	Financial Provision (FP)	C3_AB_01_PTT	0.857	0.696	0.873
		C3_FE_01_PTT	0.768		
		C3_FA_01_PTT	0.874		
5.	Service Quality (SQ)	C4_Ass_01_PPT	0.650	0.503	0.752
		C4_Rel_01_PBT	0.733		
		C4_Tan_01_PTT	0.742		
6.	Assessment (AS)	C5_ALR_01_PTT	0.719	0.501	0.750
		C5_ASC_01_PBT	0.687		
		C5_ABC_01_PPT	0.716		
7.	Resources Allocation (RA)	C6_CM_01_PPT	0.836	0.643	0.844
		C6_SP_01_PPT	0.788		
		C6_TE_01_PPT	0.780		
8.	Safety and Health (SH)	C7_Health_01_PTT	0.609	0.529	0.769
		C7_Health_02_PTT	0.735		
		C7_Health_02_PBT	0.822		

Finally, after confirming the convergent validity (CV), the discriminant validity (DV) was assessed using HTMT method. The DV assessment shows that all the HTMT values were significantly lower than 0.9. According to Tehseen et al. (2017), the constructs were distinct from each other because they were below the suggested cut-off of 0.9. All the HTMT values were significantly lower than the threshold value and different from 0.9. Thus, this result indicates as valid and significant to measures the structural model analysis in the next sub-topic. Table 3 shows the discriminant validity (HTMT).

Table 3: Discriminant Validity (HTMT)

	MKMP	OM	PS	FP	SQ	AS	RA	SH
Masjid Kariah Maintenance Planning (MKMP)								
Organization Management (OM)	0.425							
Planning and Scheduling (PS)	0.087	0.757						
Financial Provision (FP)	0.311	0.347	0.468					

	MKMP	OM	PS	FP	SQ	AS	RA	SH
Service Quality (SQ)	0.307	0.128	0.274	0.781				
Assessment (AS)	0.203	0.603	0.186	0.342	0.017			
Resources Allocation (RA)	0.497	0.010	0.601	0.141	0.379	0.720		
Safety and Health (SH)	0.293	0.870	0.322	0.521	0.433	0.300	0.363	

The evaluation of analysis on PLS-SEM (version 4.1.0.0), the determination of model fitness is achieved through PLS-predict analysis – these involves examining measures of goodness-of-fit, including R^2 (evaluate the extents to which the model explains variance) and Q^2 (assesses the model's ability to predict outcomes accurately). A Q^2 value greater than 0 indicates adequate predictive relevance for the model (Ramayah, 2016 and Abu, 2021). In this study, the Q^2 for Masjid Kariah Maintenance Planning (MKMP) was 1.000 which means, the model's ability to predict outcomes are accurate. Besides, the measurement of model-fit and predictive relevance was confirmed by collinearity statistic (VIF). The predictor constructs' VIF values were assessed to ensure that there are no collinearity issues between the construct's indicators. As all of the VIF values were below 3, the results presented ideal VIF values (VIF < 3) indicating no multi-collinearity problems (Hashim et al., 2023). Thus, this study indicates all the VIF values constructs are below than 3 (OM : 1.124; PS : 1.213; FS : 1.038; SQ : 1.176; AS : 1.199; RA : 1.066; SH : 1.034) and the model's ability to predict outcomes (Q^2) are accurate.

Structural Model Analysis

According to Hair et al. (2019), by utilized a 5,000-sample re-sample, bootstrapping procedure are used to assess the structural model's path coefficients, standard errors, t-values and p-values. This method, recommended for its robustness, involves generating numerous bootstrap samples from the original dataset to estimate the sampling distribution of statistics. Moreover, in response to the critique raised by Hahn & Ang (2017) regarding the limited reliability of p-values as the sole criterion for hypothesis testing, the integrated a variety of criteria has been used in their analysis – these included not only p-values but also confidence intervals. By incorporating multiple criteria, the researchers aimed to provide a more comprehensive evaluation of the hypotheses, thereby enhancing the validity and reliability of their findings. Therefore, these criteria were incorporated into the analysis and have been examined. Table 4 shows the hypotheses testing results of this study and Figure 5 shows the research framework of relationship between Maintenance Strategy Criteria's indicators and Maintenance Planning via Maintenance Performance Measurement's

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indicators in which visually illustrates the findings of the study, showcasing several significant relationships (Constructs: AVE, Outer model: P values, Inner model: Path coefficients and P values).

Table 4: Hypotheses testing

Hypotheses	**Path Co-Efficient (β)**	**Standard Deviation**	***t*-Value**	***p*-Value**	**Bias Confidence Interval (BCI)**		**Results**
					5.0%	95.0%	
H1: OM → MKMP	-0.058	0.169	0.344	0.365	-0.595	0.031	Not Supported
H2: PS → MKMP	0.254	0.184	1.385	0.000	0.103	0.588	Supported
H3: FP → MKMP	-0.203	0.053	3.814	0.000	-0.292	-0.116	Not supported
H4: SQ → MKMP	0.070	0.076	0.929	0.000	0.066	0.179	Supported
H5: AS → MKMP	0.037	0.073	0.511	0.000	0.111	0.129	Supported
H6: RA → MKMP	0.100	0.057	1.754	0.040	0.056	0.169	Supported
H7: SH → MKMP	-0.059	0.049	1.210	0.113	-0.100	0.140	Not Supported

The results presented in Table 4 above and Figure 5 below reveal that three out of seven hypotheses did not demonstrate a statistically significant positive relationship i.e. (1) Organization Management (OM) has not significantly positive influence with Masjid Kariah Maintenance Planning (MKMP) (β=-0.058, p<0.365), (2) Financial Provision (FP) has not significantly positive influence with Masjid Kariah Maintenance Planning (MKMP) (β=-0.203, p<0.000), and (3) Safety and Health (SH) has not significantly positive influence with Masjid Kariah Maintenance Planning (MKMP) (β=-0.059, p<0.113). In contrast, the remaining four out of seven hypotheses exhibited a statistically significant positive relationship i.e. (1) Planning and Scheduling (PS) has significantly positive influence with Masjid Kariah Maintenance Planning (MKMP) (β=0.254, p<0.000), (2) Service Quality (SQ) has significantly positive influence with Masjid Kariah Maintenance Planning (MKMP) (β=0.070, p<0.000), (3) Assessment (AS) has significantly positive influence with Masjid Kariah Maintenance Planning (MKMP) (β=0.037, p<0.000) and (4) Resources Allocation (RA) has significantly positive influence with Masjid Kariah Maintenance Planning (MKMP) (β=0.100, p<0.040). Thus, the findings supported hypothesis for H1, H2, H3, H4, H5, H6 and H7.

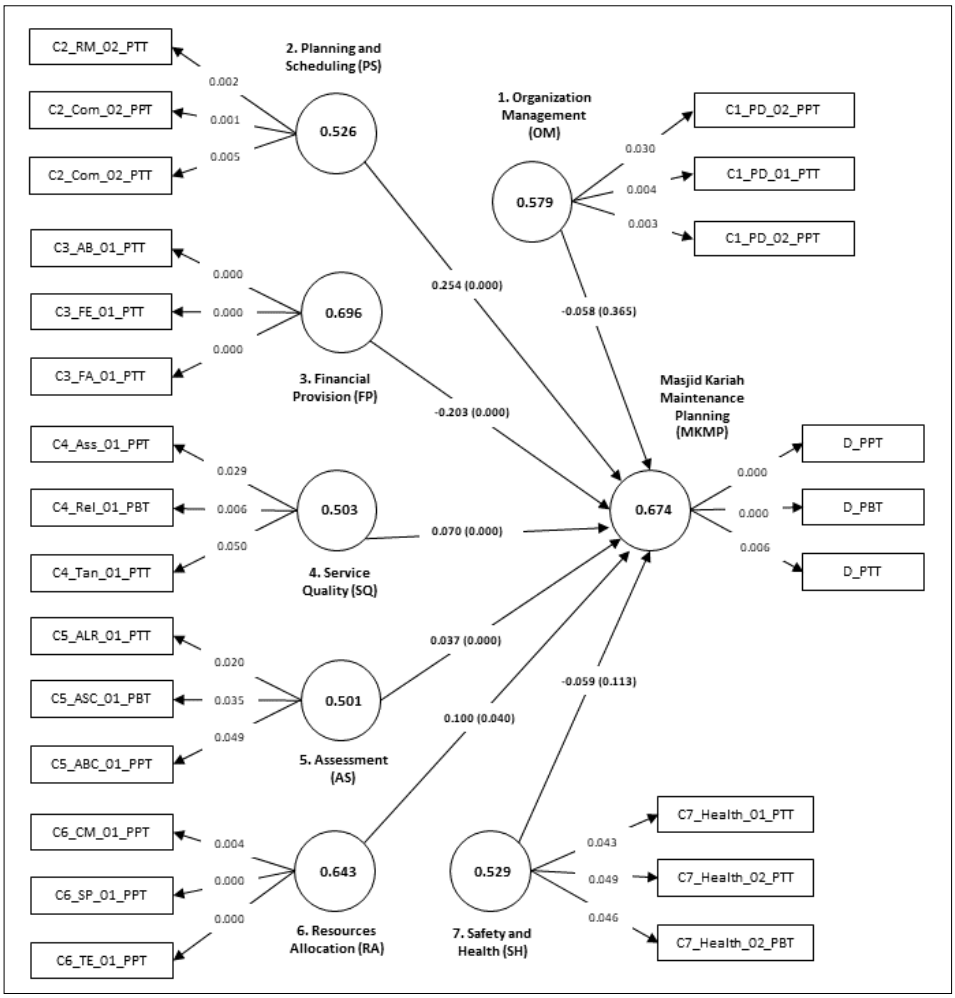


Figure 3: The Research Framework of relationship between Maintenance Strategy Criteria's indicators and Maintenance Planning via Maintenance Performance Measurement's indicators

DISCUSSION AND CONCLUSION

This study aimed to assess the relationship between seven key indicators of Maintenance Performance Measurement—organization management, planning and scheduling, financial provision, service quality, assessment, resources allocation, and safety and health—and the Maintenance Planning strategies of Planned Preventive Maintenance, Planned Corrective Maintenance, and Unplanned Maintenance. Using PLS-SEM, seven hypotheses were tested within the Masjid Kariah maintenance planning framework. Findings indicate that

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Planning and Scheduling (PS), Service Quality (SQ), Assessment (AS), and Resource Allocation (RA) significantly influence Masjid Kariah Maintenance Planning (MKMP), while Organization Management (OM), Financial Provision (FP), and Safety and Health (SH) showed no significant impact. Specifically, record management and communication under PS were found to enhance maintenance planning, and adequate budgeting and fund allocation under FP were crucial despite lacking significant influence. The study highlighted the importance of tangible elements and trustworthiness in SQ, and the role of contract management and spare parts availability in RA. Additionally, policy usage within OM was seen as more influential than human resource management, though it did not significantly impact maintenance planning. The study emphasizes the importance of improving record-keeping, financial management, and resource allocation to enhance maintenance effectiveness, ensuring sustainable management of Masjid Kariah facilities.

Therefore, based on the study's findings, it is evident that three independent constructs – Organizational Management (OM), Financial Allocation (FP) and Safety and Health (SH) – did not show significant relationship values in the context of Masjid Kariah Maintenance Planning in the Kelantan State. It is crucial to address the need for improvement in these areas when planning a maintenance strategy for Masjid Kariah in the Kelantan State by:

a. **Organizational Management (OM):** since there was no significant relationship found between OM and Masjid Kariah Maintenance Planning, efforts should be focused on enhancing organizational management practices within these establishments. This may involve improving communication channels, streamlining decision-making processes, and fostering a culture of accountability and efficiency.
b. **Financial Allocation (FP):** the lack of significant relationship between FA and Maintenance Planning suggests that attention should be given to how funds are allocated and utilized for maintenance activities in Masjid Kariah. This may involve conducting thorough financial assessments, budget planning, and ensuring transparency and accountability in financial management practices.
c. **Safety and Health (SH):** given the non-significant relationship between SH and Maintenance Planning, it is imperative to prioritize safety and health measures within Masjid Kariah. This includes implementing proper safety protocols, conducting regular inspections, addressing potential hazards, and providing necessary training and resources to ensure the well-being of staff and worshippers.

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In summary, addressing the need for improvement in Organizational Management, Financial Allocation, and Safety and Health aspects is essential for developing effective maintenance strategies for Masjid Kariah in the Kelantan State. By focusing on these areas, it is possible to enhance the overall management and maintenance practices, leading to better upkeep and sustainability of these important religious institutions.

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Received: 22nd January 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 290 – 302

EXPLORING THE CHALLENGES IN DEVELOPING EQUESTRIAN TOURISM: A CASE STUDY OF MALAYSIA

Nur Jannah Mohd Esa[1], Hairul Nizam Ismail[2]

[1,2]*Urban and Regional Planning, Faculty of Built Environment & Surveying,*
UNIVERSITI TEKNOLOGI MALAYSIA

Abstract

Equestrian tourism is a highly specialised sector with enormous growth potential for Malaysia's tourism industry. However, its development faces numerous challenges, particularly regarding financial, infrastructure, and government support. This study will investigate the major challenges to developing equestrian tourism in Malaysia. In-depth interviews with 22 equestrian and tourism industry participants were conducted using a qualitative methodology. The findings highlight several issues, including inadequate funding, poor infrastructure, and a lack of government support and training. Recommendations for overcoming these obstacles and realising Malaysia's equestrian tourism potential are provided.

Keywords: Equestrian Tourism, Challenges, Development, Stakeholders, Equine Industry

[1] Corresponding author. Email: jannahesa1103@gmail.com

INTRODUCTION

Equestrian tourism, a specialised sector within the larger tourism product, is gaining global prominence for its ability to combine adventure, nature, and cultural experiences (Helgadóttir & Sigurðardóttir, 2018; Danby & Grajfoner, 2022). Horseback riding is a niche industry that allows tourists to explore rural landscapes (Fredman & Margaryan, 2021), participate in outdoor sports (Jaelani, Erdinaya, & Perbawasari, 2020), and learn about local traditions (Pickel-Chevalier, 2020). Countries such as Australia, Germany, the United Kingdom and Spain have successfully integrated equestrian sports into their tourism offerings (Douglas, Owers, & Campbell, 2022), considerably contributing to rural economic (Lupoae & Radu, 2022) development and broadening the tourism portfolio (Kedebe, 2020). Equestrian tourism in these areas appeals not just to adventure seekers, but also to a growing need for environmentally beneficial travel experiences (Helgadóttir & Sigurðardóttir, 2018; Fredman & Margaryan, 2021).

Malaysia, known for its diverse landscapes that include coastal regions and dense rainforests, possesses considerable untapped potential for the growth of equestrian tourism (Salleh & Ismail, 2015). It also benefits from a well-developed tourism infrastructure, strong governmental backing for the tourism industry, and a rich cultural heritage, making it an ideal candidate for promoting equestrian tourism as a distinct attraction (Mahzan & Tan, 2017; Ng & Lee, 2020). However, despite these strengths, the sector remains underdeveloped. Although there are some equestrian centres and events, the industry lacks coordinated growth, clear policy guidance, and adequate resources to compete with more established tourism sectors such as eco-tourism and cultural tourism.

The global success of equestrian tourism in rural regions is frequently linked to the direct economic benefits it provides to local communities, particularly job creation and rural development (Helgadóttir & Sigurðardóttir, 2018; Lupoae & Radu, 2022). However, in Malaysia, the development of equestrian tourism confronts several problems, including insufficient funds, inadequate infrastructure, less support from the government, and a lack of specialised training. These limitations limit the sector's potential to grow and attract both domestic and foreign tourists. Thus, the purpose of this research is to investigate the key impediments to the growth of equestrian tourism in Malaysia, as well as to examine the perspectives of industry stakeholders. By identifying these constraints, the study will shed light on how Malaysia can better leverage the potential of equestrian tourism to diversify and improve its tourism offers.

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LITERATURE REVIEW

Equestrian Tourism: A Global Perspective

Equestrian tourism is becoming an increasingly popular niche within adventure and rural tourism (Sandor & Adam, 2019), drawing visitors looking for immersive experiences in nature and culture. Horseback riding has been integrated into tourism services in nations such as New Zealand, Argentina, Spain, and South Africa, allowing visitors to see natural landscapes, wildlife, and rural communities (Kedebe, 2020; Fredman & Margaryan, 2021). These places offer a wide range of equestrian activities, including trail riding, equestrian safaris, and cultural riding festivals, while also benefiting from sustainable tourism practices and the economic benefits they give to rural regions (Danby & Grajfoner, 2022). The industry encourages environmental conservation by offering low-impact tourism options, and it also helps local economies by creating jobs in rural tourism-related companies (Pickel-Chevalier, 2020). Equestrian tourism caters to an increasing need for environmentally friendly travel and provides a distinct alternative to other types of adventure tourism, helping to diversify local economies (Bunchmann, 2019).

However, the growth of equestrian tourism presents certain concerns. Key challenges include a shortage of infrastructure (Helgadóttir & Sigurðardóttir, 2018), such as stables (Bunchmann, 2019) and trained horses (Mahzan & Tan, 2017), as well as a demand for competent experts (Jaelani, Erdinaya, & Perbawasari, 2020), such as instructors and guides (Lupoae & Radu, 2022). These constraints hinder the sector's expansion, especially in resource-constrained areas (Sandor & Adam, 2019). Equestrian tourism's seasonality, as well as competition from other adventure tourism activities, impede its development (Bunchmann, 2019). Despite these obstacles, the potential for growth remains high, particularly with rising interest in sustainable travel experiences and the rise of digital platforms that improve accessibility (Helgadóttir & Sigurðardóttir, 2018; Lupoae & Radu, 2022). Strategic cooperation between governments, the business sector, and local communities can help establish the infrastructure and regulations required for sustainable development, hence supporting future growth in the industry (Bunchmann, 2019).

Stakeholders in the equestrian tourism industry

The equestrian tourism industry's stakeholders include a varied group of players who contribute to the sector's growth and sustainability (Sturød, Helgadóttir, & Nordbø, 2020). Local governments, tourism agencies, equine operators, riders, and rural communities are all common stakeholders (Helgadóttir & Sigurðardóttir, 2018; Lupoae & Radu, 2022). Local governments and tourism authorities play an important role in policymaking, infrastructure development, and marketing activities to attract visitors (Pickel-Chevalier, 2020). Equestrian

operators and service providers, such as riding schools and stables, are critical for providing experiences while maintaining safety and quality (Le Clinche, Martinent, & Chanavat, 2017). Equestrian tourism also benefits rural areas by creating jobs and increasing demand for local goods and services, which promotes rural economic development (Douglas, Owers, & Campbell, 2022). Collaboration among these stakeholders is essential for building a comprehensive plan for equestrian tourism development and sustainability, ensuring reciprocal benefits and long-term success (Pavić, Blešić, Petrović, Radovanović,, & Prišenk, 2019).

Challenges in equestrian tourism development

Equestrian tourism growth faces several significant hurdles (Brzezińska-Wójcik & Baranowska, 2012; Le Clinche, Martinent, & Chanavat, 2017; Sturød, Helgadóttir, & Nordbø, 2020). One important difficulty is a lack of suitable infrastructure, such as good-quality riding trails (Helgadóttir & Sigurðardóttir, 2018), stables (Danby & Grajfoner, 2022), and transportation choices (Fredman & Margaryan, 2021), which are required to provide tourists with a safe and enjoyable experience (Pickel-Chevalier, 2020). Furthermore, skilled specialists are scarce, such as horse trainers and tour guides, particularly in areas where equestrian tourism is still growing (Kedebe, 2020). Seasonal variations can influence demand for equestrian activities, and increased competition from other types of adventure and eco-tourism can make it difficult to market equestrian tourism effectively (Sandor & Adam, 2019). Finally, the lack of effective government policies and cooperation among key actors makes it more difficult to overcome these obstacles and promote the expansion of equestrian tourism (Le Clinche, Martinent, & Chanavat, 2017; Mahzan & Tan, 2017; Pavić, Blešić, Petrović, Radovanović,, & Prišenk, 2019). Addressing these difficulties will necessitate infrastructural investment, professional training, and improved policy formulation.

RESEARCH METHODOLOGY

This study used a qualitative research approach to investigate the problems of establishing equestrian tourism in Malaysia. Qualitative interviews provide in-depth insights into the experiences and viewpoints of people directly involved in the industry. An in-depth interview method allows participants to express their thoughts on the topic (Creswell & Creswell, 2017), resulting in rich, thorough data. A purposive sampling strategy was utilised to select 22 participants, who included equine operators, associations, tourism authorities, and stakeholders interested in equestrian sports and associated sectors. The informants must have experience in the equine industry and tourism (more than 5 years or less than 5

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years). The interviews were done physically and face-to-face to collect the actual data. Table 1 represents the study informants' backgrounds.

Table 1: Informants background

No.	Code	Job Title	Categories	Experience
1.	Informant 1	Coach	Equestrian	More than 5 years
2.	Informant 2	Coach	Equine operators	More than 5 years
3.	Informant 3	Coach	Equine operators	More than 5 years
4.	Informant 4	Operation manager	Equine operators	Less than 5 years
5.	Informant 5	Web blogger	Equestrian	Less than 5 years
6.	Informant 6	Owner	Equine operators	More than 5 years
7.	Informant 7	Coach	Equine operators	More than 5 years
8.	Informant 8	Owner	Equine operators	More than 5 years
9.	Informant 9	Executive secretary	Association	More than 5 years
10.	Informant 10	Owner	Equine operators	More than 5 years
11.	Informant 11	Owner	Equine operators	More than 5 years
12.	Informant 12	Owner	Equine operators	More than 5 years
13.	Informant 13	Owner	Equine operators	More than 5 years
14.	Informant 14	Owner	Equine operators	More than 5 years
15.	Informant 15	Operation manager	Equine operators	More than 5 years
16.	Informant 16	Owner	Equine operators	Less than 5 years
17.	Informant 17	Owner	Equine operators	More than 5 years
18.	Informant 18	Owner	Equine operators	More than 5 years
19.	Informant 19	Coach	Equestrian	More than 5 years
20.	Informant 20	Deputy director	Tourism authorities	More than 5 years
21.	Informant 21	President	Non-profit organisation	More than 5 years
22.	Informant 22	Operation manager	Equine operators	More than 5 years

N=22

In-depth interviews were conducted between February and June 2024. Each interview lasted 30 to 90 minutes and was recorded with the participant's consent. Interview questions were aimed to go into a variety of issues, such as infrastructure, horse welfare, government support, training, marketing, and challenges specific to equestrian tourism in Malaysia. The interview data were transcribed and analysed thematically to identify main themes based on the informants' input. Turboscribe was utilised for transcription, catching exact words and key information like pauses and background noise to eliminate bias. The transcripts were examined several times for accuracy, and audio recordings

were double-checked. The data was then entered into NVivo 14 for coding, where themes and sub-themes were found and properly classified for the next interpretation procedures.

DATA ANALYSIS

It is worthwhile to mention that theme analysis is used while analysing the interview data (Braun & Victoria, 2021). To provide consistency, the word 'informant' is applied to all twenty-two (22) selected individuals from various groups. Four major themes emerged from the informants' responses: (i) Operation Cost, (ii) Infrastructure and Services, (iii) Government Support, and (iv) Training and Knowledge.

Challenges of Equestrian Tourism

The following findings were obtained based on interview data processing using the NVivo application:

Table 2: Informant facing operation cost challenge

Informant	Quote
Informant 3	"…our costs are quite high. For example, RM2500 for 25 bales just to last until the end of the month."
Informant 6	"… the performance horse must be fed with 8 kilos of hay per day and the hay costs around RM385 for 61 kilos and only last for a few days."
Informant 7	"…the operational cost is high. That is why people say the one who runs a horse stable has another side business."
Informant 13	"…we can't cover it because of the horse feed costs for me it is very high."
Informant 15	"…we only facing financing issues to maintain the horse need, overhead cost, grass and building condition and we are unable to provide a comfortable stable for horses that got rained during the heavy rain and it made it difficult for them to get comfortable in the stable."
Informant 16	"…the cost of horses is high, and the business must adapt to alternative resources like straw and sawdust."
Informant 18	"…. the maintenance cost is quite high and our income is not too high to cover all the costs."
Informant 19	"….the cost of operation is the biggest challenge for me."

Table 2 shows most of the equine operators having operation cost issues. Equine operators often struggle with the cost of operations, where revenue is highly dependent on riding school events, and training programmes. This unpredictable cash flow makes it difficult to sustain operational costs all year since operators must manage spending with less income during off-peak months.

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Furthermore, many horse operators are tiny or family-owned businesses with insufficient collateral or financial history, making it difficult to obtain consistent income from horse owners due to stable conditions and receiving funding from financial institutions.

According to the report, equine operators confront considerable problems due to the high expenditures involved with horse care, which include food, sawdust, hay, and supplements. Additional challenges where their account exceeds their operational budgets, due to the cost of feed and bedding supplies increasing consistently over time. Equine operators reported that price changes in hay and specialised feeds, caused by domestic supply concerns and worldwide market patterns, burden their finances. Furthermore, the escalating expenses of supplements and veterinary care add to the financial stress. Many equine operators reported difficulty managing rising costs while maintaining the level of care required for the horses' health and performance. This has caused some equine operators to reduce their herd size or cut back on other services, affecting their capacity to attract and retain clients and, as a result, limiting their growth potential.

Table 3: Informant facing infrastructure and services challenges

Informant	Quote
Informant 3	"…there is also a bad review from the rider saying there is a problem with the horse here."
Informant 4	"…the biggest challenge is when the public makes unfair comparisons."
Informant 5	"…the facility condition quite uncomfortable for riders and horses, even like the saddle, sometimes it is quite worn out."
Informant 6	"….the facility has become outdated. So many repairs we need to do here and maintenance is indeed very high for old buildings."
Informant 16	"…our issue related to the community where some people might not like what I did at my property."

Table 3 indicates several infrastructure-related difficulties greatly impede their capacity to operate smoothly. Equine operators raised concerns about issues with old stable buildings, which are not only expensive to maintain but also pose safety risks to both horses and staff. The deteriorating state of these facilities, along with limited road access to the centre, makes transporting horses and equipment problematic, especially during the rainy season when key routes become inaccessible. Concerns about the centre's security were also raised where horse owners worried about their horses and the high value of horses which may trigger someone from outside to bring out the horses. These infrastructure issues cause operational inefficiencies and contribute to the overall financial strain on equine businesses.

Equine operators also have issues regarding the quality of services given, exacerbated by unskilled riders and poor opinions from the community. Several operators expressed annoyance with riders who left a bad review for their services due to the low-level handling of horses shown by the riders. The local community's negative view of equestrian activities, which is frequently caused by misconceptions about the industry's exclusivity or cost, hinders efforts to recruit new clients and establish a loyal clientele. These combined constraints impede the equine sector's growth and development, limiting its ability to prosper as a significant component in the tourism and leisure industries.

Table 4: Informant facing issues with government support

Informant	**Quote**
Informant 3	"…but now there are many affordable equestrian tourism places, yet there is no support from the government."
Informant 6	"… the changing of government led to the slow process of my horse funding proposal."
Informant 10	"…our government should grant us the permit to use the land and invest in these activities like the Dubai government where they build tracks for cycling and riding horses in the same areas."
Informant 11	"…we didn't receive any support from the government. Even during COVID time, there is no support from local authorities."
Informant 12	"…we were disturbed by a government body and then you can't listen in even though it's for work purposes, but that's the influence we don't have much strength against."
Informant 13	"…I could say very minimal support from the government because this is not a popular sport. So, the government is not interested."
Informant 15	"…we didn't receive any funds or support from the government. Currently, for water supply, we supply the water to horses through the nature supply."
Informant 20	"… we focused on which parliament has special tourism activities, and we hardly received which area needs to be promoted from the operators due to reporting's medium."

Table 4 demonstrates that one of the issues informants encounter is a lack of government support when compared to other countries where equestrian tourism is heavily sponsored and promoted. Operators expressed frustration over the limited involvement of the Malaysian government in directly supporting equine businesses through financial aid or operational subsidies. Compared to countries with successful equestrian tourism industries, where government programs give grants, subsidies, or operational funds, equine operators reported receiving little more than promotional help. The tourism department's responsibility is typically limited to marketing equestrian activities, rather than providing the financial resources needed to sustain and develop the firm. This

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inadequate support hinders equine operators' ability to expand their operations and enhance their facilities, impeding the growth of equestrian tourism as a significant economic contributor.

Equine operators also encounter problems due to a lack of government understanding and outreach about equestrian tourism. Equine operators remarked that there is insufficient effort to teach or promote the benefits of equestrian tourism in the local community, affecting both customer interest and possible investment in the sector. They also highlighted land access impediments, as various property ownership forms make it difficult to install track facilities or expand operations. These problems are exacerbated by regulatory barriers and lengthy procedures required to seek funding or sponsorship, which many operators find discouraging and time-consuming. Despite their need for financial assistance to pay high operational costs, government officials reiterated that their responsibility is limited to promoting activities rather than providing direct funds, exacerbating equine operators' frustration.

Table 5: Informants facing challenges with training and knowledge

Informant	Quote
Informant 1	"…in Malaysia, there aren't many Levels 1 coaches because it's not easy to get it and you need a lot of time to spare."
Informant 9	"…what I can see now veterinary department didn't enforce the act toward the irresponsibility horse stable. I can see a lot of horse welfare issues due to a lack of horse owner knowledge in horse care management."
Informant 11	"…equine council should improve the facilities at each stable, and assist in knowledge and expertise."
Informant 13	"…we have a coach but not at a certain level and most of the trainers are not exposed to international courses."
Informant 14	"…to find a worker with horse knowledge is also a challenge for us, and the most challenging is our management."
Informant 18	"… I only educate my staff from my previous experience and too many refer to the council because sending them for class will take a high cost."

Table 5 illustrates that the industry has significant challenges in terms of training and knowledge management. One typical proposal from operators is for more formal training in horse care management, particularly through established groups such as Majlis Ekuin Malaysia. Informants stated that, while there is an increasing interest in equine activities, there is a significant knowledge gap, particularly among horse owners who lack the essential horse care competence. This lack of understanding frequently results in poor decision-making, with some horse owners purchasing horses without sufficiently preparing for the obligations that come with their care. This knowledge gap

presents extra hurdles for operators, who may be forced to cope with the consequences of ill-prepared owners, resulting in higher operational expenses and possibly animal welfare issues.

Furthermore, equine operators raised worries about a general lack of high-level training and inconsistent understanding among coaches, trainers and groomers which they believe has an impact on service quality and the possibility for expansion in equestrian tourism. The results show that the training available to equestrian professionals falls short of the minimum criteria, with various coaches and trainers having variable levels of knowledge. This unpredictability in training harms riders' skill development and the reputation of equine centres. Additionally, there is a lack of understanding of the significance of trail riding for horses, which could serve as a major activity to increase equestrian tourism. Operators believe that if the importance of trail riding was better known and marketed, it would attract more tourists and benefit the sector economically. However, the current knowledge and training gap remains a significant impediment to realising Malaysia's full potential in equestrian tourism.

DISCUSSION

The development of equestrian tourism in Malaysia is heavily influenced by several interrelated challenges, as illustrated by the four primary themes of operating cost, infrastructure and services, government support, and training and knowledge (Table 6). A key discussion point revolves around how these variables are interconnected and must be handled comprehensively for the industry to grow. High operating expenses can be reduced by targeted government support in the form of subsidies or incentives (Elabd, 2022) for infrastructure improvements, which can increase accessibility and attract more tourists (Lupoae & Radu, 2022). Simultaneously, improving employee knowledge and training (Fredman & Margaryan, 2021) can assist minimize operational inefficiencies, resulting in cost savings and enhanced service quality (Douglas, Owers, & Campbell, 2022). As these themes are deeply interwoven, a deliberate, multifaceted approach combining both governmental and private sector partnerships is required to overcome existing impediments and support development in Malaysia's equestrian tourism industry.

Table 6: Triangulation of main theme data

Informant / Theme	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18	I19	I20	I21	I22
Operation Cost			•			•	•						•		•	•		•	•			
Infrastructure and Services			•	•	•	•										•						
Government Support			•			•				•	•	•	•		•					•		
Training and Knowledge	•								•		•		•	•				•				

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Based on data collection, equine operators face high operation costs partially attributed to insufficient infrastructure. As Bunchmann (2019) described, poorly designed facilities such as stables, route accessibility, and riding trails lead to extreme maintenance expenses. Furthermore, when infrastructure is not well-planned, equine operators may have to invest more in other services, such as transportation or additional personnel, to compensate for limited accessibility (Helgadóttir & Dashper, 2021).

