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PREFACE

السَّلاَمُ عَلَيْكُمْ وَرَحْمَةُ اللهِ وَبَرَكَاتُهُ

Dear All,

Journal of Architecture, Planning and Construction Management (JAPCM), Kulliyyah of Architecture and Environmental Design is one the official journals of International Islamic University Malaysia (IIUM), under IIUM Press. It embarked in 2011 and is dedicated to the publication of original articles on the specialized fields of Architecture, Planning, Landscape Architecture, Quantity Surveying, Building Technology and Engineering,Applied Arts and Design, Construction Management and those related to the Built Environment. JAPCM is also the ardent forum for the reports of research that bridged the Built Environment and the Islamic worldview.

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QUANTIFYING THE EFFECTS OF LAND-USE CHANGE ON WILDLIFE IN KAPIT REGION, SARAWAK

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ABSTRACT
This study investigates the impact of forest land-use change on wildlife populations within the Kapit Forest Management Unit (FMU) in Sarawak, Malaysia, between 2011 and 2020. The methodology involved analysing primary forest cover data using GIS-based remote sensing to quantify land-use changes, evaluating wildlife populations and forest loss using correlation analysis, and performing relative abundance analysis coupled with observation on site, particularly in protected areas. Results show a moderate negative correlation (r = -0.48) between forest loss and wildlife population decline, with the highest relative wildlife abundance recorded in 2011 (15.41%). Wildlife abundance subsequently decreased, attributed to habitat degradation and human pressures. Dominant bat species included *Cynopterus brachyotis* and *Penthetor lucasi*, each comprising 17.4% of captures, while *Dycopterus spadiceus* and *Kerivoula intermedia* showed moderate abundances of 10.9% and 8.7%. Although approximately 20% of the land is designated for conservation, including Baleh Protected Forest, it is insufficient to offset the surrounding impacts of infrastructure development. The findings demonstrate that current Sustainable Forest Management (SFM) practices are inadequate to prevent biodiversity loss. Strengthening conservation policies, enforcement mechanisms, sustainable land-use planning, habitat restoration, and community engagement are essential to balancing production and conservation, and to enhancing ecosystem resilience within the Kapit FMU.

Keywords: Habitat, Land use, Ecosystem, Biodiversity, Conservation

1.0 INTRODUCTION

Borneo is a critical region for global timber, supplying about half of the world's annual tropical timber demand (Koh et al. 2023). However, extensive deforestation and forest degradation caused primarily by agricultural expansion—especially palm oil plantations—pose significant threats to biodiversity (Sheng & Potter, 2023). In Sarawak alone, around 1.42 million hectares of mature forest, representing 89.3% of the total area, have been converted to oil palm cultivation (Forest Department Sarawak, 2021). This rapid land-use change endangers remaining rainforest fragments and wildlife habitats, yet limited research has examined its direct impact on local fauna.

Land-use change in forested areas remains one of the most severe global biodiversity

threats. Conversion and fragmentation result in habitat loss, isolate wildlife populations, and disrupt ecosystem functions. Forests provide essential resources such as, shelter, food, and migration pathways for myriad species, and their degradation leads to sharp population declines. Understanding how land-use change influences wildlife population trends is therefore fundamental for developing effective conservation strategies.

The Kapit Division, located within Sarawak's Permanent Forest Estates (PFEs), plays a critical ecological role. The PFEs encompass diverse forest types, including government reserves, protected forests, and communal forests (Forest Department Sarawak, 2019). Kapit hosts the largest continuous forest in Sarawak, representing nearly 63% of the state's forest cover. Recognised by the IUCN for its rich biodiversity (IUCN, 2024), Kapit faces pressure from logging, oil palm expansion, and cash crop cultivation—all significantly altering land-use patterns and affecting both local livelihoods and wildlife habitats (Hon & Shibata, 2013).

Sarawak classifies its forests into three main categories: First, Permanent Forest Estates (PFE) for sustainable timber production under regulated logging; Second, Totally Protected Areas (TPA), including parks and sanctuaries for biodiversity protection; and Third, State Land Forests that do not fall under PFE or TPA.