Most of the equine centres in Malaysia own a proper stable, car parking, and training arena. This has reduced the expensive maintenance for the established equine centres and well-developed stable. Additionally, most equine operators suggest that when the government allocates resources toward building infrastructure like roads and trails, equine operators can enhance the tourist experience by offering services like guided tours, accommodations, and horse care services.

Regarding government support, most of the visited stable and equine centres hope for strong government support to develop equestrian tourism. Their suggestion highlights that government funding can help improve infrastructure and facilities, create more accessible trails and support the development of tourism services in equestrian tourism areas. Moreover, the government should establish industry standards for safety, animal welfare, and sustainable tourism practices (Notzke, 2019), which would enhance the reputation of Malaysia as a responsible destination for equestrian tourism. Informants from the National Equine Council emphasize the mandatory horse care policy toward horse owners to avoid violence to the horse. Therefore, the training programs that equine centres practice in Malaysia should be aligned with centralized standards introduced by the National Equine Council to ensure that workers have the necessary skills to comply with safety and welfare regulations.

Furthermore, data collection found that equestrians emphasize the lack of high-level coaches in Malaysia compared to countries with more established equestrian industries like Indonesia. Equestrian critiques local coaches have not received international standard training, restricting their capacity to deliver world-class instruction and reducing the overall quality of the equestrian experience. This issue has also been rising by equine operators as they are also unable to provide high-level coaches. Even though the National Equine Council approved a large number of coaches, they tend to become freelance rather than working with equine centres due to compensation issues. Furthermore, routinely bringing in international coaches to conduct seminars and training sessions in Malaysia would allow local coaches to learn directly from top-tier pros, elevating the overall calibre of coaching and boosting the country's equestrian tourism industry.

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Therefore, equestrian tourism is considered a complex tourism product, and the discussion here illustrates that experiences can vary widely. In the final section, some of the implications of these findings for understanding equestrian tourism will be considered.

CONCLUSION

The challenges faced by equestrian tourism in Malaysia such as high operation costs, inadequate infrastructure, limited government support, and insufficient training for coaches highlight the need for a comprehensive approach to address these issues. The contribution of this study to the concept of tourism development lies in its identification of these interconnected themes, providing a structured understanding of the key factors that influence the development of equestrian tourism. By focusing on the relationships between operation costs, infrastructure, government support, and training, the framework offers a roadmap for stakeholders to enhance the sector's sustainability and growth. The implications for the national economy are significant, as improving equestrian tourism could lead to increased job creation, higher tourist arrivals, and more substantial contributions to the broader tourism and hospitality industries. By addressing the challenges and investing in this niche market, Malaysia can diversify its tourism offerings, attract international tourists, and boost local economies, positioning equestrian tourism as a vital component of the nation’s economic development.

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Received: 25th January 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 303 – 318

DESIGN STRATEGIES FOR A COMPLEMENTARY NATURE-CONNECTED INDOOR-OUTDOOR ENVIRONMENTS TO FOSTER CHILDREN'S HOLISTIC DEVELOPMENT: A REVIEW

Nor Diyana Mustapa[1], Aida Syaqirah Muhsein[2], Ismi Luqman Hamadi Ibrahim[3], Nurul Izzati Othmani[4], Khalilah Hassan[5]

[1,2,3] *Department of Interior Architecture, Faculty of Architecture and Ekistics,*
UNIVERSITI MALAYSIA KELANTAN
[1,3,4,5] *Sustainability, Urban Design and Well-being Research Group,*
UNIVERSITI MALAYSIA KELANTAN

Abstract

Reconnecting children with nature through a high-quality indoor and outdoor environment is crucial for supporting children's holistic developmental needs, such as cognitive, physical, social, and emotional growth. Nature has a long history of contributing to children's development, but today's children are disconnected from the outdoor environment where they can engage with nature directly. Indoor environments and spaces, however, also play an important role in reconnecting children with nature. Hence, it is crucial to better understand the natural context and design elements for both indoor and outdoor environments that support children's holistic development. Based on a systematic review, this paper presents a review of indoor and outdoor nature's contribution to children's development. This review highlights the importance of children's indoor and outdoor environments, which complement each other in contributing to their development. Views of nature, indoor plants, green walls, and natural lighting are important indoor design elements that need to be considered in designing children's indoor spaces. Meanwhile, green areas and natural play spaces are fundamental for children's development in the outdoor environment. The findings provide a foundation for design strategies aimed at integrating multi-natural environments in both indoor and outdoor environments and spaces to foster children's holistic development. Directions for future research are also outlined.

Keywords: Nature, Indoor-Outdoor, Children, Biophilic, Design

[1] Corresponding author. Email: farishadi18@gmail.com

INTRODUCTION

According to the United Nations Convention on the Rights of the Child 1989, children have the right to enjoy a high-quality environment that supports their developmental needs (United Nations, 2010). Hence, it is crucial to provide a such an environment including a physical environment that supports children's development. For the past two decades, numerous studies have demonstrated the importance of nature for children's holistic developmental needs (Mustapa et al., 2015; Mårtensson et al., 2014) as well as the well-being of the environment (Cheng & Monroe, 2010; Hinds & Sparks, 2008). Many studies have demonstrated that children appreciate and are very attracted to the natural environment (Mahidin & Maulan, 2012; Said & Abu Bakar, 2005), specifically, places that have trees and flowers (Castonguay & Jutras, 2009). The bonding between children and nature can be explained by ecopsychology perspectives that claim children have an innate feeling of being connected with nature since birth (Phenice & Griffore, 2003).

Recently, 1 in 6 children has been found to suffer from mental health problems, with 16.5% of children aged 5 to 15 years old facing mental health issues (National Health and Morbidity Survey, 2023) such as stress and anxiety. In turn, children encounter problems in cognition such as poor attention and concentration (Cardoso-Leiti et al., 2021). Nature has abundant benefits for children's development, health, and mental well-being (Muhsein et al., 2024; Mustapa et al., 2024). Nevertheless, for the past few years, children have become disconnected from nature. Studies have shown that the number of children playing in the outdoor environment, specifically near their home and in in neighbourhood areas where nature exists, is declining (Clements, 2004; Karsten, 2005), and this has led to children being disconnected from nature (Chawla & Derr, 2012; Myers, 2012). Also, children's trends of being active in outdoor environments have changed to children being confined to indoor environments with gadgets (Mustapa et al., 2019).Furthermore, children who have a weaker connection with nature as a consequence of this disconnection from nature will display apathy towards the environment (Mustapa et al., 2020). Hence, reconnecting children with nature has become an increasing concern

Given that reconnecting children with nature in the built environment is essential for children's developmental needs, such as cognitive, physical, social, and emotional growth and for their health and well-being, this paper aims to provide a review as a foundation for understanding the benefits of nature through multi-environmental design elements in both indoor and outdoor settings for children's. Despite increasing interest, there is only limited information on the overall contribution the indoor-outdoor nature-connected environments to children's well-being. A review by Meng et al. (2023) provides information on the effect of the visual indoor environment on children's health, while other

studies focus on the outdoor environment (Chawla, 2015; Mustapa et al., 2015). The findings from this review can form a basis for design strategies integrating nature-connected indoor-outdoor environments into the planning and design of the built environment. This study focuses on the benefits of indoor and outdoor environments on children's developmental needs and the importance of indoor-outdoor environments, places, and spaces to reposition nature in a way that will support such needs.

LITERATURE REVIEW

Children, Nature, and Environment

Children are shaped by their environment, and thus the environment is an important milieu for children's development. A good physical environment benefits children's development, health, and well-being (Mustapa et al., 2015). Over the past few decades, many studies have shown that nature contributes to children's development, including their cognitive, physical, social, and emotional growth. Studies have shown that exposure to nature can help to reduce children's stress, improve their mood, and increase their happiness (Liu & Green, 2023; Mustapa et al., 2015, 2024). The outdoor environment becomes children's preferred place to play, as they can experience the freedom to play and socialize with their peers (Said, 2012). However, as most people, including children, spend over 90% of their day indoors (Gonzalez-Martin et al., 2021), the importance of the indoor environment has also become a concern. It is essential to provide a high-quality indoor environment for children. Indeed, indoor environments also play a vital role in contributing to children's development, health, and well-being (Meng et al., 2023). For example, a study by Sandseter et al. (2022) demonstrated that children's indoor environment offers better opportunities for constructive and symbolic play through natural elements; however, functional play through physically active play is found more often associated with outdoor environments, where children can explore more and is less frequently found in indoor environments.

The Attributes of Nature in the Built Environment

In the 21st century, biophilic design, which originated from the biophilia hypothesis, has been introduced. Based on Heerwagen and Hase (2008), nature can be conceptualized differently in architecture. The most commonly used frameworks by many researchers are those by Browning and Ryan (2014) and Kellert (2018). Browning and Ryan's (2020) framework includes Nature in the Space (visual connection with nature, non-visual connection with nature, non-rhythmic sensory stimuli, thermal and airflow variability, presence of water, dynamic and diffused light, connection with natural systems), Natural Analogues (biomorphic forms and patterns, material connection with nature and complexity

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and order) and Nature of the Space (prospect, refuge, mystery, risk/peril, and awe). On the other hand, Kellert's (2018) framework includes direct experiences of nature (light, air, water, plants, animals, landscapes, weather, views, and fire), indirect experiences of nature (images, materials, textures, colours, shapes and forms, information richness, time changes, geometries, stimulated natural light and air, and biomimicry), and experiences of space and place (prospect and refuge, organized complexity, mobility, transitional spaces, place, and integrating parts to create wholes). These design patterns have various applications for indoor and outdoor environments and illustrate the relationship between human biology, nature, and the built environment.

RESEARCH METHODOLOGY

Literature searches on the benefits of nature in indoor and outdoor environments on children's developmental needs were conducted from SCOPUS and WOS databases including Science Direct, SAGE, Springer, and Taylor and Francis. Using the combination of keywords (children, nature, natural environment, biophilic, indoor plants, natural ventilation, natural lighting, view of nature, material, cognitive, physical, social, and emotional), relevant journals were identified. The journals were from different disciplines: children's environment, environmental psychology, environmental design, health and place, environment and behaviour, environmental education and building and environment, and sustainable cities and society. This review paper selected only empirical papers published between 2015 to 2025 and related to the benefits of nature on children's developmental needs in both indoor and outdoor contexts. Hence, this review includes studies on nature in early childhood, middle childhood, and early adolescence. In total, 65 journals were found, but only 23 empirical papers were selected. This review emphasizes the benefits of nature in both indoor and outdoor settings on children's developmental needs and categorizes them as cognitive, physical, social, and emotional. This review also highlights the environment, places, and spaces in both indoor and outdoor settings that are important in connecting children with nature.

ANALYSIS AND DISCUSSION

Nature in Outdoor and Indoor Environments that Contribute to Children's Cognitive, Physical, Social, and Emotional Development

This review elucidates that studies on nature and children have been conducted in different settings, such as green areas in neighbourhoods (Buczylowska et al., 2024; Reuben et al., 2019; Singh et al., 2024), schools (Amicone et al., 2018; Dadvand et al., 2015; Kuo et al., 2021), and natural play spaces (Prins et al., 2023; Zamani, 2016) as shown in Table 1. The school environment and spaces have

become a frequent focus for research on and with children since children spend most of their time at school. The natural context and natural design elements found have been categorized into indoor and outdoor environments. The outdoor environment includes green areas and natural play spaces. Meanwhile, indoor environment studies comprise research on views of nature, natural lighting, indoor plants, and green walls. Also, the researchers have started to focus on exploring the impact of biophilic design at school on children's developmental needs, which have been categorized into indoor and outdoor environment categories. The impact of nature on both indoor and outdoor environments has been mapped to children's cognitive, physical, social, and emotional development (refer to Table 1).

Table 1: Natural Context and Natural Design Elements and their Contribution to Children's Development

Natural Context/ Natural Design Elements	**Cognitive**	**Physical**	**Social**	**Emotional**
Indoor Environment				
Views of nature from inside (window) (Primary school and high school)	Increase focus, and improve cognitive skills and academic performance. Li & Sullivan (2016), Lindemann-Matthies et al. (2021), Pearson et al. (2023), Studente et al. (2016)	-	-	Enhance positive mood and happiness. Charlotte et al. (2022), Li & Sullivan, (2016), Mustapa et al. (2024)
Natural lighting (Primary school)	Improve concentration and increase achievement. Baloch et al. (2020), Oppusunggu & Santoso (2024)	-	-	Increase positive mood. Mustapa et al. (2024)
Indoor plants and green wall (Primary school)	Increase focus and improve academic achievement.	-	-	Improve mood, and foster a more relaxed and positive atmosphere

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Natural Context/ Natural Design Elements	**Cognitive**	**Physical**	**Social**	**Emotional**
	Bernardo et al. (2021), Lindemann-Matthies et al. (2021), Mustapa et al. (2024), van de Bogerd et al. (2020), van den Bogerd et al. (2017)			conducive to learning. Charlotte et al. (2022), Mustapa et al. (2024), van de Bogerd et al. (2020), van den Bogerd et al. (2017)
Outdoor Environment				
Green areas (Neighbourhood and school)	Improve attention and academic performance. Amicone et al. (2018), Dadvand et al. (2015), Kuo et al. (2019, 2021), Reuben et al. (2019)	Increase motor development. Buczylowska et al. (2024), Kuo et al. (2019), Singh et al. (2024)	Foster interaction with peers. Buczylowska et al. (2024), Kuo et al. (2019)	Lower stress levels. Amicone et al. (2018), Kuo et al. (2019)
Natural play space (Natural elements such as trees, sand, water, and vegetation) (Primary school and preschool)	Enhance problem-solving skills and creativity. Prins et al. (2023), Zamani (2016)	-	Foster interaction with peers. Zamani (2016)	Give restorative effect. Bagot et al. (2015)
Indoor and Outdoor Environment				
Biophilic design (Primary school)	Enhance creativity and problem-solving abilities, focus and motivation. Abdul Malek et al. (2024), Barbiero et al. (2021)	-	-	Improve positive mood, increase happiness, and give restorative effect. Abdul Malek et al. (2024), Barbiero et al.

Natural Context/ Natural Design Elements	Cognitive	Physical	Social	Emotional
				(2021), Ghaziani et al. (2021), Mustapa et al. (2024)

Indoor Environment

Views of Nature from Inside (Window)

Views of nature play an important role in children's cognitive and emotional development. Studies have found that views of nature from inside through windows can significantly increase children's cognitive skills, increase focus and visual creativity, and improve academic performance (Li & Sullivan, 2016; Lindemann-Matthies et al., 2021; Pearson et al., 2023). For example, studies have demonstrated that children's attention increases in classrooms with window views of green landscapes (Li & Sullivan, 2016; Lindemann-Matthies et al., 2021). Similarly, studies by Lindermann-Matthies (2016) and Pearson et al. (2023) have demonstrated that children reported being more focused on tasks in classrooms with more natural window views. Meanwhile, in a study by Studente et al. (2016), children's visual creativity increased by exposure to natural views, plants, and the colour green. Emotionally, the presence of a window view towards greenery reduces children's stress and anxiety (Charlotte et al., 2022). Also, window views of green landscapes speed up children's recovery from stress (Lindemann-Matthies et al., 2021). A study by Mustapa et al. (2024) also found that a view of nature from a classroom enhances children's positive mood and happiness providing a refreshed feeling, and hence they can be more focused during learning.

Indoor Plants and Green Wall

Studies have demonstrated that indoor plants and green walls affect children's cognitive and emotional development. Cognitively, children are reported to have greater attention in indoor classrooms with plants than in classrooms without plants (van den Bogerd et al., 2020). Similarly, a study by Mustapa et al. (2024) found that the presence of indoor plants in learning spaces including classrooms gives a feeling of calmness, and thus children can focus better during learning. Potted vegetable plants also significantly increased attention and work memory in a study between the experimental and a control group (Bernando et al., 2021). Green walls were also found to have a significant impact on children's attention. A study by van de Bogerd (2017) showed that children in four classrooms with green walls scored better on a test for selective attention compared with children

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in classrooms without green walls. Emotionally, the presence of green walls has also been shown to reduce children's stress and anxiety levels (Charlotte et al., 2022). The presence of indoor plants and green walls in classrooms fosters a more relaxed and positive atmosphere that is conducive to learning and improves indoor air quality; thus, children have a positive mood and greater happiness during learning (Charlotte et al., 2022; Mustapa et al., 2024; van de Bogerd et al., 2020; van den Bogerd et al., 2017).

Natural Lighting

Natural lighting also plays an important role in children's cognitive and emotional development. Natural lighting for school interiors has been found to affect children's eyes, which in turn impacts their vision, observation skills, and ability to receive information, thus contributing to their overall cognitive development (Oppusunggu & Santoso, 2024). Another study by Baloch et al. (2020) demonstrated a positive relationship between performance scores and type of window shading, latitude, percentage of the window facing south, and window glazing, with the highest impact due to the window-to-floor area ratio that allows natural lighting. Another study by Mustapa et al. (2024) found that children prefer classrooms with sufficient daylight, as it makes them feel calm and allows them to focus on learning.

Outdoor Environment

Green areas

Studies have demonstrated that green areas in neighbourhoods and surrounding schools play an important role in children's holistic development, particularly their cognitive, physical, social, and emotional needs. Cognitively, studies have demonstrated that being in and walking in green areas improves children's attention, concentration, memory span, and academic performance (Amicone et al., 2018; Dadvand et al., 2015; Kuo et al., 2019, 2021; Reuben et al., 2019). For example, in a study by Kuo et al. (2021), children performed better in reading and maths tests when there was greenness within 250m of their school. Another study by Singh et al. (2024) demonstrated that attention for children with and without Attention Deficit Hyperactive Disorder (ADHD) improves when the children are surrounded by trees or in domestic gardens, or if there are water bodies in the neighbourhood areas. Physically, the diversity of natural elements in green areas allows children to be explorative and further increases their motor skills (Buczylowska et al., 2024; Kuo et al., 2019; Singh et al., 2024) and subsequently fosters interaction with their peers (Kuo et al., 2019; Singh et al., 2024). Also, physical activity while being under tree cover and in gardens was found to provide higher social cohesion and lower children's ADHD (Buczylowska et al., 2024). Emotionally, green areas significantly lower children's stress and have a

restorative effect (Amicone et al., 2018; Kuo et al., 2019); children were found to perceive greater restorativeness from the pre-test to the post-test after being in green areas in school during recess time (Amicone et al., 2018).

Natural Play Space

Natural play spaces and playgrounds also have an important role in children's cognitive, physical, social, and emotional development. Various natural elements in natural play spaces provide affordance for children to play. Those elements enhance children's creativity and problem-solving skills (Prins et al., 2023; Zamani, 2016). A study by Zamani (2016) showed that incorporating natural features and settings in outdoor preschools supports a diverse spectrum of cognitive play by inspiring children's imagination, social engagement, and games. The diversity of natural elements in natural play spaces also stimulates children's social skills, as children start to communicate with peers during play (Zamani, 2016). Emotionally, vegetation volume has been found to be significant in predicting perceived restorativeness. Smaller and greener playgrounds were found to yield the strongest restorative benefits (Bagot et al., 2015).

Indoor and Outdoor Environment

Biophilic Design

Studies have demonstrated that biophilic elements in both indoor and outdoor environments make a crucial contribution to children's cognitive, social, and emotional development. A study by Mustapa et al. (2024) found that connection to natural systems (views towards nature) and dynamic and diffuse light are the most crucial biophilic elements that need to be imparted in children's spaces to enhance children's well-being. Views towards greenery from inside the classroom, as well as natural light coming into the learning spaces, give children a feeling of calmness and refreshment so they can focus on their learning. Natural ventilation is also preferred, as it elevates children's positive emotions and reduces stress. Meanwhile, in a long-term study by Barbiero et al. (2021), children preferred the nature-based classroom compared to the conventional classroom. Children were found to be more focused in nature-based classrooms, which have restorative effects, and this increased their affiliation with nature. Similarly, a study by Abdul Malek et al. (2024) indicated that biophilic elements such as animals (pets), natural lighting, and water elements are the most preferred; they contribute to children's calmness and well-being and help them develop a connection with nature.

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Design Strategies for Integrating Nature in Children's Indoor and Outdoor Environments

Designing indoor and outdoor environments that incorporate nature is vital to support children's development. For the indoor environment, the review highlights the most important design elements, such as views of nature, indoor plants or green walls, and natural lighting coming into the spaces, which play an important role in fulfilling children's cognitive and emotional developmental needs. Meanwhile, green areas and natural play spaces in neighbourhoods and schools are vital for the outdoor environment to support children's holistic development. Hence, rethinking and repositioning nature is vital in children's habitual range, particularly the innermost zone, including at home, the home yard, play spaces, and the neighbourhood. Furthermore, repositioning and reconnecting with nature in children's frequent range, particularly, the intermediate zone, which is at school, is also crucial, as children spend most of their time learning at school (see Figure 1).

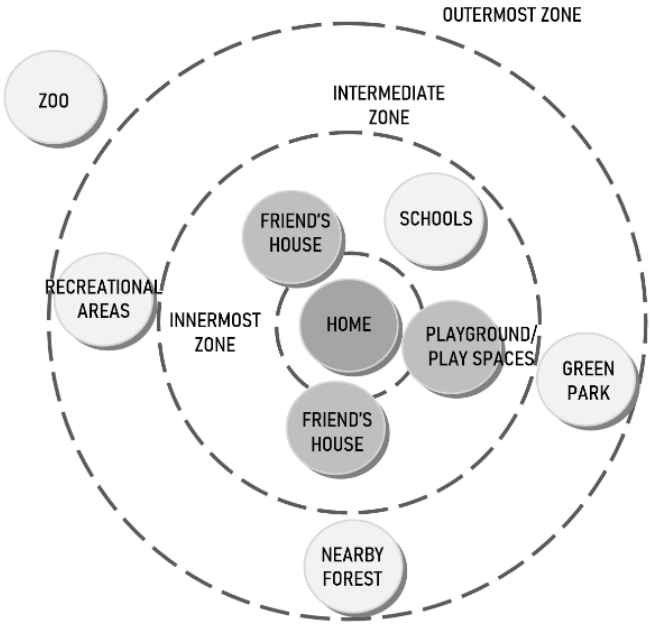


Figure 1: Children's Environment Range
Source: Author

As children increasingly spend more time indoors, integrating nature into their everyday environments at home, and in play spaces, neighbourhoods, and schools is essential for their development, health, and well-being. At home, nature can be introduced through domestic gardens, indoor plants, green walls, and balconies, especially for those living in high-rise buildings. Beyond the home, children's play spaces and neighbourhood areas should prioritise natural elements. Designers and planners play a key role in replacing conventional playgrounds with natural playgrounds that encourage creative play, independent mobility, and exploration. Exposure to diverse natural elements in parks and neighbourhoods provides both direct and indirect experiences with nature, positively influencing children's emotional and cognitive well-being. Schools are particularly important settings, as children spend a significant amount of time there. The implementation of green school grounds and biophilic design, such as views of nature, indoor plants, green walls, natural lighting, ventilation, and water elements, can enhance children's focus, academic performance, and emotional well-being. Even indirect exposure to nature through classroom windows contributes positively. Overall, the thoughtful integration of nature across children's daily environments is vital in supporting holistic development and fostering a lasting connection with nature.

CONCLUSION

The synthesis confirms that the presence of nature in indoor and outdoor environments is vital for children's holistic development: cognitive, physical, social, and emotional. Both indoor and outdoor contexts play an important role in contributing to children's development, as different natural contexts and design elements contribute differently and complement each other. All natural contexts complement each other, as the indoor environment contributes more to the cognitive and emotional aspects of children's development, while the outdoor environment can contribute to their holistic development. This review highlights the importance of green areas, natural play spaces, views of nature, indoor plants and green walls, and natural lighting on children's cognitive, physical, social, and emotional. Views of nature, indoor plants and green walls, and natural lighting seem to be important design criteria to be considered for implementation in indoor contexts, such as in school classrooms. Meanwhile, in the outdoor environment, green areas and natural play spaces, especially in the neighbourhood context and the school, make a crucial contribution to children's holistic development.

In addition, schools in children's intermediate-range can be seen as an important environment that supports children's holistic developmental needs as they spend most of their time at school. The findings suggest that a combination of a multi-environment design in the built environment can help to promote

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children's holistic development. The practitioners in the built environment, including architects, interior architects, and landscape architects, should play an important role in reconnecting children with nature. Educators can also help by designing spaces that incorporate nature into school classrooms, while parents should have a better understanding of the benefits of nature, and so provide their children with access to nature even in their home yard and inside the home. Future research can be conducted to explore other natural contexts and elements that contribute to children's development and well-being, and investigate further the impacts of indoor-outdoor nature-connected environments towards creating a sustainable environment and facilitating the sustainability of future generations.

ACKNOWLEDGEMENT

The authors would like to acknowledge Universiti Malaysia Kelantan for the continuous support.

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Received: 28th January 2025. Accepted: 15th November 2025

PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 319 – 334

FROM LOCAL AGENDA 21 TO SDG LOCALISATION: A PATHWAY FOR SUSTAINABLE DEVELOPMENT IN MIRI

Khalid Zanudin[1], Kiky Kirina Abdillah[2], Yusfida Ayu Abdullah[3], Bemen Wong Win Keong[4], Arnold Puyok[5]

[1,2,4,5]*Faculty of Social Sciences and Humanities*,
UNIVERSITI MALAYSIA SARAWAK
[3]*College of Built Environment,*
UNIVERSITI TEKNOLOGI MARA CAWANGAN SELANGOR

Abstract

Local Agenda 21 (LA21) was introduced in Malaysia in 2000 with four local authorities including Majlis Bandaraya Miri (MBM) selected as pioneers for its implementation. The purpose is to establish partnerships between local authorities and the community in achieving sustainable development. This initiative continues with the Sustainable Development Goals (SDGs). Few studies have examined the contribution of LA21 implementation by local authorities in Malaysia to enhancing their capacity to implement the SDGs in their respective localities. Lack of financial and institutional capacity, along with communities' limited awareness, potentially dampened the transition process between the two agendas. This research addresses the question "To what extent does the implementation of the LA21 contribute to the localisation of the SDGs by MBM?" A case study approach was employed, utilising reports and in-depth interviews with key stakeholders, namely public officers, councillors, and academicians. Findings show that MBM's LA21 initiatives, such as solid waste reduction and pollution control, have laid the foundation for localising the SDGs. However, challenges such as financial constraints and a lack of political support hindered the full realisation of these agendas. The research concludes that while LA21 provides a platform for community participation, stronger integration of community involvement and institutional support is necessary to fully localise the SDGs in Miri.

Keywords: Local Agenda 21, Sustainable Development Goals, localisation, local authority, Miri

[2] Corresponding author. Email: akkirina@unimas.my

INTRODUCTION

The global community has witnessed an increasing commitment to achieving sustainable development through the 2030 Agenda and its 17 Sustainable Development Goals (SDGs), which serve as a comprehensive roadmap for addressing pressing environmental, social, and economic challenges worldwide. While the SDGs provide a universal framework, their successful implementation requires localisation efforts to address each country's unique socio-economic and environmental contexts (GTF & UCLG, 2021).

A key mechanism for localizing the sustainable development agenda is the adoption of Local Agenda 21 (LA21), a participatory framework that originated from the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 (Ningrum et al., 2022). LA21 encourages local governments to collaborate with local stakeholders in developing sustainable strategies.

As a nation with a diverse cultural and ecological landscape, Malaysia recognised the importance of localising the sustainable development agenda and hence embraced the principles of LA21 to achieve this objective. Thus, SDGs implementation at the local level demonstrates Malaysia's commitment to ensuring sustainable development practices aligned with the country's diverse and unique challenges and characteristics (Salleh et al., 2023).

This research paper examines the role of LA21 in localizing the SDGs in Malaysia, with a focus on Majlis Bandaraya Miri (MBM). By examining the current implementation and experiences of MBM, this research aims to provide insights for policymakers, local governments, and stakeholders in Sarawak, offering strategies to enhance localization efforts. The findings seek to contribute to a broader understanding of LA21's impact on the localization of the SDGs, fostering sustainable development in Sarawak and potentially Malaysia.

THE NEXUS BETWEEN LOCAL AGENDA 21 AND SUSTAINABLE DEVELOPMENT GOALS

The connection between LA21 and the SDGs demonstrates a significant shift in how the sustainable development agenda is approached, linking global objectives with local actions. While LA21 provided a strategic framework for community-driven sustainable development (Ningrum et al., 2022), the SDGs provide a structured approach in addressing the fundamental challenges of sustainable development – economy, society and environment (Guha & Chakrabarti, 2019).

The introduction of LA21 acknowledges that most sustainability-related issues and challenges arise at the local level (Ningrum et al., 2022). It emphasises the importance of engaging local authorities with communities to enable a bottom-up approach to decision-making. It is based on recognising that local authorities are institutionally close to communities, which provides them

with better opportunities to communicate effectively and thus respond to local interests (Caruana & Pace, 2018).

In addition, community participation in the LA21 initiative will instil a sense of ownership and responsibility, leading to increased community support and long-term commitment to the sustainable development agenda (Caruana & Pace, 2018). By incorporating the experiential knowledge of communities ensures that sustainability strategies taken today will not compromise future generations' ability to meet their needs. Additionally, LA21 promotes continuous evaluation, enabling consistent reviews and revisions of actions to ensure that any action taken is responsive to the dynamism of global challenges.

The successful implementation of LA21 relies on several factors namely community participation, institutional capacity, political commitment, stakeholder collaboration and continuous monitoring and evaluation (Guerra et al., 2019). Active community participation ensures that sustainable development initiatives align with community priorities. At the same time, well-equipped local authorities, armed with clear frameworks, funding, and skilled personnel will drive sustainability efforts. Political leadership, meanwhile, is essential for resource allocation and sustaining long-term commitment.

The formation of the SDGs in 2015, meanwhile, builds on the Millennium Development Goals (MDGs) by addressing a broader range of global sustainability challenges (Ningrum et al., 2022). Although the SDGs represent a global agenda, their success depends on effective localization by translating global goals into actionable local strategies. SDG localisation involves setting context-specific targets, implementing mechanisms, and monitoring indicators (Guha & Chakrabarti, 2019).

Therefore, a bottom-up approach is critical to ensure that SDG initiatives align with local needs and aspirations (GTF & UCLG, 2021). It is because engaging local stakeholders promotes accountability and ownership, thus enhancing the effectiveness of sustainable development efforts. Subsequently, local authorities play a key role in leveraging local knowledge through strategic partnerships with local stakeholders, hence developing integrated sustainability solutions. Localization strategies for SDGs implementation include engaging communities in planning, strengthening intergovernmental collaboration, and promoting comprehensive, multi-stakeholder approaches (GTF & UCLG, 2021).

The link between LA21 and the SDGs highlights a paradigm shift where the former provides the groundwork for the latter. Nonetheless, both frameworks emphasize a bottom-up approach, encouraging partnerships between local authorities and communities (Ab Rahman et al., 2021). The success of the SDGs, however, depends on local strategies established through LA21 (GTF & UCLG, 2021).

Moreover, both frameworks emphasise the importance of continuous

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monitoring and evaluation to ensure the effectiveness and adaptability of sustainability initiatives (Ab Rahman et al., 2021). Substantially, by adopting LA21's monitoring mechanisms, local authorities can create a solid foundation for tracking SDG implementation and ensuring policies remain responsive to local needs and challenges (Caruana & Pace, 2018).

MIRI LOCAL AGENDA 21 AND SUSTAINABLE DEVELOPMENT GOALS INITIATIVES

LA21 in Miri was initiated in 2000 as part of Malaysia's pilot project (MBM, 2018; Md Zan, 2012). The MBM's ongoing commitment to this agenda reflects its integration of sustainable development principles in managing critical development issues, such as pollution control of the river, solid waste reduction, and improvement of the city's drainage network. These initiatives have involved various stakeholders including government agencies, the private sector, NGOs and communities. Moreover, MBM's transition from LA21 to SDGs initiatives demonstrated its dedication to the sustainable development agenda (MBM, 2020; MBM, 2018).

Local Agenda 21 Initiatives in Miri

The implementation of LA21 in Malaysia began with Projek Perintis LA21, which involved only four (4) local authorities (Md Zan, 2012). MBM started the Miri Local Agenda 21 (LA21) program in February 2000, involving various local stakeholders including government and non-government sectors, civil society, and communities (MBM, 2018). MBM's commitment to integrating sustainable development principles into its urban development is visible in the LA21 initiatives that are being implemented to this day. The aim is to enhance communities' and other stakeholders' awareness and participation in addressing sustainable development challenges.

A total of 58 issues are highlighted following a series of engagements such as forums, workshops, and town halls. Eventually, four (4) key areas, namely (i.) Pollution Control of Rivers in Miri, (ii.) Solid Waste Reduction and (iii.) Miri Drainage Network are highlighted as the most critical for the sustainability of the Miri city (MBM, 2018). In implementing LA21, MBM has established several committees composed of members from different backgrounds, including councillors, the corporate and private sectors, civil society, non-governmental organisations, schools and institutions, individuals, and other government agencies.

Generally, "Solid Waste Reduction" programs focus on educating the community about waste composting and recycling. A few workshops were held at various schools, including Sekolah Jenis Kebangsaan (SJK) Chung Hua and Sekolah Kebangsaan (SK) Pendidikan Khas Miri, and in communities around

Miri, involving hands-on activities such as decoupage (Table 1). Likewise, programs and initiatives under the "Pollution Control of Rivers" also focus on workshops on soap production from used cooking oil. Additional workshops were organised in various schools and communities, such as Rumah Ayai Sg, to further extend the impact. Saeh Niah, and Sekolah Menengah Kebangsaan (SMK) St. Joseph.

Table 1: Miri Local Agenda 21 Programs and Initiatives in 2018

Miri Local Agenda 21 Program				
Focus Area	**Frequencies**	**Venues**	**Total Number of Participants**	**Method of Engagement**
Solid Waste Reduction Implementation Working Group	1	Miri LA21 Seminar Room	34	Waste composting program
	4	Miri LA21 Seminar Room	102	Workshops on recycling products: Decoupage
	1	SJK Chung Hua Pujut	211	
	1	SK Pendidikan Khas Miri	82	
Pollution Control of Rivers in Miri Implementation Working Group	3	Miri LA21 Seminar Room	90	Soap production workshop from used cooking oil
	1	Rh Ayai Sg. Saeh Niah	35	
	1	SMK St. Joseph, Miri	243	
	1	SJK Tukau	80	
	1	SK Lambir Village	127	
Miri Drainage Network Implementation Working Group	1	Kpg. Nanga Angkari	132	Awareness campaign and community services
	1	Kpg. Lereng Bukit	132	
	1	Kpg. Pulau Melayu	118	
	1	Pantai Lutong	262	
	1	Kpg Lusut	42	
	1	Kpg Bersatu Batu 8	103	
Miri Local Agenda 21 Promotion Program	1	Kpg. Nelayan Kuala Baram	67	Exhibition on LA21 & Environment
	1	Padang Majlis Bandaraya Miri	482	
	2	SJK Chung Hua Miri	221	
	1	SJK Chung Hua Krakap	672	
	1	SMK St. Joseph	80	
	1	SK Kuala Baram	53	

Source: Majlis Bandaraya Miri, 2018

Meanwhile, the Miri Drainage Network Implementation Working Group conducted several campaigns and community service activities to maintain and improve the local drainage systems around Miri. These campaigns were held in various communities, including Kampung Nanga Angkari, Kampung Lereng Bukit, and Kampung Pulau Melayu (Table 1). In relation to the promotion of

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Local Agenda 21, MBM has organised several exhibitions and promotional programs to raise awareness and understanding of environmental issues and LA21. These exhibitions have been held in public areas, such as Padang Majlis Bandaraya Miri, which attracts a high turnout of 482 participants.

Continuity of Local Agenda 21 to Sustainable Development Goals

The MBM's continuity between LA21 and the SDGs reflects a progression in the city's commitment to sustainable development, building on past frameworks while adapting to the new global agenda.

Table 2: Miri Sustainable Development Goals (SDGs) Programs and Initiatives in 2020

Miri Sustainable Development Goals (SDGs) Program				
Focus Area	**Frequencies**	**Venues**	**Total Number of Participants**	**Method of Engagement**
Solid Waste Reduction Implementation Working Group	1	Kpg Melayu Beluru	60	Waste composting program
	2	SMK Merbau	69	
	1	Piasau Nature Camp	45	
	1	Jabatan Bomba & Penyelamat Zon 6	33	
	1	Kpg Long Apu	145	
	1	SJK Chung Hua	35	
	1	Sustainable Development Seminar Room	30	Workshops on recycling products: Decoupage
	1	SK St. Joseph	30	
	4	Sustainable Development Seminar Room	105	
Pollution Control of Rivers in Miri Implementation Working Group	1	SMK Merbau	22	Soap production workshop from used cooking oil
	1	SMK Luak	47	
	1	Facebook	319	
Miri Drainage Network Implementation Working Group	1	Marina ParkCity Beach	150	Awareness campaign and community services
	1	Brighton Cove	90	
	1	Miri Waterfront	110	
	1	Phase 5 Tudan	106	
	1	SMK St. Columbia	130	
	1	Kpg Muhibbah	130	
	1	Kpg Tudan Fasa 4 & 5	120	
	1	Pantai Lutong	194	
	1	Facebook	39	
	1	Bakam	65	
	1	Balai Raya Batu 1, Kuala Baram	112	
	1	Tanjung Batu	126	

Miri Sustainable Development Agenda	1	Kpg Senadin Jaya	136	Community awareness and empowerment
	1	Imperial City Mall	94	
	2	Jalan Bintang Miri	19	
	1	Miri Handicraft Centre	100	
	1	SK St. Joseph	80	
	1	Boulevard Shopping Mall	110	
	1	Miri Community Green Hub	27	
	1	SMK Dato Permaisuri	116	
	1	Wireless Walk Miri	64	
	1	SK St. Joseph	171	
	1	SK Pulau Melayu	72	
	1	SK South	164	
	1	Pullman Hotel	50	
	1	Facebook	143	
	1	SK Sungai Buri	30	
	1	Perumahan Interhill Park	80	
	1	Majlis Bandaraya Miri	35	
	1	Dylia Moksin Restaurant	60	
	1	Long Lellang	80	

Source: Majlis Bandaraya Miri, 2020

MBM continued its commitment to sustainability by aligning its initiatives with the SDGs. For the initiative by the Solid Waste Reduction Implementation Working Group, similar to LA21 efforts, the SDG-related programs focused on waste reduction and recycling, but with broader engagement across different venues, including schools, fire stations and a few kampungs (Table 2). For River Pollution Control, MBM continued to educate participants on sustainable practices, including workshops on making soap from waste materials. These workshops also involve schools like SMK Merbau and SMK Luak. In implementing the SDGs, MBM has also used social media, such as Facebook (reaching 319 participants), for information sharing, thereby reaching a wider audience. This approach marked a shift towards using digital platforms to spread awareness of the sustainability agenda (Table 2).

Meanwhile, based on Table 2, the Miri Drainage Network initiatives highlight more public spaces, such as Marina Park City Beach and Miri Waterfront, which are selected as a venue to involve larger portions of the community (90 to 150 participants per event). Also, schools and communities like SMK St. Columbia and Kampung Tudan Fasa 4 & 5 are involved, thus highlighting the council's efforts to engage various segments of the communities in improving urban resilience and addressing the flood issue.

In addition, MBM has maintained initiatives to promote the sustainable development agenda through a series of community engagement programs held in close proximity to the community, such as at Boulevard Shopping Mall, Perumahan Interhill Park, and a few schools like SK St Joseph and SK South.

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These programs have reportedly attracted large crowds ranging from 80 to 171 attendees. Selecting a few schools as venues underscores the importance of these institutions in fostering awareness of sustainable development from an early age. Besides physical engagement, MBM has also actively used Facebook as its primary social media platform to enhance community engagement, thereby expanding the information-sharing process. This reflected the council's adaptation to technology as a medium for communication.

In summary, the MBM SDG programs and initiatives are built on the success of the LA21 initiatives, with various stakeholders engaged and participating across different venues and locations. The promising number of participants is supplemented by the use of Facebook for engagement.

METHODOLOGY

This research focuses on the governance aspects of LA21 and examines current practices for managing and implementing the LA21 program at the local level. Moreover, this research will examine the challenges the MBM encountered. The research thus investigates the efficacy of the MBM in governing the LA21 program and how it contributes to their readiness to localise the SDGs.

Research Approach

This research employs a Case Study method and inductive reasoning. It is based on the suitability of the inductive approach for investigating the practices of LA21 and the SDGs by observing the current state of their implementation, thereby identifying patterns before reaching a tentative conclusion about the event (Babbie, 2010). MBM was purposively selected as the case study following MBM's status as one of the first four (4) local authorities to implement Local Agenda 21 in 2000.

Two (2) documents – the Miri Local Agenda 21 Annual Report (2018) and the Miri Sustainable Development Programs Annual Report (2020) – have been retrieved from MBM to analyse the current implementation and initiatives undertaken under both agendas. These documents were selected based on their availability and the potential of their data to indicate trends in participation during the transition period between LA21 and SDGs implementation.

In-depth Interview

A series of in-depth interviews with key informants among public official from MBM, local councillors, and academicians was conducted (Table 3). Purposive sampling is employed to ensure that qualitative data are gathered from those involved and knowledgeable about the implementation of the LA21 and SDGs agenda in Miri. The questions focus on their perceptions of the implementation of the LA21 program, especially its contribution to grounding the localisation of

the SDGs in Miri. The in-depth interview is selected as this method allows the researcher to gather a more comprehensive picture of a phenomenon through a small number of respondents, based on their experiences (Boyce & Neale, 2006). The in-depth interviews are conducted by establishing connections with informants, in person or via online platforms such as WhatsApp and Zoom.

Table 3: List and Background of Key Informants

ID	Position/ Agency	Role in LA 21/ SDGs
PO1	Senior officer Majlis Bandaraya Miri	Facilitate and directly involve in the LA21 and SDGs program and initiative by MBM
LC1	Local Councillor Majlis Bandaraya Miri	Committee member for LA21 and SDGs program and initiative by MBM
LC2	Local Councillor Majlis Bandaraya Miri	Committee member for LA21 and SDGs program and initiative by MBM
LC3	Local Councillor Majlis Bandaraya Miri	Committee member for LA21 and SDGs program and initiative by MBM
AC1	Senior Lecturer Universiti Teknologi MARA	Expertise in sustainability practices and implementation by local authorities
AC2	Lecturer Universiti Malaysia Sarawak	Expertise in LA21 and SDGs practices in Sarawak

Content Analysis

This research employed content analysis to analyse and interpret both primary and secondary data gathered. The content analysis approach outlined by Hsieh and Shannon (2005) will be adopted, in which transcribed data will be read several times to understand the entire dataset. It is followed with each line of words being read using the skimming and scanning technique (SST) to retrieve key information and the main idea of the in-depth interviews (Yusuf et al., 2017). It is done by familiarising hence categorising the transcribed data into broader themes that address the research question. Likewise, similar methods are used to analyse the secondary documents.

Data Source Triangulation

Data source triangulation in this research combines findings from primary and secondary data to gather multiple perspectives on a phenomenon, thereby validating the data (Alele & Malau-Aduli, 2023). In this research, findings from in-depth interviews will be triangulated with secondary data gathered from the LA21 annual report and the SDGs annual report prepared by MBM.

RESULTS AND DISCUSSION

The analysis highlights the current implementation of LA21 by the MBM, thereby preparing it for its transition to the broader sustainable development

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agenda - the SDGs. At the same time, the challenges in implementing both agendas are also highlighted.

Current Implementation of Local Agenda 21

LA21's implementation by MBM showcases a multifaceted approach that is both community-driven and collaborative with various stakeholders. As stated in the document, MBM conducted its LA21 program and initiative involving various stakeholders, including civil society and communities. The involvement of the community has been highlighted by four (4) respondents as a cornerstone of LA21's success [PO1; LC1; LC2; LC3]. One of the respondents further emphasised the importance of broad-based community engagement, highlighting that the success of initiatives like solid waste reduction relied heavily on inclusive participation [PO1].

"LA21 mempunyai pelbagai peringkat masyarakat, semua gabungan idea, inisiatif, bergerak seperti mana yang dikehendaki oleh masyarakat itu sendiri."
Respondent PO1

Three (3) respondents further highlighted that community leaders and NGOs are integral in fostering a sense of ownership among participants, leading to more effective and sustainable outcomes [LC1; LC2; LC3]. However, despite these efforts, few key informants highlighted gaps in public awareness and education on sustainability issues, indicating that continuous efforts are needed to fully engage the community [LC2; LC3]. This corresponds to the argument made by Guerra et al. (2019) that active participation among communities is fundamental, as their experiential knowledge can ensure that any decision made by the government is sustainable.

Collaboration with the private sector and NGOs emerged as another critical element of LA21's implementation. Two (2) respondents highlighted successful campaigns such as "Say No to Plastic," which relied on supermarket and other business support [PO1; LC1]. One respondent also mentioned the collaborations with the private sector for biodegradable products and the involvement of NGOs in promoting environmental awareness [LC1]. It is displayed from a few programs and initiatives conducted close to the target group, predominantly the community (Table 1). These examples underline the importance of multi-stakeholder partnerships in enhancing community involvement in sustainable development, thereby building trust in the government as the decision-maker and policymaker (Guerra et al., 2019; Ab Rahman et al., 2021).

"... in politics, a lot of people go for gimmick, rather than sustain it. Get the publicity, move on to the next publicity, and then you do not care what happens. ..the advantage of NGOs is NGOs tend to go for something that is sustainable"

Respondent LC1

Both respondents from academia further supported this by noting that LA21 encourages a collaborative approach that brings together local authorities, communities, NGOs, and the private sector, enhancing the effectiveness of sustainable development initiatives [AC1; AC2].

Leadership and support from authorities are crucial in driving LA21 programs. Strong support from MBM management is vital for mobilising resources and sustaining initiatives [PO1]. One respondent also stated that feedback gathered from the community and stakeholders is essential in refining and improving LA21 implementation [LC3]. This top-down approach, supported with grassroots involvement, creates a balanced framework.

"Selain daripada masyarakat, sokongan daripada pihak atasan amat penting dalam memastikan kejayaan satu program."

Respondent PO1

As highlighted by Caruana and Pace (2018), the successful implementation of LA21 also depends on local authorities' capacity, both financial and institutional. It requires a clear institutional framework, adequate funding, and skilled personnel to drive the agenda.

The findings demonstrate that the implementation of LA21 programs benefited from active community involvement, effective collaboration with the private sector and NGOs and strong leadership. These insights contribute to a greater understanding of the current implementation of sustainable development initiatives at the local level, specifically MBM.

Implementation Challenges

The implementation of LA21 in Miri faces challenges, particularly due to financial capacity constraints and resource limitations. As several respondents highlighted, the local authority's reliance on tax-based revenue and limited external funding may have constrained the scope and sustainability of LA21 initiatives [PO1; LC3]. In parallel with previous studies, the significance of adequate funding to sustain the initiatives (Guerra et al., 2019). However, PO1 believed that stakeholder commitment, including from the community, could help MBM overcome this challenge.

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"…tidak ada peruntukan. but, itu bukan merupakan satu alasan untuk tidak melaksanakan. Sebab konsepnya, apabila ada komitmen, suatu benda boleh dilaksanakan walaupun tiada sumber peruntukan…"

Respondent PO1

Apart from financial barriers, a few respondents also highlighted political influence as a critical factor in determining the success and continuity of LA21 programs [LC1; LC2]. The impact of political changes often results in shifts in focus and the discontinuation of ongoing sustainability projects. It requires political will and commitment, demonstrated by local leaders, to champion the sustainable agenda (Guerra et al., 2019).

"…. when political leaders change, sometimes the focus also shifts."

Respondent LC2

This is shown in the "Say No to Plastic" campaign, which lost its momentum following different initiatives focused on due to a change in leadership. In other words, a lack of political will or a change in leadership might further undermine these programs' effectiveness and long-term sustainability, as short-term political gains often outweigh sustained environmental efforts [LC1; LC2].

Community participation and public awareness are crucial components of LA21. Nonetheless, ensuring continuous and consistent participation among the community has been challenging. It is due to difficulties in changing societal behaviour, such as reducing plastic use, which have faced resistance from the community [PO1]. Therefore, a few respondents have underlined the importance of community ownership for the success of projects [LC1; LC2]. Likewise, few researchers emphasised the importance of local authorities in encouraging local communities to actively participate (Guerra et al., 2019).

Unfortunately, the transition from LA21 to SDGs has diminished community involvement, shifting the focus from community or NGO-led to council-led initiatives [LC1]. It corresponds to other respondents' responses, which highlighted the need for increased public awareness and education on the sustainability agenda, as low participation rates in programs will hinder the effectiveness of LA21 or SDGs initiatives [AC1; AC2]. Furthermore, the current approach tends to be program-oriented and reactive, rather than based on long-term planning, thus posing significant barriers to achieving LA21's sustainability goals [AC1].

"I think the program should be rakyat oriented...means, it organised by people."

Respondent AC1

The shift from a bottom-up to a top-down approach in implementing sustainability initiatives has raised concerns among the respondents who represent their communities [LC1; LC2; LC3]. They believe the bottom-up approach of LA21, which involved NGOs and community groups in decision-making, was more effective at fostering community ownership and ensuring program longevity. The transition to a top-down approach under the SDGs framework has reduced community influence in planning and implementing the programs, making it more difficult to sustain [LC1; LC2; AC1]. As a result, two (2) respondents called for decentralizing the SDGs initiatives to enhance the effectiveness of sustainability efforts [LC2; AC1].

In summary, MBM's challenges in implementing LA21 highlight the need for increased funding, more substantial political commitment, and greater community involvement. Addressing these barriers will be essential to successfully transitioning from LA21 to the SDGs.

Impact of Local Agenda 21 on Sustainable Development Goals in Miri

Based on the findings, the programs under LA21 have successfully raised community awareness and instilled a sense of responsibility towards sustainability [PO1; LC1; LC2; LC3; AC2]. This shift in perception has provided a solid foundation for the transition to SDGs, with many LA21 initiatives such as solid waste reduction and pollution control, aligning with the broader, holistic framework of the SDGs (Table 1 & Table 2). LA21 has established local strategies that provide the platform for localising the SDGs (GTF & UCLG, 2021). Furthermore, the LA21 initiatives have laid the groundwork for community-driven sustainability, which has been progressively integrated into the SDGs agenda, particularly after 2020 [PO1].

"Di dalam Local Agenda 21, kebanyakan elemen tersebut boleh dicapai sebab seperti mana yang kita ketahui, penglibatan komuniti, ketidak ciciran, semua ada didalam elemen-elemen tujuh belas."

Respondent PO1

However, the transition from LA21 to the SDGs faces challenges. It has been noted that aligning LA21 initiatives with the SDGs requires balancing local priorities with broader sustainability goals and securing sufficient resources [LC3; AC1]. Despite these challenges, the SDG initiatives have demonstrated resilience, particularly in adapting to emerging challenges such as the COVID-19 pandemic (Table 2). This corresponds to Ab Rahman et al. (2021) argument on the need for continuous monitoring and evaluation for both agendas to ensure the initiatives are adaptive and effective in terms of their implementation.

Several respondents, meanwhile, agreed with the importance of the

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awareness built through LA21, noting that it made the community more receptive to SDGs implementation [LC1; LC2; LC3; AC2]. Noticeably, the number of participants in the awareness campaign and pollution control demonstrates high turnouts (Table 2). Nonetheless, a few respondents warned that a lack of sustained community involvement in current SDG initiatives could hinder their long-term success [LC1; LC2].

"As I mentioned, there is nothing wrong with any SDG initiatives. However, to make it more effective, bring back the LA21 structure into the SDG implementation."

Respondent LC1

Another critical aspect highlighted is the need for enhanced collaboration and resource allocation. It appears that the majority of respondents emphasised diversifying participation and strengthening partnerships among local authorities, communities, and private entities [CR1; CR2; AC1; AC2], with both CR1 and CR2 advocating increased involvement of NGOs, which played a pivotal role during the LA21 era. They believed that the sustainability of a program can be achieved if it is led by NGO or community. Meanwhile, a respondent highlighted the positive outcomes of LA21 in fostering social cohesion, suggesting that expanding these programs to cover a larger geographical area and more demographic groups could further enhance the localisation of SDGs [AC2].

"The implementation of LA21 have enhanced the social cohesion among the community as well as the sense of ownership among local communities."

Respondent AC2

As stated by several past studies, LA21 has laid the foundation for a more localized sustainable development initiative where this sustainable development agenda provides a comprehensive framework of SDGs to address various issues, especially concerning the communities (Ab Rahman et al., 2021; GTF & UCLG, 2021; Caruana & Pace, 2018).

Overall, the insights from the key informants suggest that while LA21 has laid a strong foundation for sustainability in Miri, the transition to SDGs requires continued community engagement, enhanced collaboration and resource allocation to ensure its long-term success.

CONCLUSION

In conclusion, this research highlights the importance of LA21 in establishing a foundation for sustainable development in Miri, particularly in localising the

SDGs. The programs and initiatives implemented by MBM under LA21 have instilled a spirit of community participation, thereby embedding sustainability into local community culture. Through programs and initiatives focused on waste reduction, pollution control and drainage management, LA21 has demonstrated the role of local authorities like MBM in driving sustainable change with community involvement.

However, the transition process from LA21 to the SDGs uncovers both opportunities and challenges. While the SDGs offer a more holistic framework for the sustainable development agenda, it requires stronger community-driven programs and initiatives, similar to LA21, to ensure effective and sustainable localisation of the SDGs. The findings suggest that MBM could benefit from decentralising implementation structures and enhancing resource allocation to foster a wider, more inclusive approach to the sustainability agenda.

Overall, the lessons learned from MBM's LA21 experience provide valuable insights for policymakers, local authorities and stakeholders in Malaysia, particularly in Sarawak. By reinforcing collaborative networks and adapting to local socio-political dynamics, cities like Miri can advance SDG localisation efforts rooted in community involvement and aspirations.

ACKNOWLEDGEMENTS

Authors wish to express their gratitude to Universiti Malaysia Sarawak (UNIMAS) for its support of this project through the PILOT Research Grant Scheme (UNI/F06/PILOT/85384/2023). Authors would also like to extend their appreciation to Majlis Bandaraya Miri, along with the councillors and academicians, for their valuable perspectives and contributions of time.

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Received: 31st January 2025. Accepted: 15th November 2025

PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 335 – 349

CRITICAL ANALYSIS OF PAYMENT DELAYS, UNDER-PAYMENTS AND NON-PAYMENTS ENCUMBERING ENGINEERING CONSULTANCY PRACTICES IN CONSTRUCTION PROJECTS

Ting Sim Nee[1], Lee Yee Yong[2], Gui Hun Chuen[3], Chong Wan Siang[4], Ng Chee Khoon[5]

[1, 2, 5] *Department of Civil Engineering, Faculty of Engineering*,
[3,4] *Department of Quantity Surveying, Faculty of Built Environment,*
UNIVERSITI MALAYSIA SARAWAK

Abstract

Engineering Consultancy Practice (ECP) plays a crucial role in Malaysia's construction industry, supporting the nation development and progress. Engineering consultants through their professional practices provide essential technical services and expert advice to clients throughout construction projects. In Malaysia, consultants are typically reimbursed based on the Board of Engineers Malaysia (BEM) Scale of Fees, which serves as the primary revenue source sustaining ECP operations. However, despite the adherence to BEM's Scale of Fees, engineering consultants in Malaysia continuously encounter payment issues, namely payment delays, under-payment and even non-payment, posing a concerning scenario within the nation's construction industry. To determine the extent and significance of payment issues affecting engineering consultants, this study employed a structured questionnaires survey targeting engineering consultants in Malaysia. A total of 174 responses were collected through online questionnaires, telephone interviews, face-to-face engagement and email correspondence. The findings show that late payment, underpayment and non-payment are prevalent across government, GLC and private projects, with the private sector recording the greatest incidence, delays averaging one to three months, and typical payment deficits of 10–30%. The study contributes empirical benchmarks that support more effective contractual, regulatory and payment management frameworks to strengthen financial sustainability within engineering consultancy practice.

***Keywords*:** Payment, Delays, Non-Payment, Engineering, Consultants

[1] Corresponding author. Email: snting@unimas.my

INTRODUCTION

Engineering Consultancy Practices (ECP) refers to a specialised professional service within the engineering industry, in which chartered engineers, who are also known as engineering consultants, offer expert advices, technical solutions, and comprehensive engineering services to an array of private as well as public clients through their authorised consulting firms recognised in each of their respective countries (du Preez, 2018). The primary purpose of an engineering consultancy practice is to assist individuals, businesses, governments, and organizations in making informed decisions, solving complex engineering challenges, and successfully executing projects within the field of engineering (Hoffman et al., 2023). Engineering consultants utilise their technical expertise, knowledge of industry standards, and innovative problem-solving skills in a variety of engineering disciplines to develop designs that meet their clients' needs while considering safety, sustainability, cost-effectiveness, and regulatory compliance (Wan Zukifli et al., 2008; Ying and Wang, 2020). Their contribution plays a vital role in shaping the built environment and thus, advancing multiple upstream and downstream industries along its path.

ECP provide essential engineering services and expert advice to clients, enabling informed decisions in construction projects. Their technical responsibilities encompass various tasks, including designing and producing drawings for tender and construction stages, supervising construction work, offering specialized technical guidance, and providing project management support, including contract administration (Lai et al., 2016). Their design scope encompasses a wide range of items, which includes but is not limited to significant infrastructure projects, residential and commercial buildings, mechanical and electrical systems, and communication networks (Lai et al., 2014). The comprehensive expertise of engineering consultants across these diverse domains contributes significantly to the advancement of engineering practices and fosters sustainable development within various sector.

For any businesses, a steady and seamless monetary flow is essential for survival and performance (Mohd Badroldin et al., 2016). Engineering Consultants, for the large part, operates as a project-based organisation, encapsulating the execution of projects from design to construction (Chitongo and Pretorius, 2017). Thus, the Engineering Consultant seeks to benefit financially (good financial performance, and thus good business performance) during project execution. In Malaysia, ECP typically receive reimbursement based on the Board of Engineers Malaysia's (BEM) Scale of Fees, commonly known as professional fees. These fees serve as the primary revenue source, sustaining ECP operations. In order to maintain ethical conduct and safeguard clients from potential fraud, the Board of Engineers, Malaysia (BEM), strictly

regulates and registers ECP in adherence to relevant acts under Registration of Engineers Act 1967 (Lai et al., 2016).

However, ECP incur significant operational costs, including salaries and benefits for engineers, technical, support, and administrative staff involved in project delivery and business management (Salehin, 2007); office space and utilities; and investments in software, hardware and engineering equipment necessary for design, analysis, and project management (Lee et al., 2022; Syed Jamaludin et al., 2022). Regular maintenance and upgrades further add to these expenses. ECP must also maintain professional and general liability insurance, obtain and renew licences and certifications required by professional bodies and regulators, and bear the associated compliance costs to meet prescribed standards. In addition, consultancy practices allocate resources to marketing and professional development (Jaafar et al., 2008), including continuous training, workshops, seminars, online courses, and certifications to ensure staff competency and service quality. Collectively, these expenditures place considerable financial pressure on consultancy operations, necessitating prudent financial management. Despite adherence to the BEM Scale of Fees, ECP in Sarawak and other parts of Malaysia continue to encounter payment issues, posing concerns for financial sustainability within the construction industry.

Payment issues in engineering and construction refer to challenges and problems related to the financial transactions and compensation processes within the industry (Hasmori et al., 2012). Payment concerns have been an old age issue that have undoubtedly occurred the Malaysian construction industry over the years. Some common payment issues in ECP can be widely divided into three (3) categories. According to Judi and Rashid (2010) and Mohd Badroldin et al., (2016) late payments where there are delays in receiving payments for completed work which resulted in cash flow problems for engineering consultants to meet their financial obligations. In some cases, clients may fail to make payments for completed work or may dispute the payment owed, leading to the second issue of non-payment for engineering consultants (Maritz and Robertson, 2012). Thirdly, under-payment is another common problem faced by engineering consultants in ECP. Under-payment to a situation where the engineering consultant receives a payment that is less than the agreed-upon or expected amount for completed work or services rendered. It is a type of payment issue that can arise due to various reasons and can have adverse effects on the affected party and the overall project.

This study analyses prevailing payment practices and the associated challenges faced by ECP in Malaysia, focusing on the occurrences of late payment, underpayment and non-payment for ECP. The study seeks to provide empirical evidence on current payment conditions and their implications for consultancy operations within the construction industry. The findings will be used to form informed data on the dynamics of ECP payment practice. It hopes

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to support practical improvements in contractual compliance, payment management and regulatory practices, contributing to enhanced financial sustainability and operational stability within the engineering consultancy sector.

RESEARCH METHODOLOGY

The study encompasses four main phases, starting with an in-depth literature review, followed by the design of a structured questionnaire, data collection and data analysis. Employing a quantitative approach, the research seeks to achieve its objectives by gathering crucial feedback from practicing engineering consultants in Malaysia. The survey duration spanned three months, during which approximately 300 questionnaires were distributed, out of which 174 respondents actively participated, representing a 58% return rate. The questionnaire was designed with a number of four sections as follows.

Section A: Respondent Information
Section B: Awareness of Respondent's on Existing Payment Conditions
Section C: Current Payment Practices
Section D: Satisfaction Level and Improvement Required on Current Practice

The results obtained were then analysed statistically by computing the Cronbach's Alpha coefficient to determine its reliability. The analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) software. Table 1 below shows a commonly accepted rule of thumb for describing internal consistency that ranges between zero and one. Reliability testing only applies to questions using Likert scale only, therefore the following results were analysed using Cronbach's Alpha for Section C and Section D of the questionnaires.

Table 1: Reliability Coefficients

Reliabililty Coefficients	Description
Reliability Coefficient > 0.9	Highly reliable
Reliability Coefficient > 0.8	Good
Reliability Coefficient > 0.7	Acceptable
Reliability Coefficient > 0.6	Questionable
Reliability Coefficient > 0.5	Poor
Reliability Coefficient < 0.5	Unacceptable

Subsequently, analysis of Relative Importance Index (RII) provided insights on the priority of each criterion by using a value of 0.2 to 1.0, in which 1.0 reflects 100% of the respondents strongly agreed to the statement presented, while on the other end of the scale, 0.2 reflects 100% of the respondents strongly

disagreed to the proposed statement. Mohammad Badroldin et al. (2016) explained that relative index is based on a formula stated in Equation 1:

$$\text{RII}_1 = \frac{\sum \quad x_c}{A\ X\ N} \qquad (1)$$

Where,
RII = Relative Importance Index
W = Weight given to each factor by the respondents (scale 1 to 5)
A = Highest weight (scale 5)
N = Total number of respondents

The classification of RII in this study is described in Table 2 as follows:

Table 2: Classification of RII

RII	Description
0.00 ≤ relative important index < 0.25	Strongly Disagreed
0.25 ≤ relative important index < 0.50	Disagreed but have to accept to a certain extent
0.50 ≤ relative important index < 0.75	Agreed but it can be better
0.75 ≤ relative important index < 1.00	Strongly Agreed

The following section presents the findings of the structured questionnaire survey, providing an empirical assessment of the prevalence, frequency, and characteristics of payment delays, underpayments, and non-payments of ECP fees.

RESULTS AND DISCUSSION

Background of Respondents

The summary of the ECP's background participating in the survey is shown in Figure 1.

From the results, among 174 respondents that had participated in this study, majority of the respondents are Director/Partner/Sole Proprietorship which represents 66.09% (115), followed by 18.39% (32) are Professional Engineer with Practising Certificate, 12.07% (21) are Senior Engineer and remaining 1.72% (3) are 'Others' comprises of Chief Operating Officer and Engineers.