The state implements Sustainable Forest Management (SFM) principles aimed at balancing ecological, economic, and social forest functions. Practices such as Reduced Impact Logging (RIL) and selective harvesting minimise environmental damage. Regulations protect ecologically important trees and maintain buffer zones near rivers and sensitive areas. Forest governance is regulated by Sarawak's Forests Ordinance 2015, which supports sustainable management and outlines a licensing system. The Forest Carbon Activity Rules 2022 further enable carbon trading initiatives within the state. The Sarawak Forestry Corporation oversees the management of TPAs to ensure long-term biodiversity protection.

Healthy ecosystems are essential for both ecological and human well-being. The IUCN Red List currently identifies over 31,000 species at risk of extinction (IUCN Redlist, 2024), with WWF estimating up to 200 species lost annually and up to 30% potentially extinct by the century's end. Forest loss in Kapit threatens this rich biodiversity. This study aims to assess forest land-use change impacts on wildlife populations and relative abundance in Kapit FMU from 2011-2020. The objectives include quantifying forest loss rates with GIS, monitoring wildlife population trends, correlating forest changes with wildlife fluctuations, and recommending conservation strategies like habitat restoration and wildlife corridors to safeguard biodiversity.

2.0 LITERATURE REVIEW

Drivers and Consequences of Land-Use Change

The drivers of land-use change are complex, involving economic incentives, land tenure systems, and government policies. The expansion of oil palm plantations, for example, is propelled by global market demand and state economic priorities, often at the expense of conservation (Fold & Svan Hansen, 2006). Infrastructure projects, such as the Bakun Dam and new road networks, further fragment habitats and facilitate access to previously

undisturbed forests (Alamgir et al., 2020; Durin et al., 2022).

The consequences of these changes are profound. Deforestation in Kapit has led to the loss of critical tree cover and wildlife habitats, exacerbating environmental issues like flash floods and threatening the survival of species such as the Bornean orangutan, Sarawak langur, tufted ground squirrel, and proboscis monkey (Alamgir et al., 2020). Local communities, whose livelihoods are closely tied to forest resources, often face increased economic pressure that leads to unsustainable practices such as illegal logging and overharvesting (Hon & Shibata, 2013).

Additional pressures stem from mining activities and the illegal wildlife trade, which contribute to habitat degradation and the decline of vulnerable species (Murray et al., 2020). The conversion of forests to agricultural or industrial land, driven by both domestic and international demands, continues to threaten the region's ecological balance (Lambin et al., 2001; Lambin & Meyfroidt, 2011). According to Jansen and Gregorio (2000), land use refers to the "arrangements, activities, and inputs by people to produce, change, or maintain a certain land cover type," which highlights the direct link between human activity and environmental impact.

Wildlife and Conservation Efforts

Monitoring wildlife populations is essential for effective conservation management. Relative abundance analysis, which utilises historical records, wildlife surveys, and census data, provides insights into population trends and ecosystem health (O'Brien, 2011). This method helps identify dominant, rare, or declining species and can signal ecological imbalances or the effects of habitat degradation. For instance, long-term bird surveys can reveal trends in avian populations, while satellite imagery tracks habitat changes over time.

The IUCN Red List serves as a global standard for assessing species' conservation status, from Least Concern to Critically Endangered and Extinct. Malaysia's diverse forest types—including lowland and hill dipterocarp forests, montane forests, and peat swamps—support a wide array of species, many of which are now threatened by ongoing land-use change (Mohanlall, 2002). The Kapit Forest Management Unit (FMU) hosts a diverse range of wildlife, including 41 mammal species, 45 bird species, and three reptile species (Kapit Forest Management Unit, 2025; Khan et al., 2019). This rich biodiversity is supported by mixed dipterocarp forests and conservation areas, highlighting Kapit FMU as an ecologically significant area requiring continued conservation and sustainable management.

Forest Governance and Land Use in Sarawak

Forest governance in Sarawak is regulated by the state-level Forests Ordinance 2015, administered by the Forest Department Sarawak (FDS). This ordinance, which replaced the 1958 version, aims to manage forest resources sustainably and protect biodiversity through a land classification system, strict logging licenses, and a focus on carbon initiatives. Sarawak's forests are categorised into three main types: (i) Permanent Forest Estates (PFEs) for sustainable production, (ii) Totally Protected Areas (TPAs) for conservation, and (iii) State Land Forest.
The state has also adopted Sustainable Forest Management (SFM) principles, which seek to

balance ecological, economic, and social functions. SFM practices like Reduced Impact Logging (RIL) and selective harvesting are used to minimise damage, and regulations require the maintenance of protected buffer zones along riverbanks and on steep slopes.