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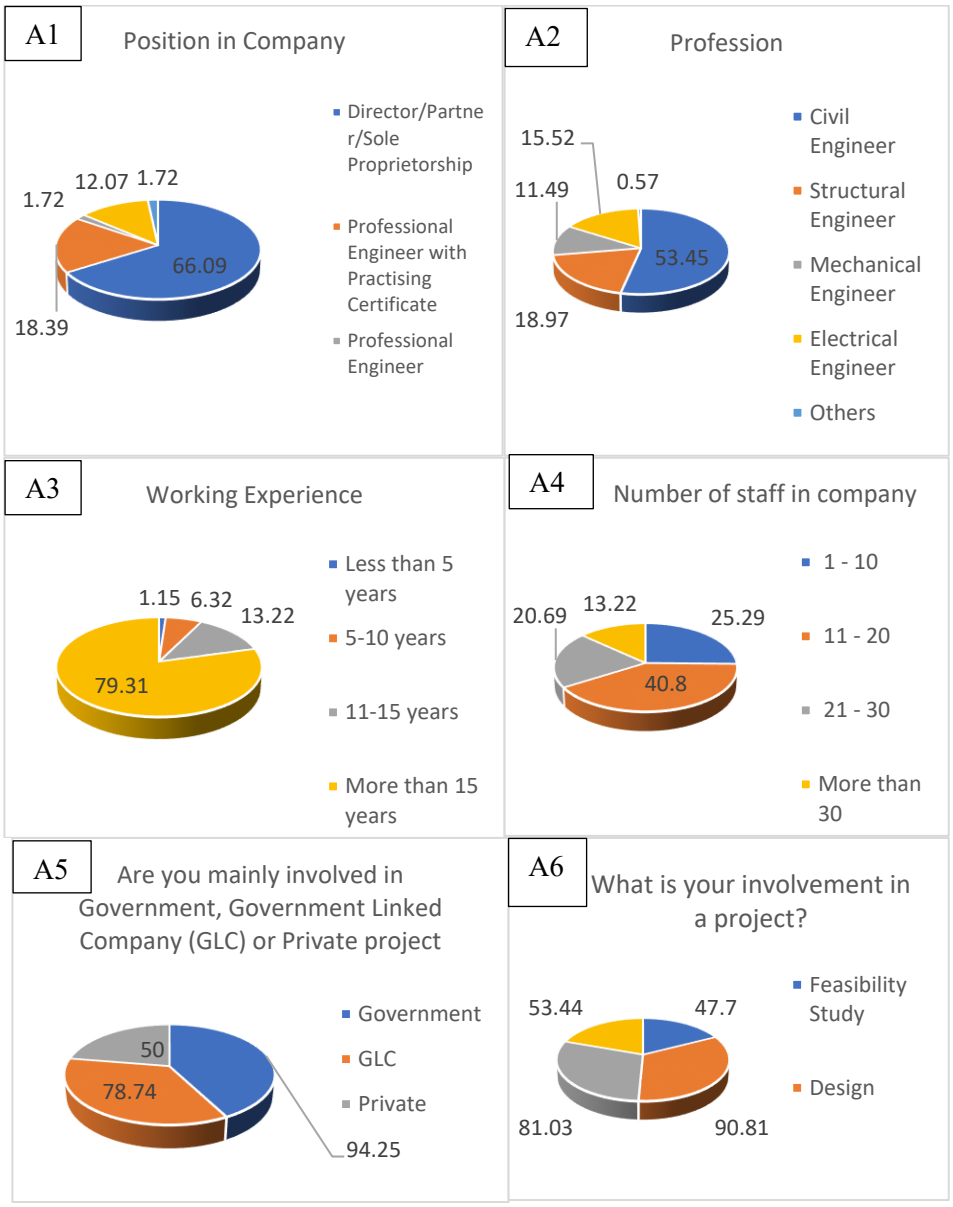


Figure 1: Summary of Respondents Background

Most of the respondents' profession are Civil Engineer represents 53.45% (93) and 18.97% (33) are Structural Engineer. Moreover, there are 15.52% (27) respondents are Electrical Engineer, 11.49% (20) respondents are Mechanical Engineer and Others 0.57% (1). The study categorized the total years of work

experience of the respondents into five categories. Among 174 respondents' background, more than half represents 79.31% (138) respondents have working experience of more than 15 years followed by 13.22% (23) respondents having 11 to 15 years work experience. Meanwhile, 6.32% (11) of them have 5 to 10 years' experience and the remaining 1.15% (2) was working less than 5 years in the industry.

Respondents were also required to indicate the number of staffs in their company. According to the results collected from the respondents, most of the them have 40.80% (71) 10-20 staffs in their company, followed by 25.29% (44) respondents which have 1-10 staffs, 20.69% (36) of them have 21-30 staffs and the remaining 13.22% (23) have more than 30 staffs in their company.

Further, the respondents were then asked on their involvement in Government, Government Linked Company (GLC) and Private project with respect to the payment issues. The respondents can select more than one answer based on their experience in the industry. 94.25% (164) respondents involved in Government Projects, 78.74% (137) of them are involved in Government Linked Company projects and 50.00% (70) respondents involved in Private Projects.

The respondents were required to indicate their involvement in a project and their selection can be more than one answer. The majority of respondent which is 90.81% (158) involved in Design, followed by 81.03% (141) in Project Management, 53.44% (93) in Supervision and last but not least 47.70% (83) in Feasibility Study.

Overall, most of the respondents were Director/Partner/Sole Proprietorship with more than 15 years' experience and majority of them involved in Government project. The Government in this study including Federal and State Sarawak related projects. Their esteemed background will assist in getting more accurate result through their experience which enables them to answer based on their real-life experiences and practices in the industry.

Payment Issue: Late Payment

This section sought to elicit responses from respondents on issues solely pertaining to late payment for the professional services rendered by ECP. Other that payment issues such as supervision claims and reimbursable will be discussed in later section. The respondents were questioned on whether their clients made payment according to the stipulated time in the consultancy agreement. The results obtained can be summarized in the Figure 2.

Out of the 164 respondents who were involved in Government projects, 62.80% (103) claimed that their clients failed to make payment based on the agreed time frame in the consultancy agreement, while 37.20% (61) of respondents faced no such issue. On top of that, from the 137 responses received from ECP who were involved in government linked company (GLC) projects,

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findings uncovered that 65.69% (90) of respondents mentioned their clients did not pay their fees on time and only 34.31% (47) of respondents stated their clients did. Additionally, the study also discovered that from the 87 respondents who were involved in private projects, 82.76% (72) specified that their private clients did not pay them on time and the remaining 17.24% (15) declared the contrary.

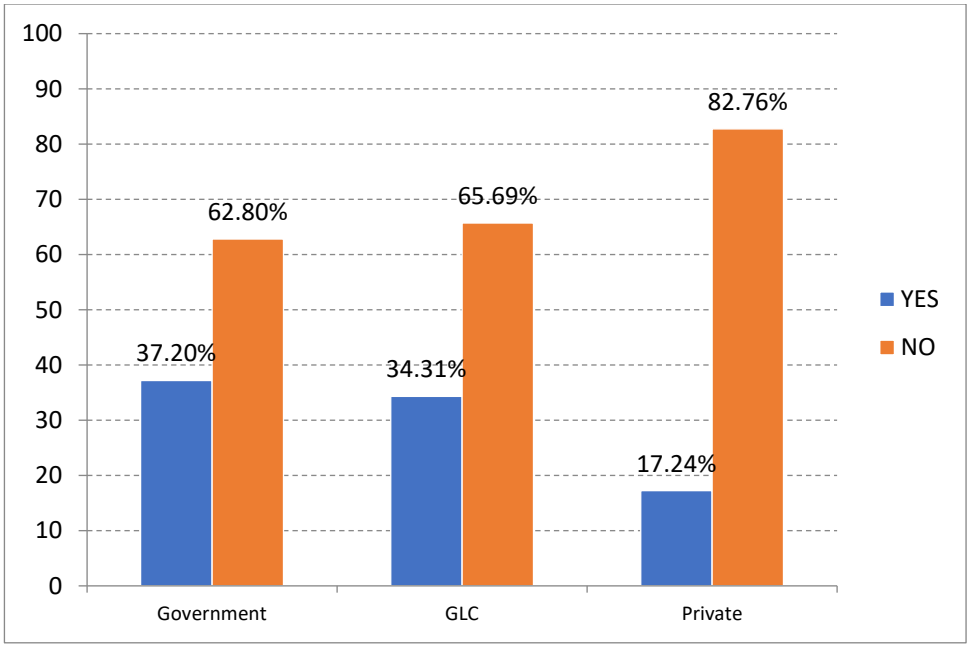


Figure 2: Experience of on time payment to ECP by Clients

Based on the results, it can be concluded that the majority of clients failed to make payments within the time as stipulated in the consultancy agreement, implying that payment delays are a major concern among the ECP in the construction industry in Sarawak.

Then, the respondents were required to specify the average duration of payment delay from their clients. Majority of the respondents claimed that they encountered payment delay, with the average duration for payment delay are shown in Figure 3. From the results acquired, almost half of the respondents 46.11% (77) claimed that the average delay ranges from 4 to 6 months, followed by 41.32% (69) of respondents specifying that the average delay was more than 6 months while the remaining 12.57% (21) stated the average payment delay was 1 to 3 months.

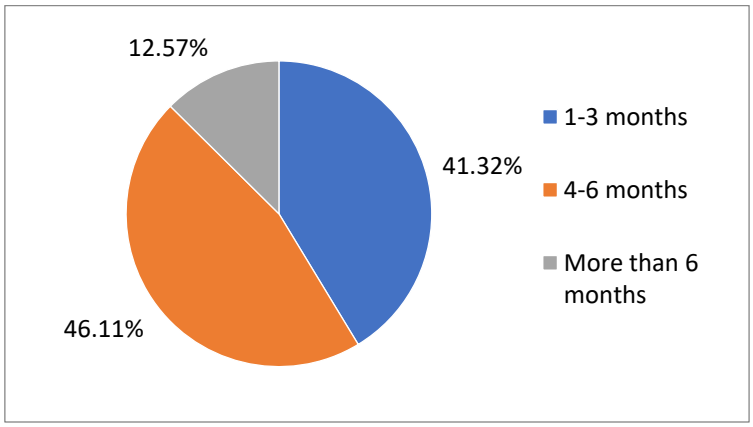


Figure 3: Average Duration of Payment Delay from Client

Payment Issue: Under-Payment

This section sought to obtain responses from respondents on issues related to under-payment for the ECP. Under-payment is depicted as the final amount received to be under the agreed the amount. The final amount will include design fees, supervision and reimbursable. The respondents were requested to specify if they have experienced under-payment by their clients as well as the magnitude of underpayment if they had. Results are shown in Figure 4 and Figure 5 respectively

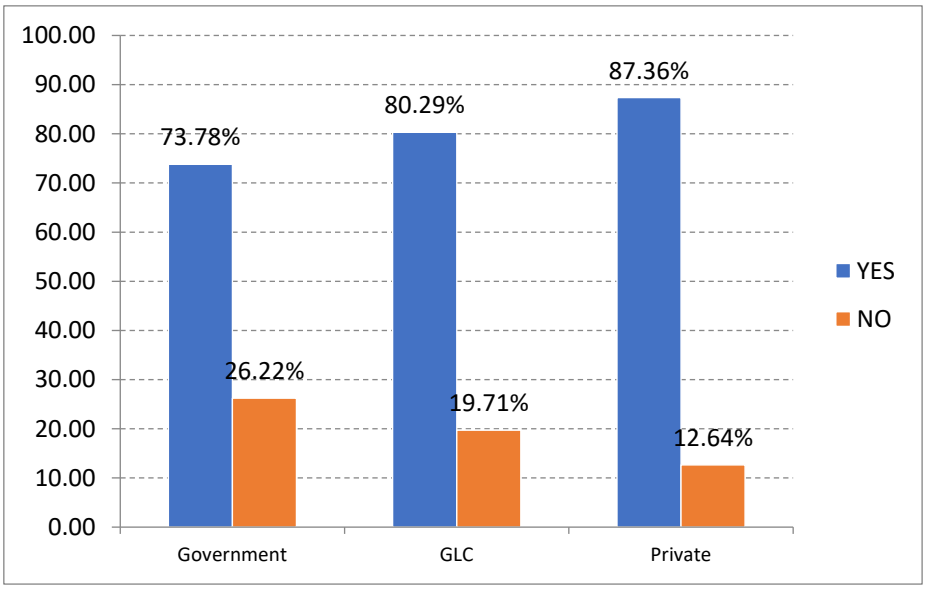


Figure 4: Experience of underpayment to ECP by Clients

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Figure 4 referred, 164 respondents who were involved in Government project, 73.78% (121) of them claimed that they had experienced underpayment from their Government clients as the final amount being less than in the agreed amount, while 26.22% (43) of respondents were paid accordingly to the actual payment claims made. Moreover, from the 137 responses received from ECP who were involved with government linked company (GLC) project, the findings revealed that 80.29% (110) of respondents claimed that they had encountered underpayment from their GLC clients and the remaining 19.71% (27) of respondents stated the opposite. The study also ascertained that from the 87 respondents who were involved in Private projects, 87.36% (76) of them specified that their private clients paid them lower than the actual payment and another 12.64% (11) of respondents declared otherwise.

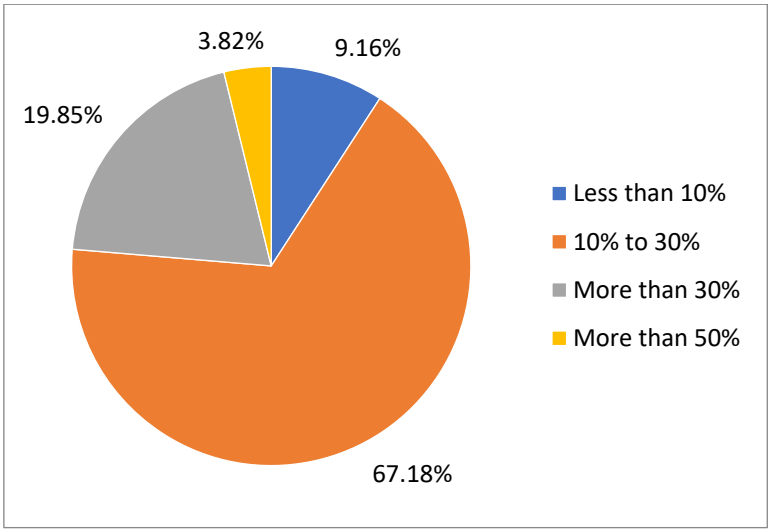


Figure 5: Average amount of underpayment compared with agreed amount

As shown in Figure 5, most of the respondents, 67.18% (88), specified that they received 10% to 30% lower payment than the agreed value, 19.85% (26) of respondents reported to have received a payment that was more than 30% less than the agreed-upon amount, 9.16% (12) of respondents claimed that they received less than 10% of actual payment, while the remaining 3.82% (5) of respondents reported receiving payments that were more than 50% lower than the agreed sum.

Payment Issue: Non-payment

This section aims to investigate on non-payment issues, where the respondents were questioned whether they experienced non-payment in any of their projects. Non-payment is depicted by not receiving payment at all after a year of project completion or after a specific claim is made, and the results are depicted in Figure 6.

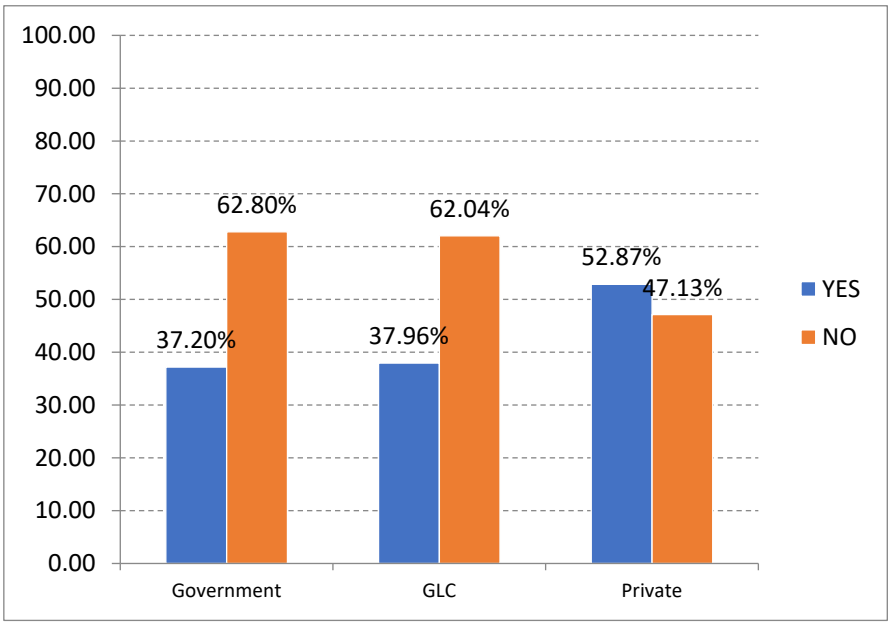


Figure 6: Experience of non-payment after a year of project completion

From a total number of 164 respondents who were involved in Government project, 62.80% (103) of them stated that they had never encountered non-payment issues from their Government clients while 37.20% (61) respondents claimed that they have yet to receive any payment after a year of project completion. Additionally, from the 137 responses received from ECP who were involved in government linked company (GLC) projects, findings discovered that 62.04% (85) of respondents had never encountered non-payment issues from their GLC clients and the remaining 37.96% (52) of respondents stated they had. The study also ascertained that 52.87% of the 87 respondents who were involved in Private projects that did not receive any payment from a year of project completion and the only 47.13% (41) of respondents declared in contradiction.

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DISCUSSION

The findings above provide empirical and factual evidences that late payment, underpayment and non-payment is happening and remain prevalent incidences, affecting ECP in Malaysia. Payment irregularities were observed across all client categories, including private, Government and Government-Linked Company (GLC) projects, indicating that the problem is systemic rather than sector-specific. Survey results show that 62.80% of consultants involved in Government projects and 65.69% in GLC projects experienced late payments, while the proportion increased substantially to 82.76% for private projects, demonstrating a higher exposure to payment risk in the private sector. In terms of duration, 46.11% of respondents reported average delays of four to six months and 41.32% experienced delays exceeding six months, suggesting that payment delays are prolonged rather than short-term administrative lapses. Collectively, these findings confirm that payment challenges are widespread and consistent with trends reported in previous studies.

Beyond delays, underpayment and non-payment were also prevalent. A majority of respondents (67.18%) reported receiving payments 10–30% below the agreed value, while nearly one-fifth experienced reductions exceeding 30%, indicating substantial deviations from contracted professional fees. Non-payment after one year of project completion was reported by 37.20% of Government project respondents, 37.96% of GLC respondents and 52.87% of those involved in private projects, further highlighting the heightened financial risk associated with private sector engagements. These patterns demonstrate that payment deficiencies extend beyond timing issues and frequently involve incomplete or absent settlement of fees.

Contractual and procedural shortcomings were evident across the industry and contributed to persistent payment irregularities. Delays in formalising consultancy agreements, particularly in Government and Government-Linked Company (GLC) projects, limit consultants' contractual protection and hinder their ability to claim progress payments despite completed work. In addition, limited enforceability of the Board of Engineers Malaysia (BEM) Scale of Fees further contributes to payment uncertainty. While the Scale of Fees is mandatory for ECP, it is not legally binding on clients, creating a regulatory gap that allows the adoption of alternative fee structures and post-agreement fee reductions. This lack of client obligation, coupled with the absence of contractual penalties for late payment, underpayment, or non-payment, increases ECP's exposure to financial risks. The issue is particularly pronounced in private projects, where clients are completely not subject to fee controls, although public sector projects are similarly affected by delays and reduced payments. In addition, existing legislative protections such as the Construction Industry Payment and Adjudication Act (CIPAA) provide limited recourse for

ECP fee claims, further constraining effective payment enforcement. Collectively, unreliable payment practices disrupt cash flow, constrain resource planning, and threaten business continuity for ECP Given the dependence of infrastructure delivery on consultancy services, persistent payment deficiencies may also affect project timelines, industry productivity and broader economic development.

In response, several practical and regulatory measures are warranted to improve payment reliability to ECP. These include stricter enforcement of the BEM Scale of Fees; clearer specification of payment terms and schedules within consultancy agreements; and timely certification and processing of claims to minimise administrative delays. Greater contractual compliance by both public and private clients, supported by strengthened regulatory oversight and standardised payment frameworks for ECP, is necessary to reduce ambiguity and deter arbitrary fee reductions or prolonged settlement periods. As existing legislative protections provide limited recourse for consultancy fee claims, extending the Construction Industry Payment and Adjudication Act (CIPAA) to ECP would offer formal avenues for payment recovery. In addition, enhanced regulatory provisions and expanded statutory payment security mechanisms are required to ensure effective legal protection for professional engineering services. Enforceable provisions, including contractual penalties, interest on late payments and formal dispute resolution mechanisms, together with defined milestones and mandatory timelines for claim evaluation, can improve accountability and transparency in payment administration. Digital submission and tracking systems may further streamline certification and reduce delays, while measures such as staged or secured payments can protect consultants' cash flow. Collectively, these operational, contractual and regulatory improvements provide a practical framework for strengthening payment discipline across the industry.

CONCLUSION

The findings confirm that late payment, underpayment, and non-payment remain prevalent across Government, Government-Linked Company (GLC) and private sector projects, indicating that payment irregularities are systemic within Malaysia's engineering consultancy environment. Delayed settlements, deviations from agreed professional fees and inconsistent adherence to the Board of Engineers Malaysia (BEM) Scale of Fees collectively undermine the financial stability of ECP. These challenges are most pronounced in private projects but are also evident in public sector engagements, demonstrating that payment risks persist regardless of client type. Overall, unreliable payment practices continue to disrupt cash flow, constrain operational planning and affect the sustainability of consultancy services within the construction industry.

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Addressing these issues requires stronger contractual compliance, clearer payment procedures and more consistent enforcement of regulatory frameworks. Timely certification and processing of claims; well-defined payment terms within consultancy agreements; and enhanced oversight by relevant authorities are essential to promote fair and reliable payment practices. The findings provide practical direction for ECP, clients and regulators to strengthen payment governance, improve contractual discipline and reduce financial risks associated with delayed, reduced, or unpaid fees, thereby supporting the operational stability and sustainability of engineering consultancy services.

Beyond individual firms, reliable payment practices are critical to the broader performance of Malaysia's construction sector, where engineering consultants play a key role in delivering public and private infrastructure. Persistent payment deficiencies can undermine project continuity, industry productivity and stakeholders', including public's confidence. By establishing empirical benchmarks on the prevalence and characteristics of payment issues, this study offers an evidence-based foundation for policy and regulatory improvements that enhance financial resilience within the consultancy profession and contribute to the long-term development and competitiveness of the national construction industry.

ACKNOWLEDGEMENTS

Acknowledgement is generously extended to GBU Consultants who initiated the study and support for data collection as well as to UNIMAS who provided the resources through the Faculty of Engineering and the Faculty of Built Environment for the completion of the study.

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Received: 4th February 2025. Accepted: 14th March 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 350 – 364

OPTIMIZING NATURAL LIGHTING TO REDUCE DISCOMFORT AND MOBILITY ISSUES IN SCHOOLS FOR VISUALLY IMPAIRED CHILDREN, BANGLADESH

Nowshin Tabassum[1], Md. Sabbir Ahsan[2], Sheikh Hameem[3], Md Faisal Mahmud[4]

[1]Architect, Studio Manifold Architecture and Design, Dhaka, Bangladesh
[2]Associate professor, Department of Architecture,
Rajshahi University of Engineering & Technology, Bangladesh
[3]Lecturer, Department of Architecture,
Rajshahi University of Engineering & Technology, Bangladesh,
[4]Architect, Age & Edge Architecture Studio, Dhaka, Bangladesh

Abstract

Proper natural lighting is essential for developing comfortable learning environments, especially for visually impaired children. It develops general comfort, spatial awareness, and lowers visual strain. However, typical schools in Bangladesh frequently lack proper lighting solutions. While for normally sighted children improper lighting makes the learning process difficult, for visually challenged students the impact is much worse as it directly affects their mobility training. The study assesses existing lighting condition in a typical classroom of the existing modular school building, and offers practical design interventions such as strategic window placement, adjustable shades, and jali screens. Problems are identified by simulating the lighting condition through high-fidelity software, then practical modifications are suggested on the basis of simulating each design intervention. The findings provide guidance for architects, educators, and policymakers in developing inclusive learning settings that encourage mobility and academic achievement for the visually impaired. This study emphasizes the importance of well-designed natural lighting in improving educational outcomes for visually impaired children in Bangladesh.

Keywords: visual impairment, blind, inclusive design, classroom, corridor, lighting, elevation

[1] Corresponding author. Email: nowshi111@gmail.com

INTRODUCTION

Lighting for children with visual impairments is a crucial aspect for specialized schools but that is usually overlooked. It is important to recognize that children with visual impairments often have problems with light sensitivity, glare, and contrast sensitivity (Gould & Herman Gould, 2003). Their difficulties are compounded by poorly designed learning environments in classrooms and other impassable learning or recreational spaces in school. These challenges in their surroundings can cause eye strain, headaches, and make it hard to do the basics like read, write, and get around the school. (Ghasemi Fard et al, 2023). These issues causing unfriendly school atmosphere result in high dropout rate among visually impaired students (Shamima Nasrain, 2017). Normal lighting varies in between 300-500 lux since these are friendly to the eyes and can help improve vision. Developing appropriate lighting standards for visually impaired individuals has been challenging, since different light levels affect people in diverse ways (Lehon, 1980). But study reveals that the optimal arrangement of the lighting in classroom can considerably enhance the educational climate for such students and consequently enhance students' orientation and interaction with environments (Gellhaus & Olson, 1993) . Glaucoma, MD and aniridia needs contrast to detect things as they lose peripheral vision. RP, DR, OA need least contrast and minimum glare. Due to different low vision disabilities, a wide spectrum of lighting options may be required to meet their usage requirements. Study shows that daylight has positive impacts on the students' learning environment and performance. (Altomonte, 2009; Kim et al., 2014). This can only be solved through architectural modifications to accommodate lighting conditions free from glare and environments that suit their needs. In this study, the architectural façade and opening design of classrooms and corridors is considered and appropriate luminance levels are examined to accommodate different types of visual impairments. This includes: changing window size, window levels, setting up adequate lighting controls; minimizing glare and the utilization of natural light in an attempt to support the students' learning (Lehon, 1980). The research presents comprehensive global design guidelines for creating inclusive, multisensory learning environments that serve visually impaired students to address these challenges. The research employs Bangladesh as a case study, aligning global benchmarks with local challenges and advocating for high-quality educational facilities that ensure accessibility for children worldwide.

RESEARCH METHODOLOGY

The methodology for this study adopts a modular approach to designing optimal lighting conditions specifically tailored for individuals with visual impairments. First, we classified various types of visual impairments (VI) and based on a thorough literature review, specified the specific lighting requirements for each

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type. The understanding underlying this was used to revise lighting standards, pointing out that traditional lighting does not meet the comfort of visual perception for individuals with visual impairments. Building on this foundational analysis, we focused on creating modular solutions that include adaptable luminous environments that can be altered according to the users' requirements, spatial conditions, and functional purposes. We assessed various facade strategies to ensure that the proposed modular units support natural lighting, minimize glare, and maintain optimal luminance levels for a range of visual impairments. By evaluating different ratios of openings and shading devices, we created adaptable facade designs that can be implemented in diverse educational settings.

LITERATURE REVIEW

According to WHO, visual impairment is recognized as a loss of visual acuity or visual field that, despite adequate refractive correction, impairs the performance of visual activities in daily functioning (Tapu et al., 2020). This impairment is classified into blindness and low vision (AlSoufi, 2014). Some of the causes of low vision are cataract, retinopathy associated with diabetes, glaucoma, and macular degeneration (Bourne et al., 2021). Glaucoma is usually characterized by the progressive peripheral field loss and this field loss becomes worse in poor lighting. A cataract is a cloudy area in the lens of the eye that leads to a decrease in vision of the eye. RP makes cells in the retina break down slowly over time, causing vision loss.(*Retinitis Pigmentosa | National Eye Institute*, n.d.) Due to macular degeneration major part of central vision can be lost. Ocular albinism is associated with nystagmus and reduced visual acuity. Aniridia a condition characterized by iris hyperplasia and is often associated with reduced visual acuity, and light sensitivity.

Lighting Level Requirements for Different Spaces

Table 1: Ideal illuminance levels for school

Space Type	Standard Illuminance (lux)
1. General Teaching Spaces	300 *
2. Teaching Spaces with close and detailed work (e.g., art and craft rooms)	500 *
3. Circulation Spaces: Corridors	80
Stairs	120
Entrance halls	175
lobbies & waiting areas	250
Reception areas	350
4. Atria	400 *

Source: Lighting Design for Schools. Building Bulletin (Loe et al., 1999)

All schools have a range of spaces, many of which are used for a number of different activities, either at the same time or at different times. The lighting design for a school needs to provide a lit environment which is appropriate for the particular interior and indeed exterior, achieving lighting which enables students and staff to carry out their particular activities easily and comfortably in attractive and stimulating surroundings. (Loe et al., 1999). This light range is considered ideal for normally sighted children.

The ideal lighting level and light distribution varies for each visual impairment. The differences can be grouped into 3 luminance level and the classrooms can be designed accordingly.

Table 2: Ideal lighting level per visual impairment

Condition	Ideal Lighting (lux)	Recommendations
Glaucoma	500-1000(Bowers et al., 2001)	Diffused lighting to reduce glare; enhance contrast for peripheral vision.
Cataract	1100-2000(Yong et al., 2024)	Ensure even lighting distribution.
Retinitis Pigmentosa	350-800(Matusiak& Fosse, 2009)	Brighter lighting to enhance remaining visual field; avoid direct light to prevent glare.
Diabetic Retinopathy	300-600(Yong et al., 2024)	Reduce glare and improve contrast sensitivity; ensure even lighting distribution.
Macular Degeneration	500-600(Bowers et al., 2001)	Focused task lighting for central vision; adjustable lighting to suit needs.
Ocular albinism	424-1190 According photosensitivity level (Matusiak & Fosse, 2009)	Reduce glare and improve contrast sensitivity;
Aniridia	194-813 (Matusiak & Fosse, 2009)	enhance contrast for peripheral vision

Source: Author

With lighting level, the next most important part is designing lighting distribution. As almost all the groups of visually impaired children have photosensitivity and sudden change in lighting level make them very uncomfortable. The ideal lighting level is for task performing i.e. for classrooms. Classrooms can be designed for 3 different groups-

Classroom module 1- for sighted children, RP, DR, (Lower luminance level)
Classroom module 2- for G, MD and Aniridia (Mid luminance level)
Classroom Module 3-for cataract with highest luminance level.

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EVALUATION OF LUMINANCE LEVELS (SIMULATION)

CLASSROOM

We have tested 6 different elevation treatments on the modular classroom layout (Fig1) in GOVT. School in Bangladesh. All Openings Have Single Pane Clear Glass with 0.71 Transmittance.