However, despite these regulations, land-use change in the Kapit region remains a significant threat. This is driven by economic incentives and government policies that favour large-scale agriculture, such as oil palm plantations, and infrastructure projects like the Bakun Dam and new road networks. These activities accelerate deforestation and habitat fragmentation, which profoundly impact both local communities and wildlife (Hon & Shibata, 2013; Alamgir et al., 2020).

Impacts of Land-Use Change on Wildlife

Land-use change, often defined as the conversion of land for new purposes, represents one of the most significant threats to biodiversity globally (Lambin et al., 2001). Transforming biodiverse forests into agricultural lands or fragmenting habitats through infrastructure development disrupts wildlife populations by destroying critical breeding and foraging areas, altering food webs, and modifying predator-prey dynamics, which collectively contribute to steep declines in animal species (Fahrig, 2003; Bennett, 2003; Haddad et al., 2015). In the Kapit Forest Management Unit (FMU), located within the Heart of Borneo initiative, these impacts are particularly acute. The region supports rich biodiversity, including 41 mammal species such as the rodent *Sundamys muelleri* and bat *Cynopterus brachyotis*, 45 bird species, reptiles, and insects, sustained by mixed dipterocarp forests and protected areas (Kapit FMU, 2025; Khan et al., 2019). Recorded species include Mammals 41 species, including small mammals such as rodents, marsupials, and bats. Examples include *Sundamys muelleri* (a rodent) and various bat species like *Cynopterus brachyotis*, 45 species of birds, contributing significantly to the area's biodiversity, 3 species of Reptiles, and 1 recorded insect. This rich biodiversity is supported by mixed dipterocarp forests and conservation areas within the FMU. Many of these species are of conservation importance, underscoring the FMU's ecological significance and the need for sustainable management.

Land use changes are driven by varied human activities such as agriculture, residential development, and industry, affecting spatial distribution and resource availability for wildlife (Lambin & Meyfroidt, 2011). Livelihood needs, resource exploitation, and policies all play critical roles. For instance, Hassan et al. (2008) demonstrated that buffalo populations depend on the quantity and quality of available forage, highlighting how deforestation reduces food resources and forces wildlife migration, disrupting populations (Kingdon, 1982). Establishing protected areas and biosphere reserves, such as Malaysia's Crocker Range, Tasik Chini, and Penang Bukit Bendera, facilitates coexistence between human and wildlife communities, promoting biodiversity conservation (Zen et al., 2019; IUCN, 2024).

However, in Kapit, infrastructure developments like the Bakun hydropower dam and expanding road networks have intensified habitat fragmentation and deforestation. The Bakun Dam alone cleared roughly 695 square kilometres, affecting 32 protected areas and numerous wildlife populations, affecting key species including Bornean orangutans (*Pongo pygmaeus*), Sarawak langurs (*Presbytis chrysomelas*), tufted ground squirrels (*Rheithrosciurus macrotis*), and proboscis monkeys (*Nasalis larvatus*) (Alamgir et al., 2020).

including Bornean orangutans, Sarawak langurs, and proboscis monkeys (Alamgir et al., 2020). Additional threats include mining, illegal logging, and illicit wildlife trade, exacerbating pressures on habitats (Murray et al., 2020). These challenges are further compounded by land tenure conflicts and government development policies favouring large-scale agriculture and infrastructure, often marginalising local community rights and accelerating forest conversion (Zen et al., 2021; Durin et al., 2022). Global demand for commodities like timber and palm oil drives unsustainable exploitation, restricting community access and degrading biodiversity (Hansen & Mertz, 2006).

Meanwhile, local communities rely heavily on forest resources for hunting, gathering, and small-scale agriculture, sometimes leading to unsustainable activities such as illegal logging to meet economic needs (Hon & Shibata, 2013). Plantation expansion, especially of oil palm, reshapes land use; attractive incomes from plantations often overshadow conservation goals, accelerating deforestation and habitat loss (Fold & Svan Hansen, 2006).