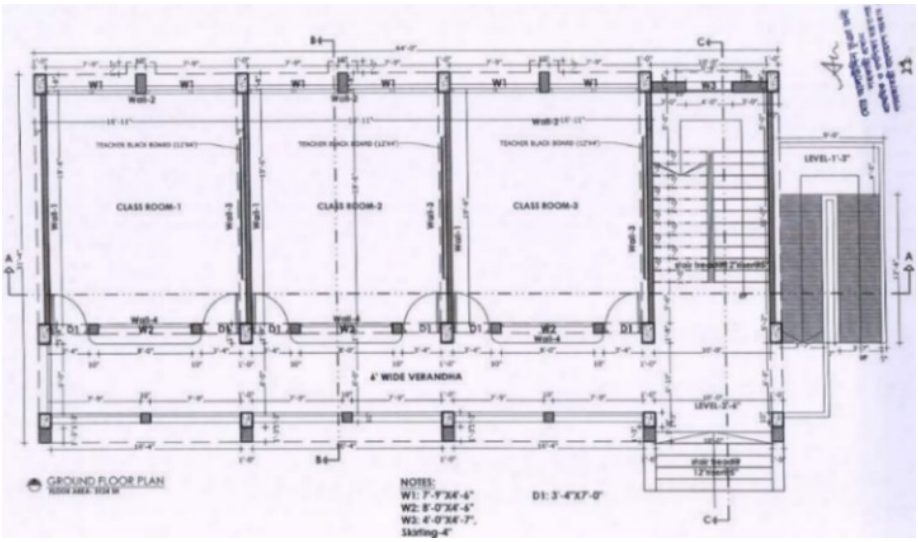


Figure 1: Existing Govt. Modular Primary school building plan
Source: Fourth Primary Education Development Program (PEDP4) (october 2018)

Classroom Façade 1- Existing Condition

Existing classroom has Sill height of 36", window height 60" (fig2). North facade has 52% opening, South facade has 20% opening as window and 5% opening as 2 doors, opening into corridor. Maximum luminance is 980.36 lux near south windows, and minimum 113 lux near north façade (Fig2)

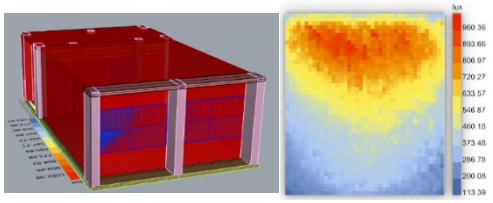


Figure 2: Existing Sill height 36", window height 60"
Source: Author's Simulation

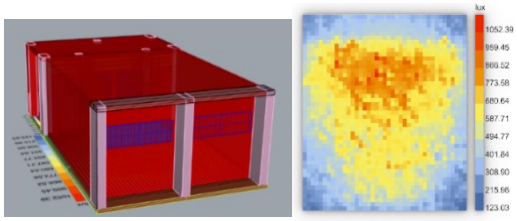


Figure 3: Facade 2; Sill height 60", window height 30"
Source: Author's Simulation

Classroom Façade 2

Sill height changed to 60", window height changed to 27.24". (Fig3) North facade has 18% opening, South facade has 20% opening as window and 5% opening as 2 doors, opening into corridor. Maximum luminance is 1052.39 lux in middle of the room, and minimum 123 lux near walls and corners (fig3).

Classroom Façade 3

Sill height 82", window height 27.24". North facade has 18% opening, South facade has 20% opening as window and 5% opening as 2 doors, opening into corridor. Maximum luminance is 647.67 lux in middle of the room and minimum 115.16 lux near walls and corners (Fig4).

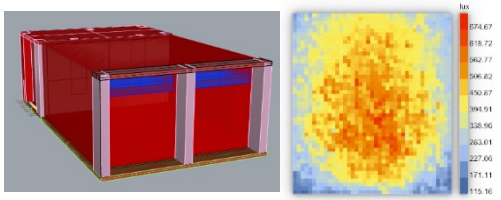


Figure 4: Facade 3; Sill height 82", window height 27.24"
Source: Author's Simulation

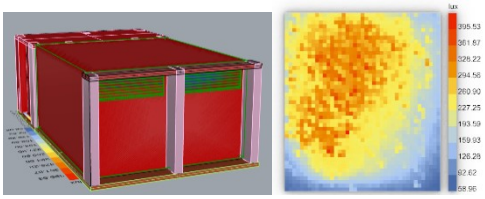


Figure 5: Facade 4; Sill height 82", window height 27.24"
Source: Author's Simulation

Classroom Façade 4

Sill height 82", window height 27.24" with horizontal louvers at 30-degree angle. North facade has 18% opening, South facade has 20% opening as window and 5% opening as 2 doors, opening into corridor. Maximum luminance is 395.5 lux left side and in middle of the room and minimum 60-100 lux near walls and (Fig5).

Classroom Façade 5

Sill height 3", window height 90" with louvre. North facade has 60% opening, South facade has 20% opening as window and 5% opening as 2 doors, opening into corridor. Maximum luminance is 1924.8 lux in middle of the room, and minimum 60 lux near walls and corners and north facade. s. Louvres depth 5in, shade count 47 with distance 3in from one another, angle 30 degree (fig6).

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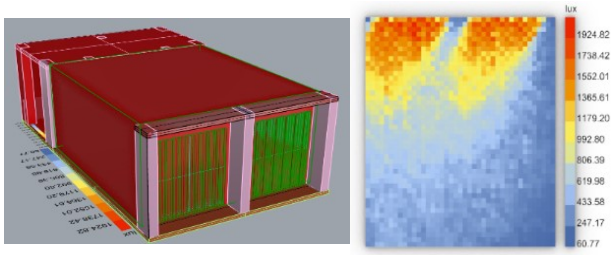


Figure 6: Facade 5; Sill height 3in, window height 90in
Source: Author's Simulation

Classroom Façade 6

Jali Pattern-1: Pattern 2.5"x7.5" perforation after solid wall of 1'-2". Maximum light 2739 lux. 400-800 LUX on maximum surface area. Minimum light 27-50 lux near the columns. (fig7)

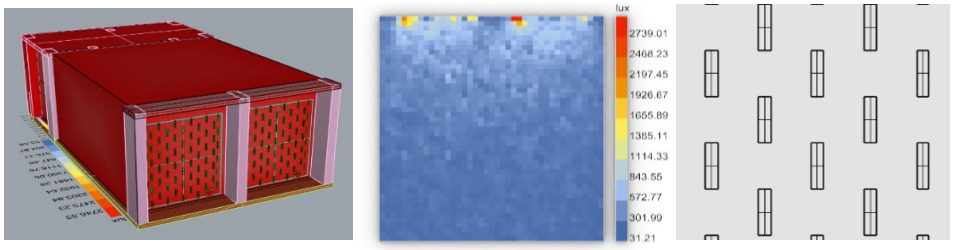


Figure 7: Facade 9; jali pattern 1
Source: Author's Simulation

Classroom Façade 7

Jali Pattern-2: Pattern 3.5"x9" perforation after solid wall of 3.5". Maximum light 3301 lux. 450-1000 LUX on maximum surface area. Minimum light 130 lux near the columns (Fig8).

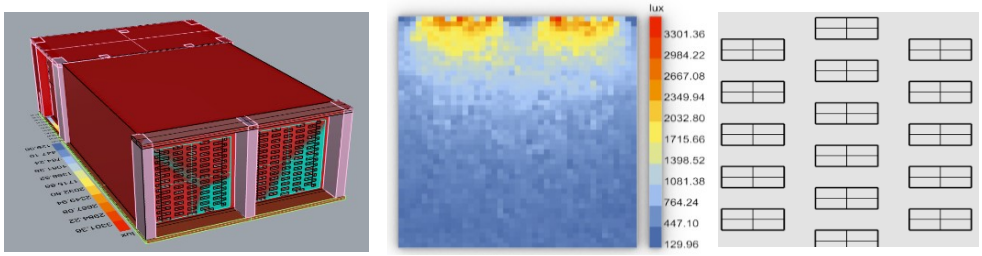
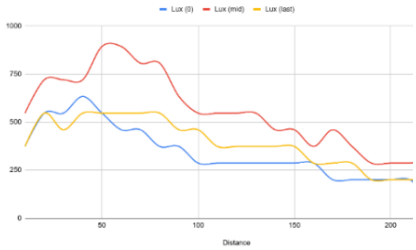
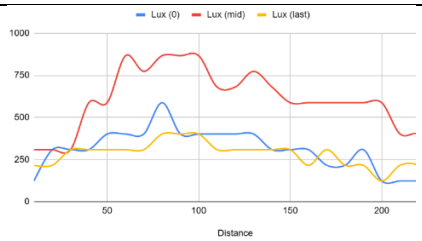
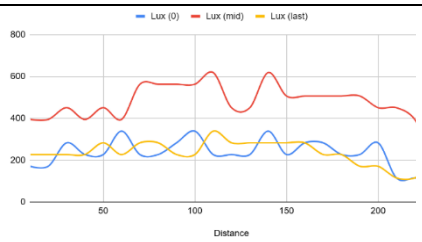
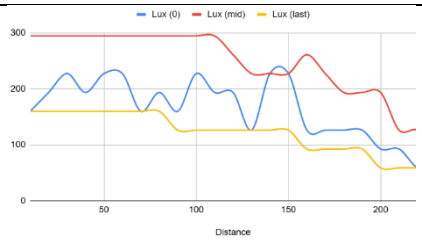


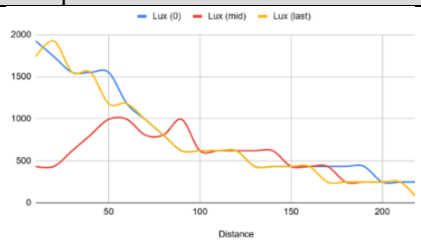
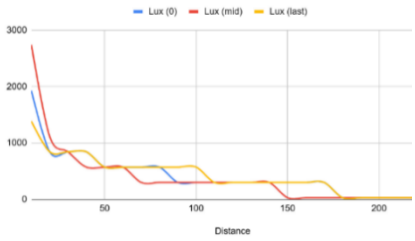
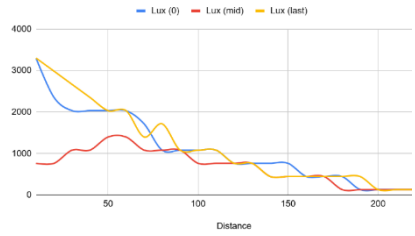
Figure 8: Facade 10; jali pattern 2
Source: Author's Simulation

Simulation graphs showing change of luminance level at 3 lines, at left side (blue line), middle (red line) and right side (yellow line) of the room. (lines taken at right angle from window position). From the graphs we can understand the light distribution quality and amount of glare caused by each façade.

Table 3: Graph Comparison

Facade	Graph	Description
Façade 1		The peak point can be seen close to the window. Most sudden changes are seen in middle line. The highest level in the beginning indicates effect of glare and decreasing graph shows very poor light distribution.
Façade 2		The peak point can be seen in the middle of the room, changes in lighting level are not that sudden, which means moderate glare. Almost gradual change shows moderate light distribution.
Façade 3		The peak point can be seen in the lower middle part of the room, some sudden changes are seen in this line too. Light change is gradual and no sudden change show good light distribution and very little glare.
Façade 4		The peak point can be seen in the upper middle, the change in luminance here seems gradual till the midpoint, then the change becomes very insignificant, side (ending) has gradual change. Light distribution poor in part of room.

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Facade	Graph	Description
Façade 5		The peak point can be seen at the nearest point of the window, near the south facade. The luminance near the south facade is very high, then decreases till the end line. Light distribution poor and will cause too much glare.
Façade 6		The peak point can be seen at the nearest point of the window, near the south facade. Glare is low near windows and almost zero in rest of the room.
Façade 7		Peak point is seen close to the window. Though light distribution seems good in maximum area of the room, near the windows the light will cause too much glare.

Source: Author's Calculation

CORRIDOR

Corridor Façade 1 -Existing Condition

North facade has 20% opening, South facade has 65% opening. Opening into corridor. Railing height is 36", opening height 6'. Maximum luminance is 5465 lux across railing, and minimum 1757 lux near north facade.

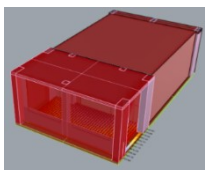


Figure 9: Corridor facade 1; existing condition
Source: Author's Simulation

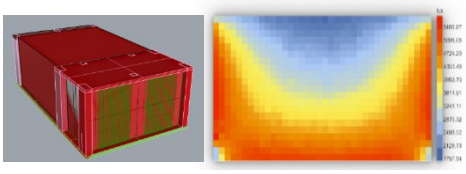


Figure 10: Corridor facade 2; with outdoor louvers
Source: Author's Simulation

Corridor Façade 2
With full height opening and outdoor louvres, 5" depth and 0-degree angle, maximum luminance 949 lux beside railing (on both side of the middle column), Minimum luminance 7.18 lux which is too low.

Corridor Façade 3
Pattern 5.5" x1'-6" perforation after solid wall of 1'-6.5". Maximum light 200-305 lux, on maximum surface area. Minimum light 27-50 lux near the columns.

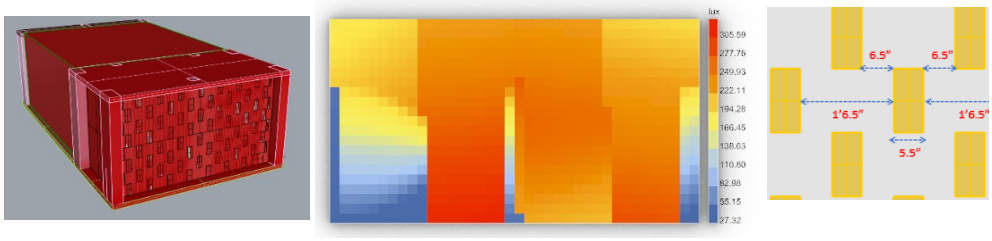


Figure 11: Corridor facade 3; Jali pattern 1
Source: Author's Simulation

Corridor Façade 4
Pattern 6"x1' perforation after solid wall of 1'. Maximum light 2982 lux, near jali wall. Minimum light 762 lux near the opposite wall.

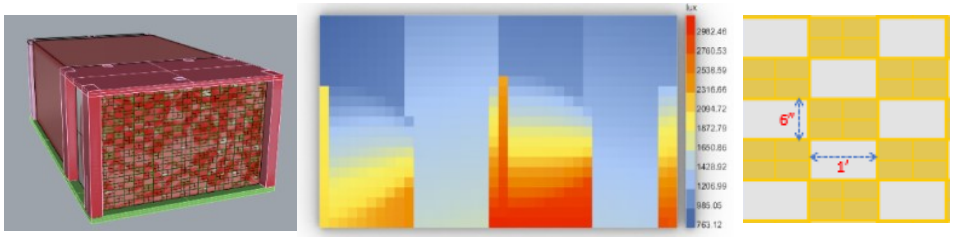


Figure 12: Corridor facade 4; Jali pattern 2
Source: Author's Simulation

Corridor Façade 5
8.5"x6.5" perforation after solid wall of 9.5". Maximum light 453 lux, maximum surface area has 150-173 lux. Minimum light 63-93 lux near the columns. 300-400 lux is coming at intervals. Which is creating a better contrast.

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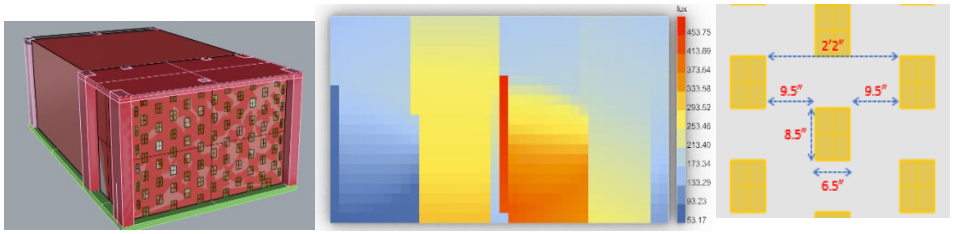


Figure 13: Corridor facade 6; Jali pattern 4
Source: Author's Simulation

DESIGN GUIDELINES

Classrooms

The existing façade of classroom does not provide ideal lighting and poor light distribution will cause too much glare for all groups. The simulation result shows the higher the sill level, light distribution is better. All classrooms are considered with corridor on the south side and fixed openings on this side.

Table 4: Classroom Façade options comparison

Façade	North Facade Opening	Max Luminance (lux)	Min Luminance (lux)	Notes
Façade 1 - Existing Condition	52%	980.36	113	Not suitable for any group
Façade 2	18%	1052.39	123	Ideal for 1st group
Façade 3	18%	674	115	Good for photosensitive children and sighted children
Façade 4	18%	398.9	60-100	Low glare, low light transition, Good for photosensitive children
Façade 5	60%	1924.8	60	Moderate glare
Façade 6	2.5"x7.5" perforation	2739	27	Can be used for cataracts
Façade 7	6"x12" perforation	3300	129	Best for RP and MD

Source: Author's Calculation

The best option for sighted children RP, DR, (Lower luminance level) is facade 2, (Sill height 60", window height 27.24"), as maximum luminance is 1052 lux, maximum area of the room has 400 to 600 lux. The transition level is low, increased sill level provides low glare. 2 is best for classrooms where practical or handicraft works are taught. Facade 4 is a good option for group of children who are highly photosensitive, having the lowest glare and slowest light transition. Facade 7, jali pattern 2 is best for G, MD and aniridia (Mid luminance level), maximum room area has illuminance from 447 to 1200 lux. For the third

group, children with cataracts will prefer façade 5, with full height window and 30-degree louvers with reduced glare. Façade 3 showing slower transition and maximum 647 lux luminance can be considered ideal for a combined classroom.

Corridor

The circulation spaces need to be designed considering all the users, children and adults (teachers and caregivers) from all groups. The minimum lighting level for circulation space is 80 lux (Loe et al., 1999). So, the corridor needs to be evenly lighted with contrast at fixed intervals with minimum glare (diffused light). The existing condition is not ideal for any group and provides very poor condition for visually impaired group.

Table 5: Corridor facade options comparison

Façade	South Facade Opening ratio	Max Luminance (lux)	Min Luminance (lux)	Notes
Corridor façade 1	65%	5465	1757	High luminance variation unsuitable for visually impaired;
Corridor façade 2	Full	949	7.18	Provides shading but overall not sufficient for all groups;
Corridor façade 3	50.5%	305	27-50	Even light on most surfaces but low contrast unsuitable for those with peripheral vision loss.
Corridor façade 4	24.8%	2982	762	High illuminance and contrast but too bright for photosensitive individuals.
Corridor façade 5	20.4%	3706	880-1160	Adequate contrast, suitable for normally sighted but too bright for photosensitive users.
Corridor façade 6	20.8%	453	63-93	Good contrast with low, diffused light, suitable for all groups;

Source: Author's Calculation

In Corridor façade 3- jali pattern 1 though light level has been acquired, this type light distribution is not good for circulation for children with peripheral vision loss. As the contrast is very low, the intervals will not be clear. Though it can be a good option for normally sighted people, not ideal for people with photosensitivity. Corridor façade 6- Jali 4 is providing good contrast with diffused low range light. In corridor façade 4- jali pattern 2, though contrast is acquired the illuminance level is too high. So, the best elevation for corridor façade 6, with pattern 8.5"/6.5" perforation after solid wall of 9.5", considering all groups of people.

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RESULTS AND DISCUSSION

Findings:

The existing condition in both classroom and corridor are not suitable for the visually impaired children. The existing classroom is divided into two zones, low light and highly intense light. The transition of light is very sudden and distribution of light is too poor. Poor light distribution and high glare make the overall school environment unsuitable and children find it difficult to even participate in regular activities. High glare will cause eye problems in normally sighted children too, this may result in various health issues. For inclusive education, the facade design needs to be changed to façade option 3. The existing corridor is not suitable for any group. Uncontrolled lighting makes it hard for them to move around and hence limit their mobility. In case of visually impaired children where walkability is very crucial for their overall growth and mobility being a must learn skill, the existing type corridor must not be used. For special schools, the corridor facade design can be changed to façade 6. For inclusive school's corridor either façade 2 or façade 6 can be used.

Implications:

• Educational Impact: Better lighting conditions should be considered as one of the ways that can help the students with impaired vision since it will make the school environment better for them it and lessen the dropout rate.
• Design Recommendations: Develop recommendations for type of lighting and design of the lighting solutions for educational facilities for visually impaired people including the principles of flexibility, control of glare and task-oriented lighting.

Limitations:

• Simulation Constraints: There are currently real-world issues for example dynamic daylight conditions which might not be aptly modelled in simulation.
• Generalizability: This may call for modifications depending on regional and architectural circumstances of each recommendation.

Future Research:

- Technology Integration**:** Exploring advanced lighting technologies like smart lighting systems that adapt in real-time to the needs of visually impaired individuals.
- Longitudinal Studies**:** Conducting studies to assess the long-term impact of optimized lighting on educational outcomes and well-being.

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CONCLUSION

The existing configurations of classroom and corridor lighting in the analyzed school module were found to be inadequate in terms of illumination levels and uniform light distribution, resulting in significant visual discomfort and limited mobility for the students. In a number of simulations, this study showed that changes in size, location, and ratio of openings: window height changes, raising sill heights; incorporation of louvers and jali patterns can greatly improve the lighting conditions. In particular, the study focuses on the difficulties for visually impaired students, especially for those who are sensitive to light: it is necessary to minimize glare, but at the same time, the luminance should be sufficiently high for some groups. The placement of modular adjustments and shading elements proposed for the facades come with valuable ideas for improving learning environment for students with disabilities. Finally, the study also highlights the need for future studies into smarter forms of lighting control and potential follow-up studies to enhance these architectural approaches. Thus, following these design guidelines, educational institutions can contribute to providing comfortable visual perception and movement opportunities for students with VI and create conditions that do not hinder the learning process and, on the contrary, will encourage independent access to learning materials for students with VI.

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Received: 13th February 2025. Accepted: 3rd March 2025

PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 365 – 379

DEVELOPING A SOCIO-DEVELOPMENT INDEX INSTRUMENT FOR THE ORANG ASLI IN MALAYSIA

Syaaibah Zulkipli[1], Mohd Nuri Al Amin Endut[2], Muhamad Ridhuan Tony Lim Abdullah[3]

[1]*Department of Management,*
[2,3] *Faculty of Science, Management & Computing,*
UNIVERSITI TEKNOLOGI PETRONAS

Abstract

The Orang Asli, recognised as the earliest inhabitants of Peninsular Malaysia, continue to face persistent challenges in achieving socio-economic advancement in national development. Despite the implementation of various government policies and initiatives, the lack of an assessment tool has limited efforts to capture their multidimensional development. This study was therefore to address this gap by identifying and validating the most relevant indicators for constructing a socio-development index tailored to the Orang Asli community. This method was used to obtain consensus among experts on the primary needs for each item in the development of the Orang Asli socio-development index instrument. As a result, this study consulted 14 experts from various fields related to the Orang Asli. This study employed the Fuzzy Delphi Method (FDM) to obtain expert input and consensus on the proposed socio-development index indicators. The results indicate that thirty-two indicators were accepted for inclusion in the index, encompassing nine domains: Level of Educational Achievement, Complete Infrastructure, Economic Empowerment, Environmental Sustainability, Leadership Empowerment, Land Recognition, Level of Health Care, Policy and Legislation, and Cultural Heritage Empowerment. The findings contribute to the establishment of an index that captures the dimensions of Orang Asli socio-development. The validated indicators offer policymakers, practitioners, and stakeholders a reliable tool to monitor progress, identify development gaps, and design more effective, inclusive, and sustainable interventions tailored to the unique needs of the Orang Asli community.

Keywords: Socio-development, Indicators, Fuzzy Delphi Method, Orang Asli

[1] Corresponding author. Email: syaaibah@gmail.com

INTRODUCTION

Malaysia is recognized as a multi-ethnic country with many races, cultures, and backgrounds. The Orang Asli, the indigenous people of Peninsular Malaysia, are one of the multi-ethnic minority groups residing in Malaysia. The term "Orang Asli" refers to the indigenous population of Peninsular Malaysia. The word "Asli" comes from an Arabic word meaning "*asali*" (Ab Rahman et al., 2022) which means 'original', 'nation', or 'aristocrat' (Carey, 1976). According to Benjamin (2016) the name "Orang Asli" initially appeared around 1960 to replace the phrase "Malaysian aborigines," which had previously been used. Approximately 150,000 Orang Asli from the three essential tribes of Semang (Negrito), Senoi, and Proto-Malays live in peninsular Malaysia. At the same time, most Orang Asli remain in rural forests while retaining their traditional rituals and cultures. Circumstances before and following independence show that changes in Orang Asli's life coincide with changes in economics, social life, politics, and culture.

This study has identified a lack of measurement for assessing the socio-development of the Orang Asli community holistically. Despite facing various challenges, the absence of a measurement tool complicates efforts to achieve socio- development for the Orang Asli community. The Orang Asli socio-development should be focused generally and holistically on areas such as infrastructure, education, or economy, as experienced by mainstream society. On the other hand, attention should also be given to other domains, such as the preservation of their culture and language, land ownership, exploitation of natural resources, political and autonomy issues, pollution, health, and prejudice (Ab Rahman et al., 2022).

In the context of the Orang Asli development, the absence of relevant multidimensional measurement of well-being for the Orang Asli causes difficulties in ensuring the Orang Asli achieve successful development. The social development of the Orang Asli community is not only limited to infrastructure development and economic improvement but also includes health facilities, preservation of culture identity, social cohesion and environmental sustainability. All of this shows the need for an encompassing measurement instrument to enable the assessment of Orang Asli social development. Accordingly, through the social development index instrument developed can provide a comprehensive tool for accessing the well-being of the Orang Asli community in the future. The main objective of this study is to develop the Orang Asli socio-development index instrument in Malaysia based on expert consensus. Development is an ongoing process of changes that significantly impacts ethnicity, nations, economics, societies, and politics. One of the most effective research mechanisms for this purpose is the creation of an index instrument capable of providing a comprehensive assessment. Thus, to fill the knowledge gap in the socio-development of the Orang Asli, this study focuses on the index instrument as a priority solution to assist the government, especially the Orang

Asli Development Department, in successfully improving outcomes for stakeholders.

LITERATURE REVIEW

Socio-development

Socio-development is a multidimensional concept that is particularly relevant to the Orang Asli, as it addresses the social, economic, cultural, and environmental challenges faced by marginalized communities. It encompasses aspects of human life such as education, economic opportunities, health, and infrastructure, aiming to improve the well-being and quality of life of individuals and communities. Social development, a core component of socio-development, focuses on strengthening social structures, relationships, and institutions while promoting equality, social justice, and inclusive participation. Unlike development defined in economic terms, socio-development integrates social, cultural, political, and environmental dimensions to enhance human well-being, equity, and sustainability (Livingston et al., 2022; Zulkipli et al., 2021). Rooted in the Latin-derived concept of "socio-" as relating to social interactions, socio-development represents an inclusive process where communities enhance their capabilities while maintaining cultural identity and social equity (Bamigbelu & Adeyeye; Tiwari & Nguyen, 2024). For the Orang Asli, socio-development entails programs and policies that address poverty, inequality, and marginalization, while promoting participation, safeguarding rights, and supporting sustainable cultural and economic advancement (Ab Rahman et al., 2022; Zulkipli et al., 2021). Overall, socio-development provides a holistic framework that prioritizes both human and community empowerment alongside material progress, integrating tangible outcomes such as education and infrastructure with intangible elements like cultural preservation, political autonomy, environmental protection, and health equity.

Index Instrument

Index instruments serve as valuable tools or systems that enable the organization and categorization of data used for organizing and categorizing data related to various subjects or procedures. This is in line with Biswas et al. (2022) who argued that utilizing index enables policymakers to gain deeper insights into areas of progress and their outcomes. This empowers them to make decisions with efficiency. Indexes can provide guidance for policies aimed at identifying and solving problems and monitoring indicators of progress. That makes policies more proactive and strategic in targeting problems. This transition to stewardship means we can think more fully about and organize problem-solving, leading us to develop better and lasting solutions. Furthermore, using indexes also allows policy makers to better understand where progress has been made and what the results are. They can then make wiser decisions about how to allocate resources

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more efficiently. In addition, Bandura (2008) emphasized that there are more than 400 official indices according to economic, political, social, environmental measures (Greco et al., 2019). For instance, the indexes such as Human Development Index, the Quality-of-Life Indicator, the Technology Achievement Index, the Competitiveness Index, the Environmental Performance, Index of Economic and Social Well-Being (Mazziotta & Pareto, 2018). However, research on Orang Asli socio-development index instrument is limited. Thus, this study provides a comprehensive overview of the development index instrument for Orang Asli socio- development, serving as a benchmark for monitoring and evaluating the impact of development programs and policies on the community.

RESEARCH METHODOLOGY

The Fuzzy Delphi Method (FDM) is a widely used approach for achieving expert consensus in decision-making and problem-solving. In this study, FDM was applied to develop a socio-development index instrument for the Orang Asli community. Using this method, 14 experts with expertise in the Orang Asli community participated in the study. The Delphi method is employed to obtain consensus among a group of experts for problem-solving (Jamil et al., 2024). Kaufman and Gupta (1991) pioneered the Fuzzy Delphi Method, which integrates fuzzy set theory with the traditional Delphi technique to enhance the accuracy and reliability of expert evaluations.

The FDM is a decision-making analytical approach that integrates fuzzy theory into the traditional method. Expert participation in this session aims to facilitate the development of index instruments for this study. This method also involves a multiple questionnaire survey to gather expert opinions on the issues under investigation. The selection of indicators and sub- indicators serving as a benchmark for Orang Asli development in Malaysia constitutes the initial step in the study. Besides saving time and money, employing FDM ensures an accurate representation of expert's judgement (Alqahtani & Noman, 2024). The approach for this study involved expert panel participation, particularly during FDM sessions. Expert participation in this session is designed to facilitate the development of instruments for this study. The step of this phase is in the next section.

1) Step 1- Selection of experts

There are fourteen (n = 14) experts selected to develop the index instrument using the purposive sampling method because it is the most acceptable strategy using the fuzzy Delphi method. In this phase, the selection of quality experts is important because it will affect the quality of the result (Ross et al., 2024). In accordance with Adler and Ziglio (1996), around 10 to 15 experts are an optimal number in the Delphi study if the uniformity is high and suggested that a total of 10-50 experts would be sufficient. The rationalization of the experts' selection is

based on the criteria of knowledge or interest, including experience of the issue of the study. Accordingly, experts in this study were selected based on several criteria, namely extensive knowledge related to the Orang Asli community, a minimum of 5 to 10 years of relevant professional experience, willingness to participate and remain committed throughout the study period, possession of at least a bachelor's degree with a doctorate preferred for academic participants, and effective communication skills (M. R. T. L. Abdullah et al., 2021; Zulkefli et al., 2025).

2) Step 2- Determine the linguistic scale

The next step is to establish a linguistic scale for the variable being considered. The linguistic scale is same as the Likert scale with an additional of fuzzy numbers given to the scale of responses based on triangular fuzzy number as shown in Figure 1 below. The triangular fuzzy number consists of three values: m1, m2 and m3. The m1 represents the lowest possible value, m2 represents a middle possible value, and m3 represents the highest possible value. For example, an evaluation score of 6 (highly agree) given by an expert will be converted into a 0.7 fuzzy score or 70% agreed minimum value, 0.9 or 90% agreed most reasonable value, and 1.0 or 100% agreed maximum value. These linguistic scales are used to convert the linguistic variables into fuzzy numbers. In this study, a 7-point linguistic scale was applied. This is because the higher and more scales were used, the more accurate and reliable the data (Dawood et al., 2021; Khalli et al., 2022). The result of the expert with the fuzzy number scale for each questionnaire was then inserted in Microsoft Excel.

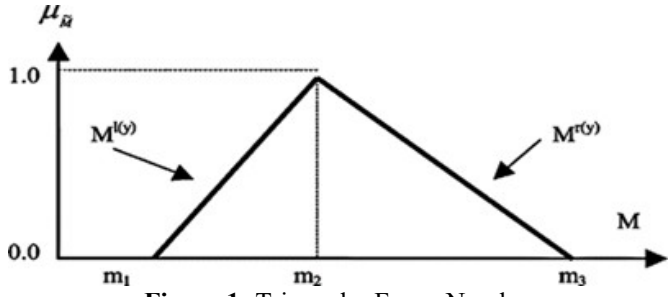


Figure 1: Triangular Fuzzy Number

3) Step 3- Determine threshold value 'd'

FDM method involves determining the threshold value 'd' where it is an important part in assessing the degree of agreement among the experts. The difference between the experts' evaluation data and the average value for each item is calculated to identify the threshold value 'd.' By using the threshold value 'd,' the consensus level among the experts will be determined. So that, the

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threshold value 'd' for each item measured must be less than or equal to 0.2 (Cheng & Lin, 2002).

$$d(\tilde{m},\tilde{n}) = \sqrt{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]}$$

Figure 2: Threshold Value Construct

4) Step 4- Calculate the defuzzification value

Once the group consensus is achieved, the overall aggregate fuzzy evaluation is determined by adding all the fuzzy numbers for each item. The process of providing information about the level of importance of a variable is called defuzzification (Yaghoobi et al., 2024). The defuzzification process is the last step of the FDM. The calculation and determination of fuzzy value using the formula

$$\text{Amax} = \frac{1}{3}(\text{m1} + \text{m2} + \text{m3})$$

The 0.5 value of α-cut serves as the foundation for the fuzzy score (A). The measured item is discarded in accordance with the expert group's consensus if the score value (A) is less than 0.5. The value is allowed if it is equal to or greater than 0.5. Most crucial element will be the one with the highest defuzzification value (Kamaruddin et al., 2024).

RESULT AND DISCUSSION

Based on the result show that, 32 of the 33 proposed indicators were accepted for inclusion in the Socio-Development Index Instrument based on threshold value (≤ 0.20), expert consensus (≥ 75%), and defuzzification value (≥ 0.50) (Cheng & Lin, 2002; Kamaruddin et al., 2024; Yeh et al., 2024), with only 'indebtedness' rejected due to a high threshold value (d = 0.261) and low expert consensus (31%). In the Level of Educational Achievement domain, all five indicators were accepted, while Complete Infrastructure had four accepted indicators. The Economic Empowerment domain included four accepted indicators, excluding 'indebtedness,' and both Environmental Sustainability and Leadership Empowerment had two and three accepted indicators, respectively. Land Recognition had three accepted indicators, Level of Health Care two, Policy and Legislation four, and Empowerment of Cultural Heritage five indicators. Expert consensus ranged from 75 to 88 percent, with defuzzification values between 0.814 and 0.960, showing strong agreement on the multidimensional aspects of Orang Asli development, including education, infrastructure, economic

empowerment, environmental sustainability, leadership, land rights, healthcare, legal and policy measures, and cultural preservation.

Table 1: List of indicators and sub-indicators

No	Indicators and Sub-Indicators	Threshold value	Expert consensus	Defuzzification value	Status
		(d) ≤0.2	(%) >75%	(a) = 0.5	
1	**Level of Educational Achievement**	**0.085**			**Accepted**
1.1	Completion of Schooling	0.066	81	0.940	Accepted
1.2	Educators among the Orang Asli	0.208	75	0.814	Accepted
1.3	Level of Literacy	0.051	88	0.945	Accepted
1.4	Skills Training	0.062	88	0.938	Accepted
1.5	Admission to Public and Private Higher Education Institutions (IPTA/IPTS)	0.037	88	0.952	Accepted
2	**Complete Infrastructure**	**0.082**			**Accepted**
2.1	Social Amenities	0.092	81%	0.919	Accepted
2.2	Public Facilities	0.087	81%	0.926	Accepted
2.3	Residential facilities	0.075	88%	0.924	Accepted
2.4	Digital Communication Facilities	0.075	88%	0.924	Accepted
3	**Economic Empowerment**	**0.179**			**Accepted**
3.1	Orang Asli Entrepreneurial Performance	0.168	75%	0.824	Accepted
3.2	Equity Savings	0.184	75%	0.845	Accepted
3.3	Employment	0.142	75%	0.886	Accepted
3.4	Household Income	0.142	75%	0.900	Accepted
3.5	Household Indebtedness	0.261	31%	0.786	Rejected
4	**Environmental Sustainability**	**0.117**			**Accepted**
4.1	Orang Asli Participation in Forest Conservation and Restoration	0.092	81%	0.919	Accepted
4.2	Level of pollution	0.143	75%	0.893	Accepted
5	**Leadership Empowerment**	**0.083**			**Accepted**
5.1	Orang Asli Involvement in NGO	0.107	75%	0.886	Accepted
5.2	Institution of Batin and Committee Leadership	0.037	88%	0.952	Accepted
5.3	Orang Asli Participation in Politics	0.107	75%	0.886	Accepted

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No	Indicators and Sub-Indicators	Threshold value	Expert consensus	Defuzzification value	Status
		(d) ≤0.2	(%) >75%	(a) = 0.5	
6	**Land Recognition**	**0.150**			**Accepted**
6.1	Gazettement of Orang Asli Land	0.102	81%	0.926	Accepted
6.2	Land Ownership	0.182	75%	0.893	Accepted
6.3	Rights of Access to Land	0.167	75%	0.900	Accepted
7	**Level of Health Care**	**0.028**			**Accepted**
7.1	Levels of Health	0.037	88%	0.952	Accepted
7.2	Accessibility of Health Services	0.020	88%	0.960	Accepted
8	**Policy and Legislation**	**0.049**			**Accepted**
8.1	National Commitment to International Instrument	0.078	81%	0.933	Accepted
8.2	National Commitment to Constitutional and Legal Provisions	0.020	88%	0.960	Accepted
8.3	Gender Equality and Empowerment	0.078	81%	0.933	Accepted
8.4	Implementation of Free, Prior and Informed Consent (FPIC) and Self-Determination	0.020	88%	0.960	Accepted
	Culture Heritage Empowerment	**0.06**			**Accepted**
	Status Enhancement of Orang Asli Language	0.078	81%	0.933	Accepted
	Participation in Cultural Events	0.020	88%	0.960	Accepted
	Customary Law and Beliefs	0.078	81%	0.933	Accepted
	Indigenous Knowledge	0.033	88%	0.960	Accepted
	Recognition of Contributions to Nation-Building	0.091	81%	0.933	Accepted
	Overall	**0.095**	**80%**		

This study successfully determined nine indicators and 32 sub-indicators to be included in the Orang Asli socio-development index instrument. Level of Educational Achievement is a critical dimension in the socio-development of the Orang Asli community, strongly influencing human development (Deli & Yasin, 2016; Salim et al., 2020). The Malaysian government has implemented initiatives to improve access, facilities, and economic support across ethnic, geographical, and religious boundaries (Choy et al., 2010; Razak, 2022). The study highlights their relevance in capturing educational attainment. Literacy levels and admission to public (IPTA) and

private higher education institutions (IPTS) were ranked highest, showing their central role in enabling Orang Asli youth to access socio-economic mobility and integrate into the national education system. Beyond basic literacy, education serves to break cycles of poverty, enhance opportunities, and align with the 2030 Sustainable Development Goals for inclusive and equitable education (Guleng et al., 2023). Ensuring progress in literacy, schooling completion, skills training, and higher education access therefore remains foundational to improving the livelihoods of Orang Asli communities.

Complete Infrastructure is a fundamental component of Orang Asli social life, supporting community functioning, well-being, and daily activities (Enneking et al., 2025; Myntti, 2024). It encompasses physical facilities, public services, and information and communication technology (ICT) networks (Zakaria et al., 2024). Infrastructure deficits, such as limited access to clean water, electricity, and internet connectivity, are particularly significant for rural communities (Ab Rahman et al., 2022). Including these indicators in the SDI underscores that Orang Asli cannot fully participate in development without equitable access to basic services. The strong expert consensus reflects a shared understanding that addressing infrastructure gaps is a prerequisite for achieving equitable socio-development outcomes.

Economic Empowerment is a determinant of long-term socio-development for the Orang Asli, encompassing access to resources, income generation, livelihood sustainability, and the preservation of cultural and ecological knowledge (M. F. Abdullah et al., 2021; Dong et al., 2022). In this domain, four indicators, entrepreneurship performance, equity savings, employment, and household income, were accepted, highlighting the importance of economic participation and asset ownership for securing livelihoods (Derani et al., 2020). Nevertheless, the indebtedness indicator was rejected, consistent with indigenous practices emphasizing financial self-reliance and freedom from debt as a key criterion for well-being (Abdul Razak et al., 2025). These findings underscore that economic empowerment for the Orang Asli should prioritize sustainable income, employment, and asset-building rather than financial burdens, ensuring the SDI reflects pathways to autonomy, resilience, and inclusive socio-economic development (Ford et al., 2020).

Environmental Sustainability is a vital dimension of Orang Asli socio-development, as the community maintains reciprocal relationships with forest ecosystems for food, water, medicine, shelter, and cultural practices (Baer, 2014; Diansyah et al., 2022). These findings underscore that Orang Asli socio-development is closely linked to environmental stewardship, ensuring that improvements in livelihoods, health, and social participation are aligned with sustainable forest management and natural resource protection (Han, 2021; Jamaludin et al., 2025). By including environmental sustainability in the SDI, experts emphasized that community progress must be integrated with ecological

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management, reinforcing the balance between socio-economic development and environmental protection.

Leadership Empowerment is essential for Orang Asli communities to actively participate in decision-making, represent their interests, and guide their own development processes (Isa et al., 2025). The Tok Batin serves as a custodian of cultural values, a mediator in community decision-making, and a link between Orang Asli communities and government agencies for the delivery of aid, socio-economic development, and problem-solving, ensuring the well-being and progress of the community (Abdullah et al., 2023; Roslan et al., 2024). This study highlights that effective leadership ensures Orang Asli are active participants, not passive recipients, in shaping their socio-development and preserving their cultural heritage.

Land Recognition is central to Orang Asli identity, cultural continuity, and economic survival (Dong et al., 2022; Khairil et al., 2025; Sadeka et al., 2020). In this domain, all three indicators, gazetted land, land ownership, and land access rights, were accepted, highlighting the importance of legal recognition and management of land for Orang Asli communities. Customary land constitutes the core of Orang Asli settlements, enabling socio-economic stability, inheritance of traditions, and continuation of cultural practices (Taman & Kasim, 2021). Expert consensus emphasizes that legal recognition of land tenure is fundamental to preserving Orang Asli culture, heritage, and livelihoods, allowing communities to manage their land, pass it down across generations, and sustain both economic stability and cultural identity (Hassan et al., 2023; Kasim, 2021; Wahab et al., 2022).

Level of Health Care is a persistent dimension of inequality affecting the Orang Asli community, with disparities in physical health, environmental exposure, access to healthcare, and cultural understandings of illness and well-being (Rosman et al., 2020). The inclusion of these indicators emphasizes that improving both health outcomes and service accessibility is essential to reducing disparities, supporting vulnerable populations, and aligning Orang Asli socio-development with national healthcare goals, ensuring that no community is left behind.

Policy and Legislation are fundamental to Orang Asli socio-development, as legal frameworks shape access to resources, protect rights, and enable participation in decision-making (Davidson & Coburn, 2021; Hassan et al., 2023). These findings highlight that while international norms and inclusive principles are important, strong domestic legal commitment and the practical application of FPIC are critical for ensuring equity, justice, and long-term sustainability in Orang Asli socio-development.

Cultural Heritage Empowerment is a core dimension of Orang Asli socio-development, as culture shapes identity, values, social norms, and everyday practices that sustain community well-being (Gan, 2022). These indicators

capture lived cultural practices and knowledge systems that anchor Orang Asli resilience and social cohesion. The inclusion of this domain in the socio-development index underscores that development for the Orang Asli must go beyond material progress to safeguard language, customary law, and indigenous knowledge, ensuring that socio-development strengthens rather than erodes cultural identity and heritage.

CONCLUSION

The development of the Orang Asli socio-development index instrument provides a valuable guideline for ensuring that the Orang Asli community is not left behind in national development efforts. This study offers a structured way to assess the advancement of socio-development for the Orang Asli community. The findings demonstrate a strong consensus among experts regarding the objectives of the socio-development index instrument. This tool has the potential to be systematically employed over the long term to assess the effectiveness of socio-development initiatives and their impact on the Orang Asli community. Furthermore, the index instrument provides a foundational framework for strategic planning and evidence-based policymaking, particularly in supporting the Orang Asli Development Department (JAKOA) in achieving its vision and mission. By adopting a multidimensional and data-driven approach, this study contributes to the broader discourse on Orang Asli socio-development and social equity in Malaysia.

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Received: 7th February 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 380 – 393

ASSESSING HIGHLAND TOURISM FACILITIES IN CAMERON HIGHLANDS FOR VISITOR EXPERIENCE

Mariana Mohamed Osman[1], Fadwa Mohd Faidzal[2], Noor Suzilawati Rabe[3] & Abdulrahman Abdulaziz[4]

[1,2,3] *Department of Urban and Regional Planning,*
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
[4] *Department of Architecture,*
College of Engineering and Architecture,
UMM AL-QURA UNIVERSITY

Abstract

Research employs an assessment framework to evaluate highland tourism facilities in Cameron Highlands, focusing on visitor experience. conducting an extensive survey on 445 visitors in the study area and performing detailed data analysis, the assessment highlights the strengths and weaknesses of local tourism facilities and services. The comprehensive study during non-peak tourist seasons underscores the importance of improving accommodation standards, recreational activities, and transportation systems to enhance overall visitor satisfaction. The same framework allows for the evaluation of overall affordability of a visit, emphasising the need for better pricing and promotion efforts. The findings of this study underscore the necessity for enhancing cost efficiency across various aspects of the tourism industry, offering a diverse array of attractions to cater to different interests and preferences. Furthermore, improving traffic and transportation services to better meet the needs of visitors is essential. The proposed strategies aim to create a balanced approach that maximises visitor satisfaction while ensuring the sustainability and resilience of the tourism industry in this unique and valuable destination.

Keywords: Highland tourism; Visitor experience; Tourism facilities; Tourism standards; Cost efficiency

[1] Coressponding author. Email: mariana@iium.edu.my

INTRODUCTION

Highland tourism represents a thriving segment of the global tourism industry, centered around mountainous and elevated regions celebrated for their scenic beauty, cooler climates, and rich cultural heritage. Understanding tourist behavior—which includes the decisions, preferences, and activities of visitors—is crucial to enhancing the tourism experience and promoting sustainable development. Cameron Highlands, situated in the Titiwangsa Mountains of Peninsular Malaysia, stands out as a leading highland destination. Renowned for its tea plantations, lush landscapes, and temperate climate, the region attracts a large number of visitors annually. However, it also faces critical challenges, particularly in the form of overtourism and high costs, both of which negatively impact visitor satisfaction and long-term sustainability.

This study addresses the pressing need to evaluate and improve tourism facilities in Cameron Highlands in order to enhance visitor experiences. Despite its popularity, the region continues to suffer from issues such as overcrowding and high expenses, which undermine its attractiveness. The core research problem focuses on identifying the key factors that influence visitor satisfaction and proposing strategic measures to address these concerns. The central hypothesis of this research is that targeted improvements in tourism facilities and services will significantly enhance visitor satisfaction and support the sustainable development of Cameron Highlands as a tourist destination. To test this hypothesis, the study adopts an exploratory research design that combines both quantitative and qualitative methods. Data is collected through extensive surveys and analyzed to uncover major patterns and challenges. This comprehensive approach enables a detailed assessment of visitor experiences and the performance of existing tourism infrastructure.

LITERATURE REVIEW

This literature review explores the multidimensional aspects of highland tourism, emphasizing the importance of evaluating tourism facilities in Cameron Highlands to enhance the overall visitor experience. It synthesizes existing research on highland tourism and identifies current gaps in the literature. The review addresses key themes, including various types of tourism, essential factors influencing the selection of highland destinations, and the challenges posed by congestion. It also examines the relationship between influencing factors and visitors' satisfaction levels in the context of Cameron Highlands. Lastly, the review outlines the structure of the subsequent chapters, establishing a coherent connection between the methodology, findings, and discussions to ensure a logical flow of information for the reader.

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Overview of Highland Tourism

Highland tourism is a vital component of the global tourism industry, drawing visitors to elevated regions that offer scenic landscapes, cooler climates, and culturally rich experiences. Typically, this form of tourism involves travel to mountainous areas celebrated for their natural beauty, outdoor recreational opportunities, and historical or cultural significance. Its appeal lies in providing a refreshing escape from the heat and bustle of lowland environments, offering travelers a chance for relaxation, adventure, and discovery. Hosni, N. (2013). The literature on highland tourism identifies several key determinants of tourist behavior and destination preference. These include the quality of the natural environment, availability of cultural attractions, accessibility, accommodation standards, and the range of recreational activities. Other critical factors influencing satisfaction include perceived safety, infrastructure development, and the overall experience offered by the destination. **Rasdi, A. L. M.** (2023).

Tourism Facilities and Their Impact

Tourism facilities play a central role in the success and sustainability of any tourist destination. These encompass a wide array of services and infrastructure, such as accommodations, transportation networks, dining establishments, recreational amenities, and visitor information centers. The presence and quality of such facilities directly affect tourists' experiences and levels of satisfaction. (Khairi, M., & Darmawan, D. (2021).

Research has shown that well-maintained and strategically developed tourism facilities significantly enhance a destination's attractiveness. This, in turn, encourages repeat visits and generates positive word-of-mouth promotion. On the other hand, insufficient or poorly maintained infrastructure can diminish the visitor experience, resulting in negative perceptions and a decline in tourist arrivals. In highland destinations specifically, facilities such as hiking trails, panoramic viewpoints, and cultural heritage centers are especially appreciated by visitors. (Jamal, S. A., Othman, N., & Muhammad, N. (2011).

Background of the Study Area: Cameron Highlands

Cameron Highlands, located in the state of Pahang, Malaysia, is one of the country's most renowned highland destinations, celebrated for its stunning landscapes and temperate climate. The region comprises three administrative sub-districts (mukims): Tanah Rata, Ringlet, and Hulu Terum. Each mukim contributes uniquely to the region's governance, land use, and socio-demographic profile. In term of administrative Divisions. The largest administrative unit, Hulu Terum, covers approximately 61,323.97 hectares, accounting for about 89.95% of Cameron Highlands' total land area. This mukim is predominantly rural, characterized by expansive tea plantations, dense forests, and robust agricultural activity. The terrain features terraced farms that yield various crops such as

vegetables, strawberries, and flowers—key drivers of the local economy. Ringlet, covering 4,835.02 hectares (7.09%), functions as a gateway to the highlands and is known for its scenic vistas and lively markets. It hosts several large-scale agricultural projects and serves as a logistical hub for distributing highland produce across Malaysia. Tanah Rata, the administrative and commercial center, spans 1,995.12 hectares (2.93%). Despite being the smallest mukim, it is a vibrant township offering a wide array of services and amenities for both locals and tourists. The town is distinguished by its colonial-style architecture, botanical gardens, and its function as a starting point for numerous hiking trails. Accommodation options in Tanah Rata range from budget lodges to high-end resorts, catering to a diverse visitor demographic.



Challenges in Highland Tourism of Cameron Highlands

Cameron Highlands, renowned as one of Malaysia's leading highland tourist destinations, offers an exceptional mix of natural beauty, cool climate, and cultural heritage. Despite its popularity, the region is increasingly confronted with a range of challenges that threaten its long-term sustainability and appeal to visitors. **Rasdi, A. L. M.** (2023). Foremost among these challenges is the issue of overtourism, where visitor numbers exceed the destination's carrying capacity. This excessive influx of tourists results in overcrowding at popular sites, increased pressure on infrastructure, and environmental degradation. Consequently, the overall quality of the visitor experience is compromised, leading to lower satisfaction and concerns over the destination's sustainability. (Mohamad, D., & Marzuki, A. (2018)

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Another major challenge is the high cost of tourism in the region. Expenses related to accommodation, transportation, and tourist activities are often considered excessive, deterring price-sensitive travelers and limiting the accessibility of Cameron Highlands to a broader market. This reduces the region's competitiveness compared to other domestic and international destinations offering similar experiences. Additionally, environmental degradation presents a critical concern. Illegal land clearing, often driven by agricultural expansion, and unsustainable farming practices have caused significant ecological damage. These activities not only threaten the natural landscape that forms the core of Cameron Highlands' tourism appeal but also contribute to soil erosion, water pollution, and habitat loss. Collectively, these challenges highlight the urgent need for integrated planning, regulatory enforcement, and sustainable tourism strategies to preserve the ecological integrity and economic viability of Cameron Highlands as a premier highland destination. Goh, H. C. (2015).

METHODOLOGY

A mixed-methods approach, incorporating both quantitative and qualitative data, was utilized to ensure comprehensive analysis. The integration of structured surveys, in-depth visitor insights, and spatial land use data enables a holistic understanding of the region's socio-economic conditions, environmental constraints, and tourism dynamics. This flexible approach is well-suited for examining emerging or poorly defined problems, enabling the development of hypotheses and guiding more in-depth future research. The target population comprises tourists and visitors to Cameron Highlands. A convenient random sampling method was employed to select 445 respondents, ensuring each participant had an equal opportunity to be included in the study. This sampling approach provided a representative cross-section of the tourist population.

The data collection was conducted in two stages, which were primary data collection was gathered through the administration of structured questionnaires distributed to tourists in various locations across Cameron Highlands. The questionnaire covered several dimensions, including respondent demographics, travel details, motivating factors for choosing Cameron Highlands, types of activities undertaken, perceived congestion at tourist sites, satisfaction with public facilities, overall trip satisfaction, and willingness to pay. Secondary data analysis was obtained from a range of sources including academic books, peer-reviewed journals, news articles, and online databases. Additional data was sourced from official documents such as the Cameron Highlands District Local Plan 2030, the Department of Statistics Malaysia, and PlanMalaysia. These secondary sources provided essential information on land use patterns, area size, existing facilities, and infrastructure in the study area. This study recognizes several limitations, such as the geographically confined scope

limited to Cameron Highlands and the brief period allotted for data collection. Moreover, as the study relies on self-reported data, there is a risk of response bias. Hence, generalizing the findings to other highland destinations should be approached with caution.

ANALYSES

Profile of Respondents by State of Origin

State of origin	Frequency	Percent
Selangor	86	19.30%
Kuala Lumpur	69	15.50%
Perak	47	10.60%
Foreigner	40	9.00%
Negeri sembilan	35	7.90%
Kelantan	34	7.60%
Pahang	29	6.50%
Johor	25	5.60%
Kedah	19	4.30%
Terengganu	19	4.30%
Melaka	14	3.10%
Pulau Pinang	14	3.10%
Putrajaya	7	1.60%
Perlis	3	0.70%
Sabah	3	0.70%
Sarawak	1	0.20%
Total	**445**	**100%**

The survey data reveals a diverse range of origins among the respondents, reflecting the widespread appeal of Cameron Highlands as a tourist destination. The highest number of visitors came from Selangor, accounting for 19.3% (86 respondents), followed by Kuala Lumpur at 15.5% (69 respondents). This indicates a strong interest from the central regions of Malaysia. Notably, foreigners also represented a significant portion, with 9% (40 respondents), highlighting Cameron Highlands' international attraction. Other states with notable representation include Perak (10.6%), Kelantan (7.6%), and Negeri

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Sembilan (7.9%). On the lower end, states such as Perlis, Sabah, and Sarawak had minimal representation, each contributing less than 1% of the total respondents. The diverse geographical origins underscore the broad appeal of Cameron Highlands and the potential for targeted marketing strategies to boost visitation from underrepresented regions. 80.2% (357 respondents) reporting that their trips were spontaneous and unplanned visits which suggests a strong impulsive travel trend among tourists, potentially influenced by the accessibility and attractive climate of Cameron Highlands. 97.1% (432 respondents) visiting in groups which include family outings, tours, or trips with friends, highlighting the social nature of travel to Cameron Highlands.

Type of Attractions Respondents Visited

Table 2: Type of Attraction respondents visited in Cameron Highlands

	Count	**Percent**
Adventure and Sports Tourism	20	4.5%
Agro and Wildlife Tourism	280	62.9%
Eco Tourism	44	9.9%
Gastro Tourism	5	1.1%
Religious and Cultural Tourism	5	1.1%
Urban and Shopping Tourism	91	20.4%
Total	**445**	**100%**

The type of attractions visited by respondents indicates a strong preference for agro and wildlife tourism, which attracted 62.9% (280 respondents). This overwhelming majority reflects the region's reputation for its agricultural heritage and natural beauty, such as tea plantations and strawberry farms. Eco-tourism also garnered significant interest, with 9.9% (44 respondents), underscoring the appeal of Cameron Highlands' natural landscapes and biodiversity.

Urban and shopping tourism attracted 20.4% (91 respondents), indicating that a substantial number of visitors also appreciate the commercial and urban offerings of the highlands. Conversely, adventure and sports tourism, gastro tourism, and religious and cultural tourism were less popular, each drawing less than 5% of respondents. This data suggests that while the primary draw to Cameron Highlands is its natural and agricultural allure, there is potential to diversify and enhance other tourism sectors.

Respondents Purpose of Visit

Table 3: Purpose of visit

	Count	**Percent**
Holiday	384	86.3%
Work/Academic Purpose	54	12.1%
others	7	1.6%
Total	**445**	**100.0%**

The primary purpose of visiting for most respondents was holiday-related, accounting for 86.3% (384 respondents). This dominant percentage highlights the highlands' role as a leisure destination. Work or academic purposes accounted for 12.1% (54 respondents), indicating a smaller but notable segment of visitors combining business with pleasure. The remaining 1.6% (7 respondents) visited for other unspecified reasons, further emphasizing the predominance of leisure travel to Cameron Highlands.

Respondents Perception of Congestion

Table 4: Respondents opinion on factors of congestion in Cameron Highlands

	Count	**Percent**
High number of tourist	103	23.1%
High number of activities	14	3.1%
Loud noise	208	46.7%
Heavy motorised vehicle traffic	4	0.9%
Not congested	116	26.1%
Total	**445**	**100.0%**

Congestion was a significant concern among respondents, with 46.7% (208 respondents) citing loud noise as a major factor contributing to their perception of overcrowding. A high number of tourists was the second most cited factor, noted by 23.1% (103 respondents). Interestingly, a considerable portion of respondents, 26.1% (116 respondents), felt that the area was not congested. Other factors, such as high numbers of activities and heavy motorised vehicle traffic, were less commonly mentioned, at 3.1% (14 respondents) and 0.9% (4 respondents), respectively. This feedback indicates that noise pollution and crowd density are primary concerns affecting the visitor experience in Cameron Highlands.

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Analysis of Visitors' Satisfaction of the trip based on purpose of visiting

All cross-tabulated analyses were subjected to a Kruskal-Wallis test, revealing highly significant relationships between the variables and visitors' satisfaction levels, as indicated by the asymptotic significance values (Asymp. Sig.). This statistical approach confirms that the factors presented correlate significantly with differing degrees of satisfaction among visitors. The findings underscore the robustness of the relationship, highlighting how all these factors impact satisfaction levels across distinct categories.

Table 5: Visitors' level of satisfaction with purpose of visiting

	Overall Satisfaction			
	Unsatisfied	Neutral	Satisfied	**Total**
Holiday	7	55	322	384
Education/Work	7	13	34	54
Others	0	1	6	7
Total	**14**	**69**	**362**	**445**

The analysis of visitor satisfaction based on the purpose of visiting Cameron Highlands reveals significant insights. Out of 445 respondents, the majority (384 or 86.3%) visited for a holiday. Among holiday visitors, 83.9% (322 respondents) were satisfied, 14.3% (55 respondents) were neutral, and only 1.8% (7 respondents) were unsatisfied. This high satisfaction rate underscores the highlands' appeal as a leisure destination. For those visiting for education or work purposes (54 respondents or 12.1%), satisfaction was lower, with 63% (34 respondents) satisfied, 24.1% (13 respondents) neutral, and 13% (7 respondents) unsatisfied. This indicates that while the majority are still satisfied, the satisfaction rate is notably lower compared to holiday visitors. The smallest group, visiting for other reasons (7 respondents or 1.6%), had a satisfaction rate of 85.7% (6 respondents), with 14.3% (1 respondent) neutral and none unsatisfied. This high satisfaction, despite the small sample size, suggests that other purposes might also align well with the attractions and services provided in Cameron Highlands.

Table 6: Visitors' level of satisfaction with public facilities and utilities

	Mean in Ranking Order
Public Toilet	2.53
Access to Clean Water	2.38
Sewage System	2.21
Waste Management	2.15
Recycle System	2.03
Road	1.96

These scores suggest that public toilets received the highest satisfaction rating, whereas road conditions were the least satisfactory. The relatively low scores across all categories highlight the need for significant improvements in public amenities to enhance the visitor experience.

Table 7: Visitors' level of satisfaction with food and beverages provided

	Mean in Ranking Order
Food Quality	2.52
Beverage Quality	2.51
Food Price	2.31
Beverage Price	2.30

These scores indicate that visitors were generally satisfied with the quality of food and beverages offered, though there is some room for improvement in pricing to better meet visitors' expectations.

Table 8: Visitors' level of satisfaction with accommodation services

	Mean in Ranking Order
Friendly Service	2.53
Cleanliness	2.48
Sufficiency of accomodation offered	2.34
Packae Price	2.21

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Visitors rated friendly service the highest, followed by cleanliness and the sufficiency of accommodation. The package price received the lowest rating, suggesting that while services are appreciated, value for money could be better addressed.

Table 9: Visitors' level of satisfaction with the overall expenditure for their visit

Range	Unsatisfied	Neutral	Satisfied	Total
RM200	7	22	46	75
RM201-RM500	3	18	89	110
RM501-RM1,000	3	15	116	134
RM1,001-RM5,000	1	7	52	60
>RM5,000	0	7	59	66
Total	**14**	**69**	**362**	**445**

Analysing satisfaction based on overall expenditure reveals distinct trends across different spending brackets. Among respondents who spent RM200 or less, 61.3% expressed satisfaction, while 29.3% were neutral and 9.3% were unsatisfied. As expenditure increased to RM201-500, satisfaction notably rose to 80.9%, with 16.4% neutral and only 2.7% unsatisfied. In the RM501-1,000 range, satisfaction levels further increased to 86.6%, accompanied by 11.2% neutral and 2.2% unsatisfied. For those spending RM1,001-5,000, satisfaction remained consistently high at 86.7%, with 11.7% neutral and a mere 1.7% expressing dissatisfaction. The highest expenditure category, exceeding RM5,000, exhibited the highest satisfaction rate of 89.4%, with 10.6% neutral responses and no reported dissatisfaction. These findings indicate a clear correlation between expenditure and satisfaction levels, suggesting that visitors who invest more tend to derive greater satisfaction from their experience. The data suggests that premium services and experiences associated with higher expenditures likely contribute significantly to overall visitor satisfaction. This trend underscores the potential impact of upscale offerings in enhancing visitor experiences and perceptions.

The analysis of visitor satisfaction in Cameron Highlands highlights the strengths and areas for improvement in the tourism experience. High satisfaction rates among holiday travelers and group visitors emphasise the highlands' appeal as a leisure and social destination. However, lower satisfaction among solo travelers and those visiting for work suggests areas for enhancement. Public amenities, food and beverage offerings, and service quality receive moderate to high ratings, indicating a generally positive but improvable visitor experience. Finally, higher expenditure is associated with greater satisfaction, suggesting that

investment in premium services could further enhance the attractiveness of Cameron Highlands as a tourist destination.

DISCUSSIONS

From the survey findings on Cameron Highlands tourism, several key discussion points and conclusions emerge. Firstly, the diverse geographical origins of respondents underscore the broad appeal of Cameron Highlands as a tourist destination, with Selangor and Kuala Lumpur leading in visitor numbers, followed by significant international interest. This geographic diversity presents opportunities for targeted marketing strategies to increase visitation from underrepresented regions.

Secondly, the strong preference for agro and wildlife tourism among visitors reflects Cameron Highlands' reputation for its agricultural heritage and natural beauty. This combines the high satisfaction rates reported by holiday-goers, indicating that the region effectively caters to its primary visitor interests. However, the lower interest in adventure, sports, and cultural tourism suggests potential for diversification to appeal to a wider audience.

Thirdly, the high incidence of unplanned visits highlights a trend towards spontaneous travel decisions influenced by the region's accessibility and climate. This impulsive behaviour presents both opportunities and challenges for tourism management in balancing visitor volumes and maintaining a positive visitor experience.

CONCLUSION

In conclusion, the analysis of visitor satisfaction based on purpose of visit, expenditure levels, and accompanying group dynamics reveals clear patterns. Higher satisfaction rates among holidaymakers and group travelers indicate strong performance in leisure and social tourism sectors. However, opportunities exist to improve satisfaction among solo travelers and those visiting for work or education purposes. Addressing infrastructure concerns, enhancing service quality, and diversifying tourism offerings could further elevate Cameron Highlands' appeal and competitiveness in the tourism market. These insights provide a foundation for strategic planning aimed at sustaining and enhancing Cameron Highlands' position as a premier destination in Malaysia.

ACKNOWLEDGMENTS

We acknowledge information and insights provided during many valuable discussions and contributions by PlanMalaysia, the department of urban and regional planning IIUM and EPG Planning Sdn Bhd.