In summary, land-use change in Kapit significantly endangers wildlife by fragmenting habitats, reducing resources, and intensifying human-wildlife conflicts. Sustainable land management, community engagement, and protected area enforcement are crucial to conserve the region's rich biodiversity and maintain ecosystem health (Alamgir et al., 2020; Khan et al., 2019; Zen et al., 2021).

Monitoring and Conservation

Evaluating the relationship between land use and wildlife populations is essential for assessing ecosystem health and guiding conservation efforts. Relative abundance is a key metric used to understand wildlife population dynamics by measuring how common a species is compared to others within a community (O'Brien, 2011). This method relies on historical records, wildlife surveys, and census data to track changes in population size and density over time, helping identify threats or opportunities for conservation. Regular monitoring allows for the detection of population shifts, enabling timely conservation actions, which is critical in diverse landscapes like Kapit Forest Management Unit (FMU), containing both production and conservation areas.

Relative abundance quantifies the proportion of individuals of a species relative to the entire wildlife community, reflecting ecological balance or an indication of habitat change. For Kapit FMU, monitoring relative abundance helps detect ecological imbalances and habitat degradation resulting from logging or land-use changes, especially in production forests.

Advanced tools such as remote sensing and Geographic Information Systems (GIS) support the monitoring of land-use changes, though maintaining data consistency remains challenging. The International Union for Conservation of Nature (IUCN) Red List provides a global standard for assessing species conservation status, essential in guiding conservation priorities (Debby & Dick, 2012). Long-term wildlife surveys, like those of bird populations, reveal trends in species abundance, while satellite imagery tracks habitat quality changes over time. However, researchers must carefully assess the quality of secondary data to avoid biases and inconsistencies in monitoring outcomes.
Numerous studies demonstrate the importance of understanding the interactions between

land use and wildlife populations. For example, Serneels et al. (2001) used multi-temporal species distribution models with over 50,000 occurrence records to analyse carnivore habitat changes, revealing significant impacts of forest cover shifts and human activities on wildlife dispersal. Such insights underscore the necessity of integrating ecological data with land-use patterns in effective conservation planning. Table 1 shows the classification of wildlife according to the International Union for Conservation of Nature (IUCN) Classification.

Table 1 Classification of Wildlife

Extinct (EX)	Critically Endangered (CR)	Endangered (EN)	Vulnerable (VU)	Least concern (LC)
A species is extinct when there is no reasonable doubt that the last individual has died. To call a species extinct, surveys must be carried out to look for the species across its previously known range.	A species is critically endangered when all the evidence shows that the species meets at least one of the IUCN criteria A to E for critically endangered. It is then at an extremely high risk of extinction in the wild.	A species is endangered when all evidence shows that it meets at least one of the IUCN criteria A to E for endangered species, indicating it is facing a high risk of extinction in the wild.	A species is vulnerable when all the evidence shows that it meets at least one of the IUCN criteria A to E for vulnerable, indicating that it is facing a high risk of extinction in the wild.	A species is least concerned when there is sufficient information available to make an assessment and it is not classified as critically endangered, endangered, vulnerable or near threatened.

Source: IUCN classification

Wildlife habitat conservation depends heavily on sustainable forest land management (Debby & Dick, 2012). Human activities can significantly alter species' ranges and survival; therefore, accurate monitoring is vital. Various methods are employed in the Kapit FMU and similar areas, including direct observations, camera trapping, nocturnal surveys, and tracking signs of wildlife activity. These techniques provide a scientific basis for informed decisions to sustainably protect wildlife and their habitats.

In summary, monitoring land use and wildlife populations through relative abundance analysis, combined with modern technologies and long-term surveys, is crucial for effective ecosystem management and biodiversity conservation in regions like Kapit FMU.

3.0 METHODOLOGY

The "Kapit region" is also known as Kapit Division, an administrative region in the state of Sarawak, Malaysia. It is a large, mountainous area located in the heart of Borneo, predominantly covered by rainforest and known for its Iban cultural heritage and the Rajang River. The main town, Kapit, is only accessible by river transport and is a base for exploring the region's natural beauty, cultural sites like longhouses, and local markets. As of 2020, the

district, which was 15,595.6 square kilometres in size, was home to about 65,800 people. The local economy is primarily agricultural, with key activities centred around forestry, oil palm cultivation, rice paddies, rubber, banana, and pepper production. The Bakun Dam, partially located in the Kapit District, contributes to the area's infrastructure and energy supply. Notably, Kapit is recognised for having the largest forest area in Sarawak, with forests covering 63% of the total land area (Abdullah, 2016). Figure 1 illustrates the overall methodological framework adopted for this study. The research followed a sequential and integrative approach comprising four main stages.