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Received: 28th January 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 394 – 413

SOCIETAL PERCEPTION AND SOCIOECONOMIC VULNERABILITY TO TRAFFIC-INDUCED-AIR POLLUTION IN THE RAPIDLY URBANIZING CITY OF KUALA LUMPUR, MALAYSIA

Siti Haslina Mohd Shafie[1], Anisah Lee Abdullah[2], Mohd Azmeer Abu Bakar[3]

[1,2,3] *Geography Section, School of Humanities,*
UNIVERSITI SAINS MALAYSIA

Abstract

Traffic activities from a high volume of automobiles are the main cause of urban air quality deterioration that affects public health. This study focuses on the link between socioeconomic status and their perception of the causes of urban traffic pollution from motor vehicles and traffic activities in the equatorial city of Kuala Lumpur, Malaysia. Several statistical techniques, including chi-square and exploratory factor analysis, analyzed the survey data of 200 residents. The results showed more than half of the respondents perceived a basic knowledge of traffic pollution and over 70% were aware of the negative impact of air pollution on human health. However, only 58% of the residents positively identified the technical processes of the sources of traffic pollution. Instead of emissions from motor vehicles, most of the respondents perceived that environmental factors are significant contributors to urban pollution. Furthermore, the residents' awareness and attitudes towards vehicular traffic pollution are influenced by socioeconomic aspects, such as the level of education, gender, and age. Understanding the impact of socioeconomic status differences among the residents is crucial in addressing the issue of deteriorating urban air quality and reducing the negative impacts faced by vulnerable urban low-income communities.

Keywords: Urban Traffic Pollution, Societal Perception, Socioeconomic Status, Statistical Analysis, Kuala Lumpur, Malaysia

[1] Corresponding author. Email: haslinashafie@usm.my

INTRODUCTION

Urbanization and rapid economic development in cities worldwide have significantly increased the reliance on vehicles, leading to high levels of traffic-induced air pollution. This issue is prevalent in many urban centers globally, particularly in densely populated cities, where vehicular emissions are a major source of fine particulate matter ($PM_{2.5}$), nitrogen oxides (NOx), and other air pollutants (Ali et al., 2021). Traffic-induced air pollution affects public health by increasing the risk of respiratory and cardiovascular diseases and contributes to climate change and environmental degradation. Furthermore, the perception of air pollution among urban residents is shaped by socioeconomic factors such as income, education, and occupation, which vary across regions and demographics (Mahmood et al., 2022).

Globally, there is a growing recognition of the importance of understanding public perception as part of a holistic approach to tackling air pollution. Research has shown how residents' perception of air pollution affects their willingness to engage in mitigation efforts and support policy measures. For instance, studies conducted in Europe, North America, and parts of Asia have demonstrated that socioeconomic characteristics significantly influence the perception of traffic-induced air pollution and the acceptance of measures like congestion charges and emissions regulations (Shen et al., 2023). Despite this, disparities remain in how these perceptions are studied across regions, with limited focus on rapidly urbanizing cities in developing nations.

In Southeast Asia, particularly in cities like Kuala Lumpur, Malaysia, the issue of traffic-induced air pollution is compounded by rapid urban growth and insufficient public transportation systems. Despite the global emphasis on achieving sustainable urban development as outlined in the United Nations Sustainable Development Goal (SDG) 11, there remains a gap in the literature regarding how socioeconomic factors shape the perception of air pollution in this region (Ismail et al., 2023). Most studies on urban air pollution have focused on its technical aspects, such as emission inventories and health impacts, while neglecting the socioeconomic and behavioural dimensions. Addressing this gap is crucial for developing inclusive policies that integrate public perceptions and foster collective action toward sustainable urban development.

Moreover, the socioeconomic characteristics of urban residents often determine their exposure levels to air pollution, as well as their coping mechanisms. For example, low-income groups are more likely to live in areas with higher levels of pollution, such as near major highways or industrial zones, and may have limited access to healthcare or air-purifying technologies (Rahman et al., 2023). These disparities emphasize the importance of studying public perception in the context of socioeconomic vulnerability, as it can provide

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insights into the unequal distribution of environmental risks and the necessity for targeted interventions.

The findings from studies on socioeconomic influences on air pollution perception could also aid in designing tailored awareness campaigns and urban planning strategies. Public perception shapes the political will to implement environmentally friendly policies, such as promoting the use of electric vehicles or improving public transportation systems. By integrating socioeconomic perspectives into urban environmental management, policymakers can address both the technical and social dimensions of traffic-induced air pollution, thereby ensuring sustainable urban development in cities like Kuala Lumpur. This study investigates the impact of socioeconomic characteristics on urban residents' perceptions and attitudes toward traffic-induced air pollution in Kuala Lumpur, Malaysia. This emphasizes the importance of understanding public perceptions for the successful implementation of technologies and promoting environmentally friendly policies. The findings can support the design of awareness campaigns and urban planning strategies, addressing disparities in socioeconomic status and promoting integrated awareness campaigns. This approach can protect vulnerable communities and foster sustainable urban development in Kuala Lumpur. This study offers a novel contribution by integrating socioeconomic vulnerability, environmental perception, and behavioural awareness within a rapidly urbanising Malaysian metropolis. Unlike previous studies that primarily emphasise technical emission assessments or health impacts, this research highlights the social and perceptual dimensions of traffic-induced air pollution, providing context-specific evidence to support inclusive urban environmental governance in Southeast Asia.

DATA AND MATERIALS

The study area selected for this research is Kuala Lumpur, situated in the Klang Valley region of Peninsular Malaysia, covering an area of 24,221 hectares (Figure 1). Kuala Lumpur City Hall (KLCH), a governmental body under the Federal Ministry, manages development in Kuala Lumpur. The city comprises six strategic zones: Sentul-Manjalara, Wangsa Maju-Maluri, Bandar Tun Razak-Sungai Besi, Damansara-Penchala, and Kuala Lumpur City Centre. The population of Kuala Lumpur was estimated at 1.9 million in 2019 (KLCH, 2023).

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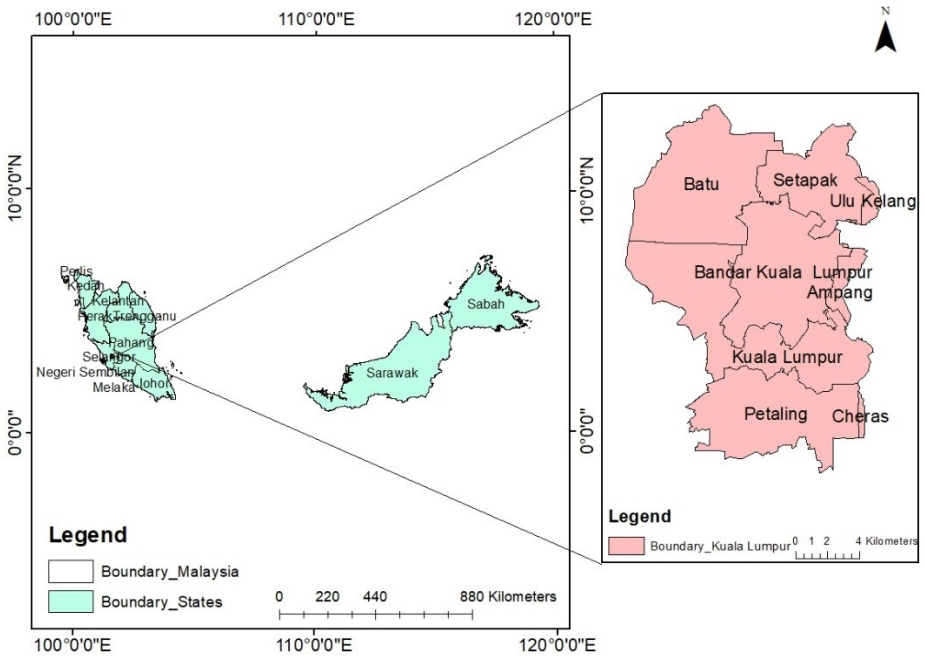


Figure 1: Map of Six Strategic Zones in Kuala Lumpur

A socioeconomic survey was conducted with a sample size of 200 Kuala Lumpur residents, determined using a simple random sampling technique. This method, which ensures each individual in a large population group has an equal chance of being selected, is straightforward and produces a structured study output. However, it can be resource-intensive and complex. A sufficiently large sample size was chosen to address the study objectives. The questionnaire included three sections: (1) background profile, (2) knowledge of traffic pollution, and (3) public awareness of traffic pollution. Several statistical methods were employed. The cross-tabulation technique identified relationships between various socioeconomic variables (Smith et al., 2022), meanwhile, the relationship between socioeconomic status and public perception and awareness was analyzed using the chi-square test. The significance of multivariate relationships among measured variables was examined using exploratory factor analysis (EFA). The chi-square test was selected due to its suitability for examining associations between categorical socioeconomic variables and perception indicators. Exploratory factor analysis was employed to identify latent constructs underlying respondents' perceptions and awareness patterns. These techniques were preferred over regression-based approaches due to the categorical nature of the data and the exploratory objective of this study.

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The chi-square analysis is a statistical method that uses frequency data to evaluate significant relationships between categorical variables. The hypothesis testing for the chi-square test of independence involves computing a test statistic, which is compared to a critical value determined by the significance level ($p < 0.05$) and degrees of freedom (Lee & Tan, 2021). In this study, differences in socioeconomic status influencing residents' perceptions of traffic pollution were analyzed based on gender, age, race, education level, and income. Socioeconomic differences were examined in relation to factors such as causes of traffic pollution, pollution levels, exposure, environmental and health impacts, and mitigation efforts to address short- and long-term effects of traffic pollution.

Exploratory factor analysis (EFA) was employed to identify, reduce, and organize questionnaire items into specific constructs under one dependent variable. In the EFA process, each questionnaire item was treated as a factor. The process included three stages: identifying correlations between factors, factor extraction, and factor rotation (Nguyen, 2023). Principal Component Analysis (PCA) was used for factor extraction to minimize the number of factors while explaining the maximum variance. Orthogonal rotation using Varimax with Kaiser Normalization was conducted in SPSS software to clarify relationships between items and factors and distinguish factor relationships. Interpretation of results depended on the researcher's judgment to define the constructs measured by each factor. While EFA is data-driven and can vary in its outcomes, it requires three key conditions: an appropriate measurement scale, a sufficient number of questionnaire items, and a sample size that represents normality.

RESULTS AND DISCUSSION

The Demographic Background of Kuala Lumpur Residents

As shown in Table 1, the majority of respondents belong to low-income households, indicating a high level of socioeconomic vulnerability. In summary, the majority of the respondents are Malay males between the ages of 31 and 50 years old and acquired a secondary level of education (Table 1). They mostly work in the private sector and earn less than RM 2,000 a month. In terms of income, 37% earn less than RM2,000 (USD 484) while 33% earn between RM2,000 to RM3,000 per month. This shows that 96% of the respondents earn less than RM4,000 (USD 725) a month. According to the Household Income and Basic Facilities Survey conducted by the Department of Statistics Malaysia, the median household income for the B40 income group is RM 3,000 while the median income for the Federal Territory of Kuala Lumpur is RM 7,620 for M40 in 2022 (Department of Statistics Malaysia, 2022). The term B40 represents the bottom 40% of the lowest income group, while M40 represents the middle 40% of the income group. In this light, approximately 96% of the respondents are from the low-income group or the urban poor, based on the median value of income in

the Federal Territory of Kuala Lumpur. The urban poor constitute a quarter of Kuala Lumpur's households (Ridzwan & Idris, 2020). Nearly 63% of respondents live in the major areas of the city, 29% live in the suburbs, and 9% live in newly developed areas.

Table 1: Demography Profile of Respondents in Kuala Lumpur

Item		**N**	**Percentage (%)**
Gender	Men	114	57
	Women	86	43
Race	Malay	114	72
	Chinese	19	9.5
	Indian	32	16
	Others	5	2.5
Age	**Younger** (<18 - 30 years)	71	35.5
	Adult (31 – 50 years)	101	50.5
	Elderly (51 - > 60 years)	28	14
Level of Education	**School** (Primary and Secondary)	99	49.5
	Pre-Graduated (Diploma and First Degree)	87	43.5
	Post-Graduated (Masters and PhD)	14	7
Occupation sector	Government	42	21
	Private	94	47
	Self-employed	63	31.5
	Housewife	1	5
Income	< RM2000	87	43.5
	RM2000 - RM4000	105	52.5
	> RM4000	8	4

The Influence of Socioeconomic Background on the Respondents' Perceptions, Knowledge, and Awareness

The determination of the significant relationship between variables utilizes the Chi-square test and exploratory factor analysis (EFA). The cross-tabulation analysis summarized that the educated middle-aged masculine gender in Kuala Lumpur, between the ages of 31 and 50 years significantly influenced the level of perception and awareness against urban traffic pollution (Table 2).

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Table 2: Respondent's socioeconomic background influencing the perception of urban traffic pollution in Kuala Lumpur

No.	Details/Questions	Respondent's Socioeconomic Background		
		Gender (Men)	**Age (Middle age between 31-50 years)**	**Level of education (Secondary School)**
Basic knowledge on traffic pollution (%)				
1.	What is the sources/causes of traffic pollution?	51.8	62.9	49.5
2.	What is the main pollutant of traffic pollution?	90.4	91.4	89.5
3.	Where is the highest pollutant released?	86.8	84.3	87.4
4.	What are the main components of a motor vehicle that emit pollutants?	99.1	100	100
5.	What is the main driving pattern that emitted highest of pollutants?	78.1	85.7	83.2
6.	What is the average speed of a vehicle releasing maximum traffic pollutants?	66.7	78.6	62.1
7.	When does traffic pollution occur seriously?	65.8	60	50.5
Information and definition of RON (%)				
8.	RON is a mixture of two basic elements namely octane and pentane which complement the properties of petrol?	66.7	65.7	41.1
9.	Does a higher RON value result in more powerful engine performance?	96.5	92.9	93.7
10.	Does RON97 provide more acceleration power but more efficient in terms of combustion rate than RON95?	98.2	97.1	96.8
11.	Does RON97 have a more positive impact on the environment than RON95?	98.2	97.1	95.8
12.	How do RON differences have a positive impact on the environment?	54.4	64.2	64.2

No.	Details/Questions	Respondent's Socioeconomic Background		
		Gender (Men)	**Age (Middle age between 31-50 years)**	**Level of education (Secondary School)**
13.	What is the main choice of fuel among the population?	75.4	71.4	87.4
14.	What are RON95 and RON97 petrol selection factors?	76.3	75.7	88.4
Human health effects (%)				
15.	Does traffic pollution have a serious impact on an individual's health?	98.2	98.6	96.8
16.	Do different types of pollutants determine the differences in diseases experienced by individuals?	91.2	88.6	84.2
17.	What are the most high-risk traffic pollutants against individual diseases?	67.5	75.7	73.7
18.	Who are the most vulnerable and high-risk groups?	27.2	45.7	31.6
Physical factors of motor vehicles emitted the air pollutants (%)				
19.	Emissions from exhaust under stable thermal engine operation	42.1	42.9	44.2
20.	Emissions from the exhaust during vehicle operation	63.2	70	60
21.	Direct emissions from the process of evaporation of fuel	63.2	64.3	58.9
22.	Particle emissions from vehicle movement operations from the road surface	41.2	40	43.2
Ambient environmental factors of air pollutants emissions (%)				
23.	Wind speed	69.3	72.9	67.4
24.	Wind direction	65.8	57.1	67.4
25.	Topography	55.3	57.1	56.8
26.	Building position along the road	64	65.7	67.4
27.	Green surfaces in urban areas	56.1	54.3	51.6

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No.	Details/Questions	Respondent's Socioeconomic Background		
		Gender (Men)	**Age (Middle age between 31-50 years)**	**Level of education (Secondary School)**
Types of diseases and health effect to the population (%)				
28.	Pneumonia	72.8	78.6	72.6
29.	Born of premature and under weight babies	37.7	47.1	46.3
30.	Childhood leukaemia	48.2	51.4	47.4
31.	Premature infant deaths	50.9	57.1	57.9
32.	Increase of allergy risks	36.8	45.7	43.2
33.	Lung cancer	65.8	61.4	66.3
34.	Asthma	68.4	65.7	78.9
Strategies and control measures of traffic pollution (%)				
35.	Use effective and conducive public transport	68.4	70	76.8
36.	Incentives / rewards for public transport users	70.2	72.9	74.7
37.	Carpooling in major cities	67.5	68.6	73.7
38.	Increase fuel prices (petrol & diesel)	39.5	37.1	33.7
39.	Imposes high charges on drivers who use congested and busy roads during peak hours	36.0	31.4	36.8
40.	Invention of high performing engines	53.5	67.1	47.4
41.	The use of high technology catalytic converter	61.4	71.4	52.6
42.	Improve chemical processes in petrol and diesel fuels	46.5	52.9	43.2
43.	Vehicles with Hybrid technology	68.4	72.9	68.4
44.	Electric powered vehicles	69.3	72.9	69.5

Chi-Square Test Analysis

Gender

This section seeks to determine the role of gender in influencing the perception of traffic pollution. The chi-square test was tested with the null hypothesis that there was no relationship between gender and the question posed. There is a significant relationship among the male population of Kuala Lumpur with a value of p = 0.016 regarding the question of "RON is a mixture of two basic elements

namely octane and pentane" (Table 3). In addition, men were significantly knowledgeable when answering the question on “Exhaust from the exhaust during engine operation” with a value of p = 0.03. The male gender is more knowledgeable about the physicality of the vehicle and the fuel used in the vehicle movement process.

In terms of the health effects of traffic pollution on the population, male respondents still showed a significant result with p = 0.041 to the question on the type of pollutants that determine the differences in diseases experienced by the population. Male respondents also demonstrated significant findings on "the most high-risk traffic pollutants against disease" with p = 0.015. These results prove that male respondents are aware of the negative impact of traffic pollution on health.

Table 3: Chi-Square Test Analysis Result Based on Gender, Age, And Education Level

No.	Details/Questions	Significance level (p < 0.05)
Gender		
Knowledge on RON		
1.	RON is a mixture of octane and pentane	0.016
Effects on human health		
1.	The type of pollutants determines the type of diseases	0.041
2.	High-risk traffic pollutants	0.015
Vehicle physical factors that influence traffic pollutants		
1.	Emission from vehicle’s exhaust during engine operation	0.03
Age		
Effects towards human health		
1.	Traffic pollutants have adverse effects on human health	0.029
2.	The type of pollutants determines the type of diseases	0.045
The effect on Ambient Environment on Traffic pollution		
1.	Diverse use of city land	0.012
Types of diseases and health effect to the population		
1.	Premature infant deaths	0.005
2.	Increase of allergy risks	0.014
The level of education		
Cause of traffic pollution		
1.	Location with the highest number of pollutants.	0.024
2.	Vehicle component which emit pollutants	0
3.	Average vehicle speed, which emits the maximum traffic pollutants.	0.049

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Age

Residents aged between 31 to 50 years are knowledgeable on the ill effects of traffic pollution to health, with a significant p-value of 0.029. This age group is also aware of the differences in the types of pollutants related to the type of diseases with a significant p of 0.045. In addition, there is also a strong relationship between the maturity of the middle-aged population and the effects of ambient environmental factors, specifically due to the diversification of urban land use ($p = 0.012$). They are also aware of the health complications brought by traffic pollution, including premature infant death and increased risk of allergies, with significant values of $p = 0.005$ and 0.014, respectively.

Level of Education

There is a strong link between the level of education and the perception of the residents toward traffic pollution as well as issues brought by traffic pollution, specifically health effects and risk of diseases. The question of whether urban roads recorded the highest level of pollutants showed a significant result with a p-value of 0.024. Concurrently, the exhaust being the main vehicle component that emits pollutants is significant at a p-value of 0. The respondents also provide a significant answer to the question of whether a vehicle speed of > 70 mph will release the highest level of pollutants with a value of $p = 0.049$.

EXPLORATORY FACTOR ANALYSIS (EFA)

Table 4 summarises the factor loadings derived from the EFA, highlighting the dominant environmental and behavioural perception patterns. Based on the results of the EFA, the main factors are identified to uncover the underlying structure of a set of variables. Factor 1 contains various items in the questionnaire selected by residents that refer to sources of traffic pollution from non-vehicles with the highest eigenvalue of 3.780 (Table 4). Factor 2 consists of three items, namely on the knowledge of exposure to pollutants with an eigenvalue of 2.478. Factor 3 recorded the lowest eigenvalue of 1.401, which refers to the sources of emissions of pollutants from vehicles. The overall combination of variance for the three factors is 69.62%, with 34.364% for factor 1, factor 2 = 22.523%, and factor 3 = 12.733%. The results of the analysis on the residents' exposure to traffic pollutants in Kuala Lumpur explained that the level of knowledge and perception on the contributing factors to traffic pollution is low, particularly on the physical factors of traffic pollution. Factor naming was based on theoretical relevance, dominant item loadings, and conceptual coherence with established literature on urban environmental perception and exposure behaviour.

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Table 4: Knowledge on Traffic Pollution in Kuala Lumpur

Questionnaire Items	Factor		
	1	**2**	**3**
1. Position of buildings along the road	0.869		
2. Topography and the earth's landscape	0.857		
3. Wind direction	0.755		
4. Diversity of urban land use	0.673		
5. Wind speed	0.665		
6. Green surface in urban areas	0.603		
7. Walking along the road without wearing a mask		0.929	
8. Cycling along the road without wearing a mask		0.919	
9. Driving a vehicle while opening the vehicle window		0.903	
10. Emission from the exhaust during temporary engine operation after the engine started			0.709
11. Direct emission from the process of fuel evaporation			0.672
Eigenvalue	3.780	2.478	1.401
% Variance	34.364	22.523	12.733
Cumulative Variance	34.364	56.887	69.620

Table 5 shows the results on the impact of traffic pollution on public health and the proposed measures to control traffic pollution in Kuala Lumpur. In total, there are three main factors with a total percentage variance of 68.493% consisting of factor 1 at 28.51%; factor 2 at 23.329%, and factor 3 at 16.654%. Factor 1 relates to the health issues regarding the types of diseases with the highest eigenvalue of 3.421. Factor 2 refers to the proposed implementation measure with a high eigenvalue of 2.799. The respondents agreed on four items related to implementation measures, including high-performance engine design, and the use of electric and hybrid vehicles to reduce traffic pollution.

Table 5: The Impact of Traffic Pollution on Kuala Lumpur Residents

Questionnaire Items	Factor		
	1	**2**	**3**
1. Premature infant deaths	0.884		
2. Born of premature and under weight babies	0.851		
3. Childhood leukaemia	0.850		
4. Increase in allergy risk	0.800		
5. Lung cancer	0.661		
6. Invention of high performing engines		0.861	
7. The use of high technology catalytic converter		0.829	
8. Electric powered vehicles		0.719	
9. Vehicles with Hybrid technology		0.686	
10. Effective and conducive public transport			0.899

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Questionnaire Items	**Factor**		
	1	**2**	**3**
11. Incentives / rewards for public transport users			0.892
12. Carpooling in major cities			0.786
Eigenvalues	3.421	2.799	1.999
% Variance	28.510	23.329	16.654
Cumulative Variance	28.510	51.839	69.493

Factor 3 is the regulatory strategy that generated the lowest agreement from the respondents. The respondents chose three main items to control the impact of urban traffic pollution, which are provisioning effective public transport, incentives for using public transport as well as car-pooling. The residents argued that the public transport system is unreliable and inefficient. As a result, they need to spend more time traveling using public transport, which causes significant inconveniences to them.

The three dominant factors identified in determining the views of the residents on the traffic pollution in Kuala Lumpur highlighted by the EFA are the perception on the causes of air pollution that are not related to vehicles but the environment, exposure to pollutants without any protection and the sources of emissions from vehicles. Thus, the attitude and level of knowledge of the population on the causes of pollution, the concentration of pollutants, and its negative effects on health also play a role in the success and efforts of the local authorities in controlling the level of ambient pollution. This situation further determines the level of awareness and acceptance of the population on proposed traffic pollution mitigation and implementation measures implemented to control the impact of pollution.

Sustainable transportation planning is crucial for achieving sustainable urban development in Kuala Lumpur and Malaysia. The integration of green transportation initiatives not only addresses environmental concerns but also enhances the quality of life for urban residents. This discussion elaborates on the strategies and measures necessary to foster sustainable transportation and urban development. One of the primary strategies for sustainable transportation is the enhancement of public transportation systems. Kuala Lumpur has made significant strides in this area with the development of the Mass Rapid Transit (MRT) system. The MRT has improved accessibility and reduced traffic congestion, contributing to sustainable urban growth (Man et al., 2024). The expansion of the MRT network and the integration of other public transport modes, such as buses and light rail transit (LRT), are essential for creating a comprehensive and efficient public transportation system (Man et al., 2024). This approach aligns with global trends in sustainable urban planning, where efficient public transit systems are pivotal in reducing reliance on private vehicles and mitigating urban congestion (Gössling, 2017). Additionally, the Green Mobility:

Public Transit initiative in Kuala Lumpur focuses on expanding public transit routes, implementing bus rapid transit systems, and integrating bike lanes and pedestrian walkways to encourage active transportation and reduce greenhouse gas emissions (SDG Centre Kuala Lumpur, 2023).

Low emission zones (LEZs) are designated areas where access by certain polluting vehicles is restricted or deterred to improve air quality. These zones typically favor vehicles that produce lower emissions, such as bicycles, micromobility vehicles, alternative fuel vehicles, hybrid electric vehicles, plug-in hybrids, and zero-emission vehicles like all-electric vehicles (Clean Cities Campaign, 2024). The Kuala Lumpur Low Carbon Society Blueprint 2030 aims to implement LEZs to decrease emissions by 70% by 2022 compared to 2015 levels (KLCH, 2017). These zones restrict the entry of high-emission vehicles, encouraging the use of cleaner transportation alternatives (KLCH, 2017). LEZs have been successfully implemented in various global cities, demonstrating their effectiveness in improving air quality and public health (Holman et al., 2015). For instance, in Central London, the introduction of LEZs has led to a reduction in nitrogen dioxide (NO2) concentrations by up to 46% (Clean Cities Campaign, 2024).

LEZs are particularly successful at reducing nitrogen dioxide (NO2) concentrations by around 20% in a wide range of conditions. In addition to improving air quality, LEZs contribute to reducing carbon emissions, mitigating congestion, and incentivizing the transition to zero-emission vehicles (ZEVs) (Clean Cities Campaign, 2024). The number of active LEZs in Europe grew from 228 in 2019 to 320 in 2022, with over 500 expected by 2025 (Clean Cities Campaign, 2024). The implementation of LEZs involves several key components, including a clear definition of objectives, area, scope, and timeline; a vision for zero-emission urban mobility; extensive communication; effective and fair enforcement strategies; monitoring schemes; targeted support for the most vulnerable; and complementary measures to promote active and public transport. These elements ensure that LEZs are not only effective in reducing emissions but also equitable and inclusive. In summary, LEZs are a critical tool in urban environmental management, promoting cleaner air and healthier living conditions for city residents. The success of LEZs in various global cities underscores their potential to significantly improve air quality and public health in Kuala Lumpur and other urban areas.

Active transportation, such as walking and cycling, plays a vital role in sustainable urban development. Creating pedestrian-friendly infrastructure and dedicated cycling lanes can promote healthier travel choices and reduce traffic congestion. Public awareness campaigns and educational programs are necessary to encourage the adoption of active transportation modes (The Star, 2023). Studies have shown that active transportation not only reduces emissions but also

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improves public health by increasing physical activity levels (Sallis et al., 2016). Active transportation significantly contributes to public health by promoting physical activity. Walking and cycling are forms of exercise that help reduce the risk of chronic diseases such as obesity, cardiovascular diseases, and diabetes. This study also found that cities with robust pedestrian and bicycle infrastructure experience lower levels of obesity and cardiovascular diseases, as residents are more likely to engage in regular physical activity. Additionally, active transportation can improve mental health by reducing stress and anxiety levels.

Moreover, active transportation reduces greenhouse gas emissions and air pollution. By replacing short car trips with walking or cycling, cities can significantly decrease their carbon footprint. Non-motorized transport modes such as walking and biking can dramatically reduce air pollution, noise, and urban heat islands. This reduction in emissions contributes to global climate change goals and improves overall air quality (Ohlund et al., 2021). Investing in pedestrian and bicycle infrastructure can also have positive economic impacts. A study by Portland State University's Transportation Research and Education Center found that improvements such as bicycle and pedestrian infrastructure had either positive or non-significant impacts on the local economy as measured through sales and employment. For example, bike lanes installed on Central Avenue in Minneapolis led to a 12.64% increase in retail employment and a 52.44% increase in food sales (Liu, 2020). These findings suggest that active transportation infrastructure can boost local businesses and create job opportunities.

Furthermore, active transportation helps reduce traffic congestion by decreasing the number of vehicles on the road. Cities with well-developed pedestrian and bicycle infrastructure experience less traffic congestion, leading to more reliable travel times and increased public transit ridership. The World Resources Institute for year 2021 reported that cities in Southeast Asia lose 2 to 5% of their annual GDP to congestion, with Manila suffering the worst loss at $67 million per day. Improving walking and cycling infrastructure can help lessen congestion and the associated economic losses (Ohlund et al., 2021). Finally, active transportation fosters a sense of community and social interaction. Pedestrian-friendly infrastructure and dedicated cycling lanes create safer and more inclusive urban environments. These spaces encourage social interactions and community engagement, contributing to a higher quality of life. The development of such infrastructure also promotes equity by providing affordable and accessible transportation options for all residents (Ohlund et al., 2021).

Integrating land use and transportation planning is essential for sustainable urban development. Mixed-use developments that combine residential, commercial, and recreational spaces can reduce the need for long commutes and promote the use of public transportation. The Kuala Lumpur Smart

City Plan 2021-2025 emphasizes the importance of such integrated planning to create a more sustainable and livable city (JASCA, 2021). This approach aligns with the principles of smart growth, which advocate for compact, transit-oriented, and walkable urban environments (Ewing & Hamidi, 2015). The Kuala Lumpur Structure Plan 2040 (KLSP2040) further supports this by integrating long-term land use with infrastructure and transportation planning, provision of affordable housing, and public and recreational facilities to meet the needs of the population while improving the quality of the environment and urban space (InvestKL, 2020).

Recent studies have highlighted the importance of integrating land use and transportation planning. For instance, Yusoff et al., (2021) examined the sustainable transport policy framework in the Klang Valley, emphasizing the need for a holistic approach that includes infrastructure provision, technological improvements, regulation, information, awareness, education, and pricing and taxation. Their findings indicate that while the current framework meets sustainable development criteria, there is still a need for greater public adoption of rail-based services (Yusoff et al., 2021).

Improving fuel quality standards is another measure to reduce vehicular emissions. The implementation of Euro 5M fuel standards in Malaysia by 2025 will lower the benzene content and NOx emissions, contributing to better air quality. These standards align with international benchmarks and demonstrate Malaysia's commitment to environmental sustainability. Enhanced fuel quality standards are critical for reducing the health impacts of air pollution, particularly in urban areas (WHO, 2016). The Department of Environment Malaysia has outlined the specifications for Euro 5 petrol and diesel, which include lower sulphur levels and other stringent requirements to ensure cleaner fuel (DOE, 2025).

Public awareness and education are crucial for the success of sustainable transportation initiatives. Environmental education programs should be incorporated into school curricula to raise awareness about the benefits of sustainable transportation and the impact of traffic pollution on health (Salleh et al., 2018). Engaging the public through campaigns and community events can also foster a culture of sustainability (The Star, 2023). Education and awareness are key drivers of behavioral change, which is essential for the adoption of sustainable transportation practices (Steg & Vlek, 2009). For instance, initiatives like the "Green Mobility: Public Transit" program in Kuala Lumpur aim to educate the public on the benefits of using public transportation and reducing reliance on private vehicles (SDG Centre Kuala Lumpur, 2023).

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LIMITATIONS

This study has several limitations that should be considered when interpreting the findings. The dominance of respondents from the B40 income group reflects the socioeconomic structure of selected residential areas but may limit the representativeness of higher-income populations. Consequently, caution should be exercised when generalising the findings to other socioeconomic groups and urban contexts. Firstly, the sample size of 200 residents, while adequate for the research objectives, may not fully capture the diversity of Kuala Lumpur's population. A larger and more diverse sample in future studies could enhance the generalizability of the findings, providing a more comprehensive understanding of public perceptions across different demographic groups. Secondly, the focus on Kuala Lumpur may limit the applicability of the findings to other cities with different socioeconomic and environmental contexts. Comparative studies across multiple urban centres' could offer broader insights and help identify common patterns and unique challenges in various settings. Thirdly, the data collected represents a specific point in time, and changes in socioeconomic conditions, public policies, and environmental factors over time could influence public perceptions and attitudes. Longitudinal studies that track these changes over time are needed to capture the dynamic nature of public perceptions and provide a more accurate assessment of the long-term impacts of traffic-induced air pollution. Additionally, the reliance on self-reported data through surveys may introduce biases such as social desirability bias or recall bias, where respondents might provide answers, they believe are socially acceptable or struggle to accurately recall past experiences. Employing mixed methods, including qualitative approaches like interviews or focus groups, could provide deeper insights and help mitigate these biases. Lastly, while the study examines key socioeconomic variables, other factors such as cultural influences, media exposure, and personal experiences with air pollution were not explored. Future research could incorporate these additional dimensions to provide a more comprehensive analysis, considering how cultural contexts and media narratives shape public perceptions and attitudes toward traffic-induced air pollution.

CONCLUSION

This study underscores the significant influence of socioeconomic characteristics on urban residents' perceptions and attitudes toward traffic-induced air pollution in Kuala Lumpur, Malaysia. This study extends existing literature by demonstrating how socioeconomic disparities shape environmental awareness and behavioural responses to traffic-related air pollution in Kuala Lumpur, offering empirical insights that remain limited in regional urban environmental research. The research reveals that factors such as income, education, and occupation are pivotal in shaping how the public perceives and is aware of air

pollution. These findings highlight the necessity of incorporating public perceptions into urban environmental management to formulate inclusive policies that address both the technical and social dimensions of traffic-induced air pollution. By understanding how socioeconomic factors influence public perception, policymakers can design targeted awareness campaigns and urban planning strategies that promote sustainable urban development and protect vulnerable communities. This approach ensures that policies are not only technically sound but also socially equitable, fostering a collective effort towards mitigating air pollution and enhancing the quality of urban life.

ACKNOWLEDGEMENT

Special thanks to all the respondents in Kuala Lumpur who participated in the survey and shared their insights, making this study possible. Also, I would like to express my deepest gratitude to Prof. Dr. Mastura Mahmud, for their invaluable guidance, support, and encouragement throughout this research.

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

DATA AVAILABILITY

Data used in this research are available upon request.

DECLARATIONS

Conflict of Interest - The author declares no competing interests.

ETHICAL CONSIDERATIONS

This study involved voluntary participation, and all respondents were informed about the purpose of the research before data collection. Informed consent was obtained from all participants. Personal identifiers were not collected, and all responses were treated anonymously and confidentially. The study adhered to standard ethical practices for social science research.

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Received: 3rd February 2025. Accepted: 15th November 2025

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PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 24 ISSUE 1 (2026), Page 414 – 432

MOTIVATION OF OUTDOOR RECREATION PARTICIPATION AMONG THE RECREATIONAL USERS: AN STUDY ON THE QUALITIES OF RECREATION AREA

Hasnizam Ab Dulhamid[1], Muhammad Ferdhaus Sazali[2], Mohamad Azal Fikry Ali[3], Nur Fatima Wahida Mohd Nasir[4], Nur Amalina Ahmad Karim[5]

[1,2,3] *Department of Built Environment Studies & Technology,*
UNIVERSITI TEKNOLOGI MARA PERAK BRANCH
[4] *Academy of Language Study,*
UNIVERSITI TEKNOLOGI MARA PERAK BRANCH
[5]*Centre of Studies for Town and Regional Planning,*
UNIVERSITI TEKNOLOGI MARA SELANGOR BRANCH

Abstract

Outdoor recreation has gained popularity worldwide, offering opportunities for people to connect with nature and enhance their overall well-being. Researchers and policymakers have increasingly focused on understanding the factors that influence the use and benefits of outdoor recreational activities. This paper seeks to identify the key qualities of outdoor recreation areas that motivate communities to engage in such activities. The findings indicate that safety is the most crucial factor for most respondents when choosing a recreation area. In addition to safety, the availability of comprehensive sports facilities and visually appealing landscapes are also highly valued. These results underscore the importance of maintaining high-quality recreation areas to ensure that users can enjoy outdoor activities safely and comfortably, ultimately achieving a satisfying experience.

***Keywords*:** Outdoor Recreation, Motivation, Recreation Qualities

[1] Corresponding author. Email: hasni435@uitm.edu.my

INTRODUCTION

This study contributes uniquely to the outdoor recreation literature by empirically linking recreational area quality with user motivation in a secondary Malaysian city. Such context-specific evidence remains limited in Malaysian planning and urban health research and offers actionable insights for local authorities in promoting active lifestyles and urban well-being (Isa et al., 2022; Ab Dulhamid et al., 2023).

Green spaces are vital components of the natural environment, serving as effective buffers against unhealthy lifestyles and playing a crucial role in stress relief. Within these areas, sports and leisure activities are particularly popular among individuals experiencing high stress levels, showing a positive correlation with serene and natural surroundings (Gao et al., 2024). Recreation, in this context, refers to activities that individuals engage in within accessible natural or green spaces as part of their daily routines (Bell et al., 2007).

Outdoor recreational activities provide opportunities for direct interaction with natural environments and serve as platforms for face-to-face social interactions (Isa et al., 2022) across diverse geographical settings (Zajchowski et al., 2022). The interplay between these factors contributes significantly to psycho-social development, enhancing social skills, self-concept, social adjustment, self-confidence, and tolerance towards others (McAvoy et al., 2006; Dorsch et al., 2016; Gonyo et al., 2024). Engaging in outdoor recreation allows individuals to connect with nature, fulfilling psychological, emotional, and spiritual needs. The presence of natural spaces is a key factor influencing health, happiness, and overall well-being (Chen et al., 2020).

It is customary for outdoor recreational activities to occur in open areas with greenery or surrounded by components or elements of nature (Hayir-Kanat & Breuste, 2020). The involvement of Malaysians in recreational activities is still at a moderate level, with an increase from 59.8% in 2017 to 63% in 2020. This is because it is influenced by several factors, such as the sedentary lifestyle of individuals, time constraints for routine activities, not caring about the importance of an active and healthy life, and limited access to sports and recreation facilities (RMKe12, 2021).

Sedentary lifestyle practices, poor time management, and a lack of awareness of the importance of an active life are among the factors that pose risks and challenges to health and the quality and well-being of life (Li et al., 2016; Siwar et al., 2016; González et al.., 2017; Diza-Godiño et al., 2019; Chen et al., 2020). Most individuals spend more than 90% of their time indoors (Klepeis et al., 2001; Chen et al., 2020), and the limited remaining time makes it more difficult for them to engage in outdoor recreational activities (Matthews et al., 2015; Chen et al., 2020). Recreational activity facilities have been developed to

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increase individual motivation to visit recreational areas to fill free time (Frochot, 2005; Sari, 2019).

Recreational areas that apply elements of appreciation to nature and recreational activities as a result of the diversity of geographical forms that exist indirectly increase the motivation of an individual's involvement (Goossen & Langers, 2010); there is good potential in producing something that benefits health (Srinivasan et al., 2003), physical, mental, social, community, and environmental benefits (Driver, 1996; Godbey, 2011; Holland et al., 2018). Pietilä et al., (2015) explained that green space access is essential for personal health and physical activity to be self-assessed for the community.

Recreational activities based on natural resources offer individuals the opportunity to fulfill their recreational needs while preserving the diversity of nature, culture, and history (Sari, 2019). As a result, people have begun to shift their priorities when selecting spaces for outdoor recreation, focusing more on areas that balance enjoyment with environmental and cultural preservation.

LITERATURE REVIEW

Over the past 50 years, numerous studies have explored the motivations behind outdoor recreation involvement (Walker et al., 2010; Dillard & Bates, 2011). Motivation plays a crucial role in understanding why individuals choose to engage in recreational activities, the benefits they derive from participation, and how this knowledge can aid in planning and environmental management (Ab Dulhamid et al., 2023a). Motivation consists of three complex components: specific motive activation, motive persistence, and motive intensity (Deci & Ryan, 2000; Ewert et al., 2020).

Research by Fredman and Heberlein (2005) and Kil, Holland, and Stein (2014) has confirmed a significant relationship between motivation and environment-based behavior. Each motivational factor is viewed as a unique concept, shaped by the likelihood of achieving desired outcomes through recreation (Fluker & Turner, 2020). For effective results, communities need to understand the motives behind outdoor recreation participation (Eriksson & Nordlund, 2013). For instance, participation in sports activities is often driven by the pursuit of rewards or recognition (Chantel et al., 1996), while outdoor recreation involvement tends to focus more on personal fulfillment and desired outcomes (Kouthouris & Spontis, 2005; Kyle et al., 2006; White, 2008).

Motivation can be defined as both a reason and an internal drive that inspires individuals to act in a certain way and direction (Sale, 2017). It encompasses passion, determination, and inner strength (Dillard & Bates, 2011). This concept highlights a strong link between motivation and emotion, suggesting that people tend to feel positive if their goals and desires are fulfilled, and

negative if they are not. Motivation can manifest in various situations and conditions, influencing both the direction and intensity of an individual's efforts, which in turn affects the outcomes of their activities. Essentially, motivation is the will, drive, and emotional energy that propel individuals to take action (Sale, 2017).

In addition to personal motivation, other factors such as politics, socio-demographics, technological advancements, education levels, funding for parks, expectations for travel alternatives, new funding structures, and climate change also influence outdoor recreation involvement (Eagles, 2014). In conclusion, the motivations and experiences associated with outdoor recreation largely depend on the natural conditions of the area, the availability of infrastructure, and the presence or absence of other recreationists. As a result, managing outdoor recreation often requires complex trade-offs in planning, adopting new concepts, or implementing new products or regulations (Pröbstl-Haider et al., 2021).

Motivation Theory

According to Maslow (1970), the primary goal of the general motivation theory is to fulfill fundamental human needs from a humanistic perspective. Maslow identified five essential needs organized into a hierarchy: physiological, safety, belonging, self-esteem, and self-actualization. In this hierarchy, physiological needs are considered lower-level, while self-actualization represents higher-level needs. As a result, all lower-level needs must be satisfied before individuals can focus on fulfilling higher-level needs.

The definition of outdoor recreation has evolved over time, influenced by a range of philosophical perspectives. However, one of the most widely accepted definitions describes outdoor recreation as the voluntary participation in activities during one’s spare time, typically conducted outdoors and requiring interaction with natural resources and the surrounding environment. Garst et al. (2001) studied adolescents involved in outdoor recreational activities and found that such participation positively influenced their perceptions. This conclusion aligns with the international research findings of Garst, Schneider, and Baker (2001).

Given the limited scope of existing research on recreation in Malaysia, it is essential to prioritize studies that explore the motivations behind participation among Malaysian respondents. According to Berger and Tobar (2007), recreational activities are closely linked to quality of life. Engaging in these activities can help maintain a healthy lifestyle, enhance physical fitness, and foster a sense of spiritual fulfillment, ultimately reducing the risk of physical decline. This assumption is supported by Landers and Arent (2007), who found that being in a positive mood can improve cognitive function, while participation in physical activities can help reduce anxiety.

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Motivation can be defined as the will, drive, or emotional force that compels individuals to take action, and it is closely intertwined with emotion (Ab et al., 2023). Therefore, this study aims to examine the characteristics of recreational spaces that encourage people to engage in outdoor activities during their leisure time.

Impact of Recreational Area Quality on Participant Motivation in Outdoor Activities

Extensive research has explored the physiological, psychological, and social benefits of recreational activities (Wolch et al., 2014). Beyond physiological advantages, outdoor recreation has been shown to foster positive psychological effects, such as heightened environmental awareness and opportunities for sociological and spiritual growth (Jenson, 1995). Additionally, studies have highlighted the benefits of high activity levels and active participation for both psychological and biomedical aspects (Longbottom et al., 2010).

Gao et al. (2024) further assert that a harmonious balance between daily life and the environment can serve as a powerful motivator for outdoor recreation. Moreover, natural and green landscapes are recognized as significant contributors to human health and well-being (Stoltz et al., 2024). The correlation between preserving mental well-being and enhancing physical activity has long been acknowledged as beneficial for physiological health (Duvall, 2011; Cai et al., 2022). Various aspects of recreational activities, including challenges, exploration, experiencing nature, rest, and social interactions, have been examined as components of motivation (Graefe et al., 2000). Motivation, in this context, can be understood as an internal force that drives individuals to pursue activities that lead to specific experiences or goals (Whiting et al., 2017).

Recreational quality is a multidimensional concept that largely depends on consumers' subjective perceptions (Dehez and Lyser, 2024). The quality of public spaces or recreational areas plays a crucial role in encouraging outdoor recreation participation (Isa et al., 2022). This quality encompasses factors such as the characteristics of the recreation area, the nature of visitors, social influences, and living conditions that can impact community involvement in outdoor recreation. Additionally, environmental qualities—such as infrastructure, accessibility, safety, congestion, pollution, visual appeal, topography, water sources, and scenic viewpoints—are significant factors contributing to the attractiveness and usability of recreational areas (Frick et al., 2007; Shores et al., 2007).

Numerous studies on outdoor recreation behavior have assessed specific areas and quality aspects, focusing on activities and user segments based on socio-demographic characteristics (Manning, 1999). Typically, the main benefits expected from outdoor recreation include health and well-being (stress

relief), an enhanced and more sustainable environment, aesthetic benefits, and nature-related experiences (Beard & Ragheb, 1983; Jenkins & Pigrams, 2006; Manfredo et al., 1996). However, factors such as safety and companionship during recreation are equally crucial in determining the quality of recreational areas (Manning, 1999; Staats & Hartig, 2004).

For example, older adults may avoid visiting recreational areas due to concerns about safety, accessibility, and a sense of belonging (Crombie et al., 2004; Sugiyama & Ward Thompson, 2005). Similarly, pedestrian recreational users often face conflicts related to environmental factors, such as the threat of wild animals (Arnberger & Haider, 2005; Frick et al., 2007). Families with children, on the other hand, tend to prefer recreational areas equipped with a variety of child-friendly facilities (Frick et al., 2007). Therefore, it is essential to improve outdoor recreation areas based on user preferences, as expressed through demand patterns (Tribe, 2011).

In addition to offering both passive and active recreational activities, recreational areas also serve vital functions in biodiversity conservation, climate change mitigation, and environmental education. They enhance aesthetic value and provide enjoyable outdoor facilities for communities (Li, 2024).

METHODOLOGY

Sampling Technique and Strategy

The study employed a convenience sampling approach with random online distribution of the questionnaire among active recreational users in Ipoh. This method was adopted due to the absence of a comprehensive sampling frame and the exploratory nature of identifying perceived recreation area qualities (Etikan et al., 2016).

The sample size for the focus group was determined using online sample size calculators provided by Calculator.net, Raosoft, and Taro Yamane. Based on a 95% confidence level and a 5% margin of error, the recommended sample size for the study was 384, considering the population size in 2022. All respondents selected for this survey were residents of Ipoh who actively participated in outdoor recreational activities. It is acknowledged that this sampling method limits generalizability beyond the study area; however, the relatively large sample size (n = 384) and demographic diversity mitigate potential bias and support meaningful local-level inference (Bornstein et al., 2013). The respondent selection process aimed to identify the characteristics of recreational areas that influence participant motivation and encourage outdoor recreation.

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DATA COLLECTION

The questionnaire comprised three sections: (i) socio-demographic characteristics, (ii) outdoor recreation participation patterns, and (iii) perceived importance of eight recreation area quality attributes measured using a five-point Likert scale. Items were adapted from established recreation motivation and quality instruments to ensure content validity (Beard & Ragheb, 1983; Frick et al., 2007). Internal consistency was acceptable for exploratory research (Cronbach's $\alpha > 0.70$).

The study employed a quantitative approach to identify the characteristics of recreation sites that influence the factors motivating people to participate in outdoor activities. This approach enabled detailed data processing and validation, providing new insights to enhance understanding of the subject. Additionally, the quantitative method helped clarify and confirm the validity and quality of the data related to specific aspects of the study.

According to Patton (2002), the quantitative approach was chosen because it allowed researchers to explore the topic in greater depth, ask more probing questions, and understand the factors contributing to the high quality of recreational spaces. The study targeted recreational users aged eighteen and above, with potential respondents selected through convenience random sampling to achieve the desired sample size. Data for the study were collected using a "self-administered questionnaire," which included both open-ended and closed-ended questions in Malay and English. Respondents could complete the online questionnaire in either language, ensuring ease of understanding and accessibility (via Google Forms). The analysis was conducted using a subset of the data collected.

The survey focused specifically on eight key attributes of outdoor recreation that motivated people to participate. These attributes included: the safety of the recreational area, accessibility, affordability, attractive landscapes, facilities for family activities, cleanliness and natural environment, and sports amenities (such as cycling and jogging). Each of these attributes has the potential to influence the expectations of potential users, as well as the aspects that are prioritized and deemed most important. User preferences for these attributes were identified through the questionnaire responses.

The findings revealed that the sample of $n = 384$ respondents effectively represented the communities in Ipoh who actively participate in outdoor recreation. The respondents were selected randomly, ensuring a diverse representation of backgrounds and demographics. Of the total respondents, 220 (57.3%) were female, while 164 (42.7%) were male. In terms of age distribution, 193 respondents (50.3%) were between 18 and 30 years old, whereas 4 respondents (1%) were 61 years or older.

Regarding ethnicity, the majority of respondents were Malays (344 participants or 89.6%), followed by 18 Chinese participants (4.7%), 19 Indian participants (4.9%), and 3 Bumiputera participants (0.8%). In terms of educational background, the respondents were generally well-educated, with 158 (41.1%) holding diplomas and 159 (41.4%) possessing degrees or postgraduate certificates.

The demographic diversity of the sample provided meaningful insights into outdoor recreation participation patterns. Socio-demographic characteristics, particularly age, emerged as significant indicators of the frequency of outdoor recreation activities. For instance, younger individuals aged 18 to 40 were found to be more likely to engage in recreational activities. This correlation between socio-demographic factors and outdoor recreation involvement highlights the importance of considering these characteristics in promoting and managing recreational spaces.

FINDINGS & ANALYSIS

Socio-Economic Analysis

Additional descriptive analysis by gender and age group indicates that female respondents placed greater emphasis on safety-related attributes, while younger users prioritized sports facilities and active-use infrastructure. These patterns align with prior outdoor recreation behaviour research (Arnberger & Haider, 2005; Sugiyama & Ward Thompson, 2006).

The findings indicated that n = 384 respondents represented the communities in Ipoh that actively engage in outdoor recreation. Ipoh outdoor recreation consumers are represented in a randomly representative group of respondents with various backgrounds and demographics. 220 (57.3%) of the total were female, and 164 (42.7%) were male. According to the statistics, the age distribution of the study's respondents was as follows: 193 persons (50.3%) were between the ages of 18 and 30, and 4 people (1%) were 61 years of age or older for the two samples of the study region combined. Regarding the study's ethnicity or race, 344 participants or 89.6% were Malays, followed by 18 Chinese participants (4.7%), 19 Indian participants (4.9%), and 3 other participants (Bumiputera) (0.8%). All respondents were viewed as having a high level of education on average; 158 (41.1%) had diplomas, and 159 (41.4%) had degrees and postgraduate certificates. The study's sample yielded nearly equal levels of respondent involvement, yielding a noteworthy result. The greatest indicators of the frequency of outdoor recreation activities are sociodemographic traits, which are also correlated with outdoor recreation involvement. For instance, youths between the ages of 18 and 40 are more likely to engage in recreation activities.

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Quality Selection of Outdoor Recreation Areas
Relative Importance Index (RII) Analysis

Figure 1 presents the Relative Importance Index (RII) ranking of recreation area qualities, highlighting safety, facility provision, and sports amenities as the most influential factors. The Relative Importance Index (RII) is used to determine the quality of recreational areas prioritized by the community. A higher RII value indicates the aspects of recreational quality that respondents consider most important. In this study, the RII was calculated using the following formula:
:

$$RII = \frac{\Sigma W}{(A*N)}$$

'W' is the weight given to each statement by the respondent from 1 to 5,
'A' is the height of the integer response (5), and while
'N' is the number of respondents

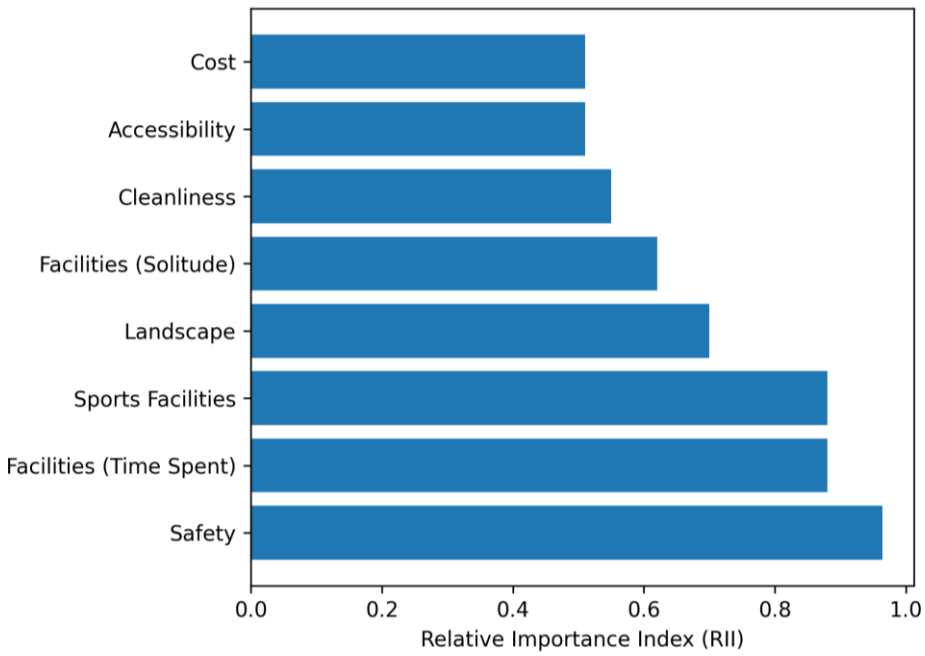


Figure 1: Relative Importance Index (RII) of Recreation Area Qualities

Table 1: Quality Selection of Recreational Areas According to Priority

Qualities	The Quality of Preferred Recreation Areas	RII	Rank
Q1	Easy access to recreation areas	0.51	7
Q2	Inexpensive recreational area	0.51	7
Q3	***Safety in a recreation area***	***0.964***	***1***
Q4	The recreation area has a beautiful landscape	0.7	4
Q5	Recreation area facilities that provide opportunities to spend time	0.88	2
Q6	The availability of facilities provides time to be alone	0.62	5
Q7	The recreation area is clean and fresh	0.55	6
Q8	Availability of facilities for sports activities	0.88	2

Every recreation area possesses its own unique character, identity, and image, shaped by the diversity of landscapes, environmental conditions, recreational resources, and geographical location. These distinct elements provide outdoor recreation users with a wide range of options when selecting a recreation destination, allowing them to choose based on the strengths and appeal of each area. Table 2 above shows the value of the RII score and the position of each selection criterion for outdoor recreation locations.

The results of the analysis have shown that outdoor recreation users agree to make the quality of 'Q3', which is a good level of safety, a primary criterion that is considered for every visit with an RII score value of 0.964. The emphasis on this factor is as a preventive measure to reduce any form of risk accidents as well as protection from any form of threat to physical, social, emotional, psychological, and health. Concerns about safety factors (e.g., criminal threats of sexual harassment, kidnapping) are the most worrying and risky things among female visitors (Johnson et al., 2001). This group is seen as more vulnerable to danger and various threats than males.

For the second criterion, outdoor recreation users make quality 'Q5', 'recreation area facilities that provide opportunities to spend time' and 'Q8', and 'availability of sports facilities', each giving an RII value of 0.88. This factor is also given attention because every recreational area that is conducive and better-planned needs to provide a set of facilities and sports equipment that is complete and safe for various ages. However, the lowest criteria and almost not the community's leading choice are the quality 'Q2', which is 'cheap cost' and the quality 'Q1', which is 'access to recreation area', each contributing to the RII value (0.51).

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Based on the RII value obtained for the two qualities, it can be concluded that all recreation areas have been provided with excellent and comfortable access facilities, making it easier for users to visit the recreation areas. In addition to that, with the ability to own transport facilities and the availability of various types of public transport facilities, the cost of engaging in outdoor recreational activities is still low in addition to the fact that every sports facility provided can be used without any payment except for certain activities such as the rental of courts, fields, etc. In addition, location selection based on low-cost factors is not a significant obstacle for the community. This is because most public recreational areas and parks still provide facilities for free for users, and it is different compared to recreational parks that are themed to a particular concept that gives financial implications (for example, theme parks). This finding can be interpreted positively, as it highlights the importance of people and communities engaging in outdoor recreation on a regular basis in order to develop self-discipline, moral character, and knowledge that will enable them to make the most of their free time and skills for the rest of their lives.

Regression Analysis of Site Selection Quality for Outdoor Recreation Participation

Linear regression analysis is used to assess whether there is an influence, as well as the extent of that influence, between independent variables and a dependent variable, expressed through mathematical equations (Pallant, 2005). Table 2 presents the regression model summary for the quality factors of recreational areas in relation to their impact on the motivation for outdoor recreational involvement. The table shows a positive linear relationship (R = .159a) for the selection of recreational areas.

The criteria for selecting recreational areas account for 2.5% ($R^2 = .025$) of the variance in the dependent variable (motivational factors), while the remaining 97.5% is influenced by other factors affecting outdoor recreational participation. The Adjusted R value reported is .002 or 0.2%, indicating a slight adjustment for the number of predictors in the model. The difference between the R^2 and Adjusted R values is .023 or 2.3%.

Additionally, the Standard Error of the Estimate (SEE) is .500, suggesting that a lower SEE value improves the model's accuracy in predicting the dependent variable. The conclusions drawn from this analysis are based on a significance level of $\alpha = .05$ (5%) or a 95% confidence level.

Table 2: Summary of the Regression Model on Site Selection Quality for Outdoor Recreation

Model Summary			
R	***R Square ($R^{2)}$***	***Adjusted R Square (R^2)***	***Std. Error of the Estimate***
.159[a]	.025	.002	.500

Table 3 presents the results of the ANOVA analysis, indicating a statistical value of .375, which is greater than the predetermined significance level of $p < .05$. These findings suggest that there is no significant statistical difference between the dependent and independent variables. Overall, the results imply that the independent variables do not have a statistically significant impact on the dependent variable in this context.

Table 3: ANOVA Summary for Site Selection Quality in Outdoor Recreation Participation

Model	***Sum of Squares***	***df***	***Mean Square***	***F***	***Sig.***
Regression	2.433	9	.270	1.082	.375[b]
Residual	93.439	374	.250		
Total	95.872	383			

Furthermore, to complete the regression analysis, Table 4 shows that all the criteria for selecting recreational areas yielded statistically non-significant values. In summary, none of the nine independent variables had a statistically significant effect on the motivational factors for outdoor recreational involvement among recreation users.

Table 4: Regression Coefficient Analysis for Site Selection Quality in Outdoor Recreation

Model	***Unstandardized Coeficients***		***Standardized Coeficients***	**t**	**Sig.**
	B	***Std. Error***	**Beta**		
Variables	3.286	.149	-	22.095	.000
Easy access to recreation areas	***-.023***	***.052***	***-.042***	***-.444***	***.657***
Inexpensive recreational area	.085	.051	.156	1.657	.098
Safety in a recreation area	-.005	.061	-.009	-.089	.929
The recreation area has a beautiful landscape	.013	.071	.024	.181	.856

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Model	*Unstandardized Coeficients*		*Standardized Coeficients*	t	Sig.
	B	*Std. Error*	Beta		
Recreation area facilities that provide	.040	.062	.074	.650	.516
Opportunities to spend time	.012	.051	.023	.236	.814
The availability of facilities provides time to be alone	-.074	.061	-.133	-1.201	.231
The recreation area is clean and fresh	-.031	.059	-.058	-.521	.603
Availability of facilities for sports activities	.057	.051	.110	1.114	.266

ETHICAL STATEMENT

This study adhered to ethical research standards. Participation was voluntary, informed consent was obtained prior to data collection, and respondent anonymity and confidentiality were assured throughout the research process.

DISCUSSION

The findings underscore the importance of context-sensitive recreational planning in Malaysian cities, demonstrating that safety and facility provision are central to motivating outdoor recreation participation. These insights provide practical guidance for planners and policymakers seeking to enhance urban liveability and public health outcomes.

Outdoor recreation users engage in outdoor activities primarily to enjoy quality time with their families and derive a sense of enjoyment from these experiences. Many respondents also express a desire to try new things, boost their confidence, and improve their fitness levels, which explains their interest in more strenuous outdoor recreation activities. Additionally, they find pleasure in spending time in natural environments. To cater to these preferences, it is essential to provide opportunities for more extreme forms of outdoor recreation. Recreational activities have also been recognized as significant determinants of quality of life and overall well-being for the aging population (Shuvo et al., 2020).

The study's findings highlight that safety is the most crucial quality factor in recreational areas for enhancing motivation to participate in outdoor activities. Safety is a fundamental aspect of recreational activities, particularly for outdoor recreation, where risks and hazards must be carefully managed. Ensuring safety involves preventing and minimizing incidents and accidents, given the complexity of recreational activities, which encompass people, activities, and

locations. To address safety needs, it is vital to consider the interactions between three components: recreation members, activities, and locations (Cheng et al., 2016). Safety concerns are significant psychological factors that can either encourage or deter involvement in outdoor recreation (Anaza & McDowell, 2013). However, the safety standards of recreational areas in Malaysia remain less than satisfactory.

One effective strategy to enhance safety in recreational areas is Crime Prevention Through Environmental Design (CPTED), a place-based approach that has been proven effective in reducing crime rates and is applicable to land-use planning, including outdoor recreation parks (Iqbal & Ceccato, 2019). CPTED is a scientific approach that emphasizes the practical design of recreational areas to reduce the threat and fear of crime (Mihinjac & Saville, 2019). Leveraging the latest advancements in cognitive and behavioral science, CPTED also focuses heavily on environmental factors, providing insights into how individuals perceive and respond to crime and security threats (Gajos et al., 2016; Gilderbloom, 2016).

Key CPTED strategies relevant to recreational areas include providing adequate and clear lighting systems, minimizing isolated or hidden pathways, reducing isolation for specific activities, ensuring a variety of recreational options, maintaining high standards of management and maintenance, offering comprehensive area information, and enhancing the overall design of the recreation space (Hilborn, 2009; Fenelly & Perry, 2020). The challenge lies in managing each park unit and public space as open areas that serve mutual benefits for all users (Iqbal & Ceccato, 2019).

Overall, the quality factors examined in this study align with the findings of previous research, reinforcing the importance of safety, environmental design, and user satisfaction in promoting outdoor recreation.

CONCLUSION

Overall, the approaches used in this study have effectively explained the reasons behind the community's need to engage in outdoor recreation activities. These approaches are aligned with the theory of psychological motivation, which complements the main scope of the study. Recreational motivation is a crucial concept in understanding recreational involvement. If different individuals respond similarly to the same stimuli, it does not necessarily reflect the concept of motivation. However, when individuals are motivated to participate in outdoor recreation for various reasons, exploring these reasons and their origins becomes essential for understanding recreational behavior and effectively managing leisure time and recreation programs.

Differences in stimulation and recreational behavior offer valuable insights into the levels of achievement and satisfaction experienced by each

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individual. Understanding the goals of outdoor recreation involvement helps clarify the factors that influence participants' sense of achievement and satisfaction. Recreational activities can be compared to a form of 'manufacturing' with a 'product' to market (McClellan & Medrich, 1969), highlighting the significance of understanding these motivations. Therefore, studying outdoor recreation serves as an effort to encourage community involvement in such activities. Additionally, it acts as a platform to empower outdoor recreation participation among the community, keeping pace with technological advancements and development.

ACKNOWLEDGEMENTS

We thank our colleagues from Universiti Teknologi MARA Perak and Selangor Branch who provided insight and expertise that greatly assisted this research.

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Received: 1st January 2025. Accepted: 15th November 2025

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Editor-in-Chief
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Journal of the Malaysian Institute of Planners
B-01-02, Jalan SS7/13B, Aman Seri, Kelana Jaya,
47301, Petaling Jaya, Selangor Darul Ehsan, MALAYSIA
Tel: +603 78770637 Fax: +603 78779636
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ISSN 16756215
9 771675 621005