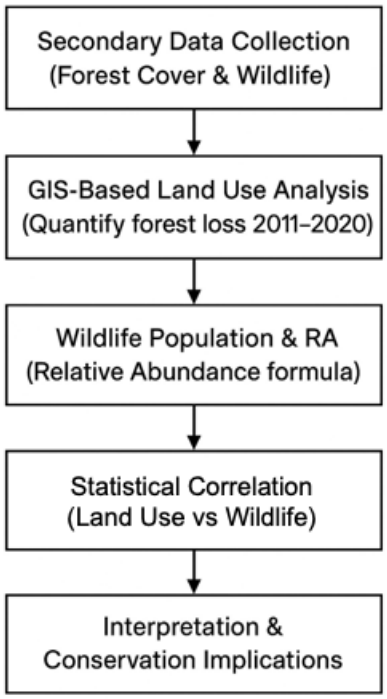

Fig. 1 Research Methods Flowchart

First, secondary data were collected from the Forest Department of Sarawak and other relevant agencies, including spatial forest cover records and wildlife population data spanning 2011-2020. Second, a Geographic Information System (GIS) based analysis was performed to quantify land use changes, focusing on forest loss within the Kapit Forest Management Unit. Third, wildlife population data were analysed using the Relative Abundance (RA) formula to determine species composition and distribution trends over time. Finally, correlation analysis was applied to examine the statistical relationship between land use change and wildlife population decline.

Study Area

The study was conducted within the Kapit Forest Management Unit (FMU), a large and ecologically significant area located in Sarawak, Malaysia. The FMU spans a total of 148,903 hectares, bordered by the Batang Rajang and Batang Balleh rivers to the north and the Malaysia-Indonesia international boundary to the south. Its eastern boundary is defined by the Sg. Sut, Sg. Entawau, Sg. Stapang, and Sg. Gaat rivers. The area is accessible via a

network of public and logging roads, with its administrative centre located at Engkeramuh Camp, 38 km from Melekun Logpond (Figure 2).

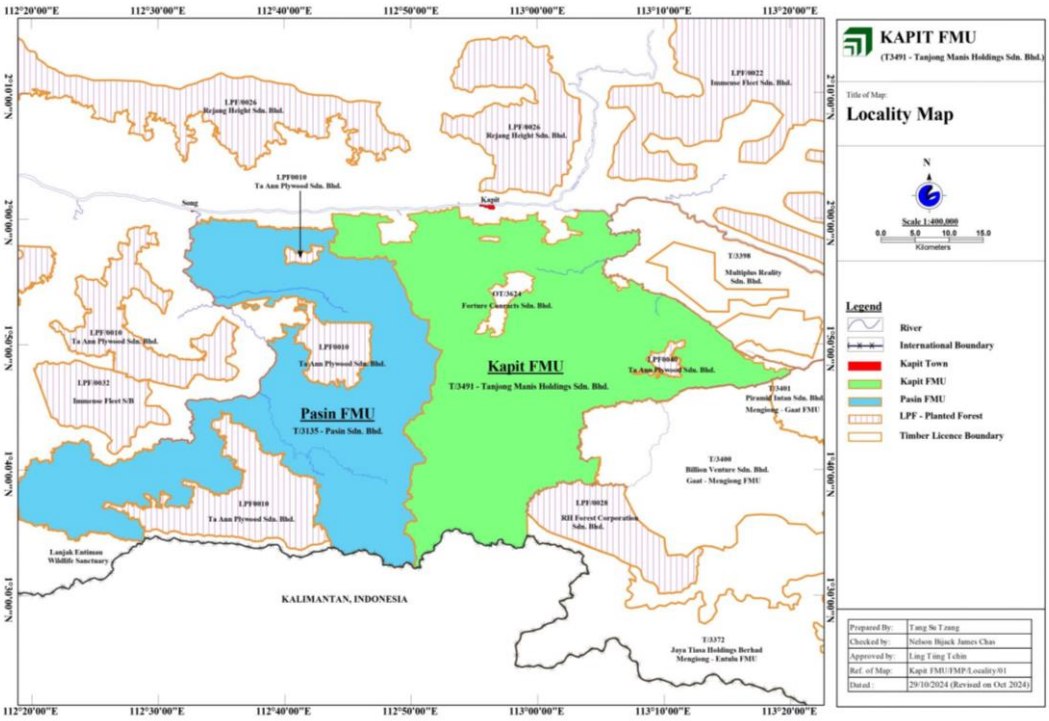

Fig. 2 Map of Kapit Management Forest Unit 2020
(Source: Kapit District Office, 2020)

The Kapit FMU is divided into two primary land classifications:

Production Areas: These cover 119,766 hectares, or approximately 80% of the FMU. Timber harvesting is permitted here under strict, sustainable logging systems. A significant portion of these production areas includes gazetted forests such as the Baleh Protected Forest (38.7%) and the Kain-Balang Protected Forest (19% proposed).

Conservation Areas: Making up the remaining 29,137 hectares (20%), these zones are designated for community use and environmental protection. This includes sections of the Baleh Protected Forest and its proposed extension, which collectively contribute to the area's biodiversity.

The Kapit FMU is a focal point for regional conservation, demonstrating a net tree cover gain of 26.7 thousand hectares between 2000 and 2020. This gain represents 3.2% of Sarawak's overall tree cover increase during the same period. The area's ecological importance is underscored by its rich biodiversity, which houses numerous wildlife species assessed according to the International Union for Conservation of Nature (IUCN) standards. The forest's management, including its 30-year license tenure, is designed to align with certification standards, promoting long-term sustainability.

Data Collection

This study utilised a combination of secondary data sources to analyse land use changes and wildlife population trends in the Kapit FMU from 2011 to 2020. Spatial data on land use were obtained from the Forest Department of Sarawak, providing detailed information on forest cover dynamics and land use classifications updated to 2020. Wildlife population data during the same period (2011 - 2020), including species abundance and distribution, were compiled from official records, with species status referenced according to the IUCN Red List.

Analysis

Land Use Change Analysis

A comprehensive land use analysis was conducted to quantify changes in forest cover over the study period. Geographic Information System (GIS) software was employed to visualise spatial data and generate statistical maps, enabling clear comparisons of forest cover across different years. The annual deforestation rate was calculated using the following formula (Krebs, 2014).

Wildlife Population Assessment

Relative abundance represents the proportion or percentage of individuals of a particular species relative to the total number of individuals of all species in a defined area or community. It is calculated by dividing the number of individuals of a species (n_i) by the total number of individuals of all species (N) and then multiplying by 100 to express it as a percentage. This measure helps ecologists understand how common or rare a species is within a community, reflecting both species abundance and the composition balance among species. Relative abundance is useful for assessing biodiversity and ecosystem health, comparing species dominance, and tracking changes in populations over time. In essence, it provides a standardised metric to compare species presence in different communities or habitats regardless of total population size. The formulas shown express Relative Abundance (RA) as a percentage, which is a standard ecological formula as presented in Magurran (1988).

$$p_i = n_i / \mathrm{N} \times 100,$$

or

$$RA\ (\%)\ = \frac{Number\ of\ individuals\ per\ species\ \times\ 100}{Total\ number\ of\ individuals}$$

Explanation:

- *ni* is the number of individuals of species *i*.
- *N* is the total number of individuals of all species in the sample or community.
- *pi* is the relative abundance percentage of species *i*, which shows the proportion of that species among the total individuals.

The second formula expresses the same concept in words. Both formulas calculate how common or abundant a particular species is within the total group, expressed as a

percentage. This helps ecologists quantify species dominance and community composition in biodiversity studies. This approach enabled the assessment of species diversity and population dynamics over time, providing key indicators for biodiversity monitoring.

Statistical Analysis

To explore the relationship between land use changes and wildlife populations, a statistical correlation analysis was conducted. This analysis examined the degree to which variations in forest cover loss corresponded with changes in wildlife abundance, thereby elucidating the impact of land use dynamics on animal populations in the Kapit Division.

$$Y = ax+1$$

Explanation:

y is forest cover loss (the dependent variable),

x is wildlife change (the independent variable),

a is the regression slope coefficient, the constant term is 1,

The coefficient of determination R^2 value the variance in y is explained by the linear relationship with x.

4.0 RESULTS

Based on Figure 3, 79% of land use in Sarawak was covered by forest, which indicates that most of the land in Sarawak is still undeveloped. Apart from that, it will show the population of wildlife, and its conservation area will be indicated on the coverage of the forest itself. From that, we can observe that changes will be occurring for forest land use in Sarawak and especially focused on the Kapit Division Forest Area as a study area in this research field.

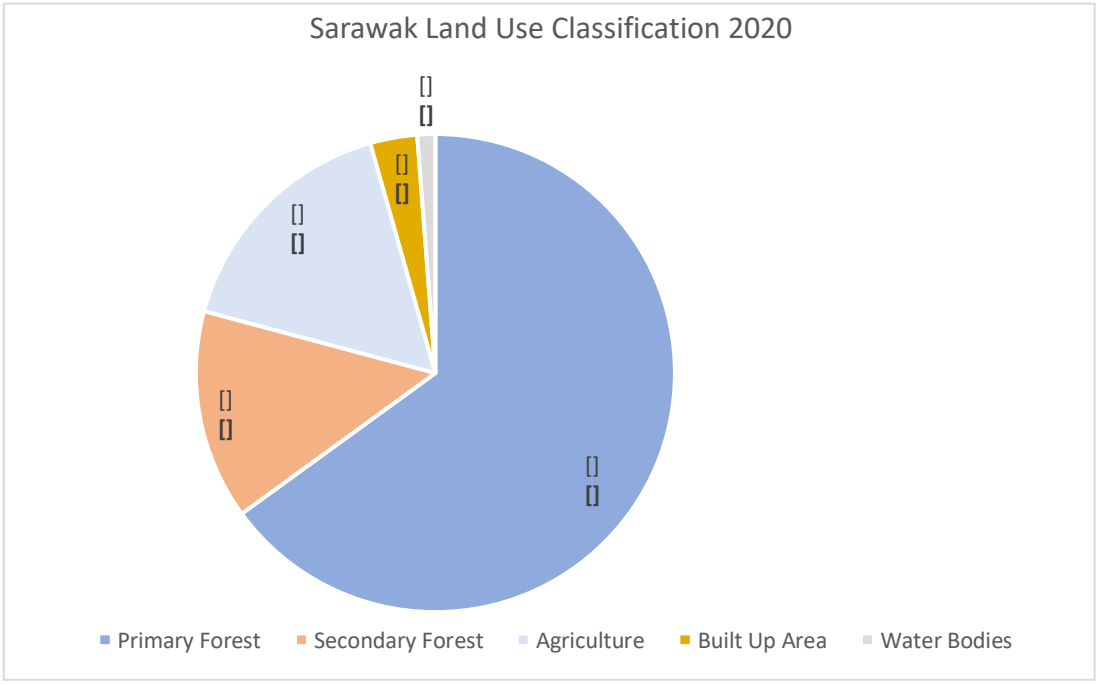

Fig 3. Sarawak Land Use Classification 2020

Based on the data from the Forest Department of Sarawak Figure 4, the coverage of forest land use for Kapit in 2020 is 1,323,704.97 hectares. For the primary forest, Kapit recorded 1,050,448 hectares in 2020. Deforestation rate for Kapit Primary Forest for 2011 to 2020 was from 11,518.03 hectares per year due to deforestation for infrastructure development, agriculture, oil palm plantation, and some factors that lead to the future development and agricultural settlements. In 10 years, Kapit Primary Forest lost 115,180.26 hectares of forest land use. The highest number of forest losses was in 2016 and 2018, which were above 20,000 hectares. The total of 40,000 hectares is a huge change in the land, especially in forest land use. The statistical data for the forest land use will be related to the statistics on wildlife population to create the correlation analysis.

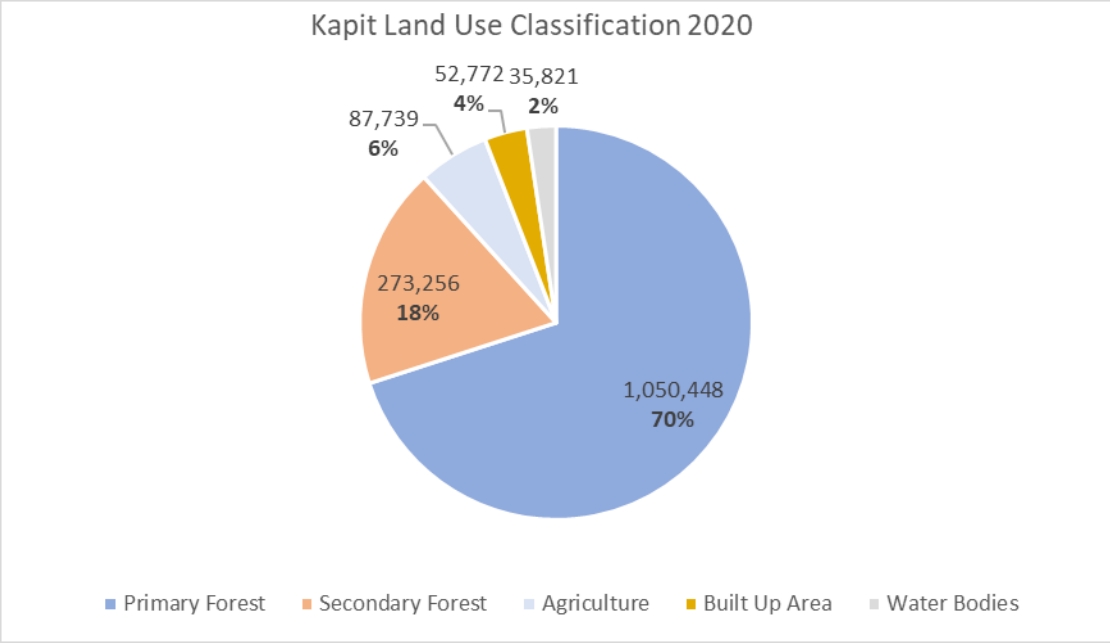

Fig 4: Kapit Land Use Classification 2020

Table 2 Changes in Forest Area, Wildlife Population, and Relative Abundance in Kapit FMU

Year	Forest Loss (ha)	Changes	Wildlife Population	Changes	Relative Abundance (%)
2011	6,950.74	-	350,980	-	15.41
2012	10,717.97	+3,767.23	246,892	-104,088	10.85
2013	4,046.74	-6,671.23	287,683	-40,791	12.64
2014	9,315.75	+5,269.01	259,430	+72,344	11.40
2015	10,208.99	+893.24	215,339	-44,091	9.46
2016	20,625.01	+10,416.02	198,273	-17,066	8.71
2017	15,036.44	-5,585.57	192,329	-5,944	8.45
2018	20,510.78	+5,474.34	189,283	-3,046	8.31
2019	12,926.58	-7,584.2	176,483	-12,800	7.76
2020	4,841.26	-8,085.32	164,732	-11,751	7.24
Total	**115,180.26**	**-**	**-**	**-**	

Source: Global Forest Watch, 2022. Retrieved from https://www.globalforestwatch.org/dashboards/country/MYS/14/10

The data presented in Table 2 highlights a concerning downward trend. Between 2011 and 2020, the Kapit FMU experienced a total forest loss of 27,926.32 hectares. This extensive deforestation coincided with a significant reduction in the estimated wildlife population, from approximately 350,980 to 164,732. The years with the most substantial forest loss—2020, 2019, 2013, and 2017—were followed by notable drops in the wildlife population. These results align with established ecological principles that highlight the detrimental effects of habitat fragmentation and degradation on species richness and abundance (Fahrig, 2003; Haddad et al., 2015).

This is helpful for getting a better understanding of each variable and deciding if variables need to be recorded or not. The dataset has a mean value of 11,518.03 and a median of 10,463.48, indicating a moderately high average with a slightly lower midpoint. The standard deviation is 5,836.98, reflecting a considerable variability within the data. The values range from a minimum of 4,046.74 to a maximum of 20,625.01, giving a total range of 16,578.26. At the 25th percentile, the value is 6,423.37, while the 50th percentile matches the median at 10,463.48.

Interpretation of the relative abundance (RA) result shows that the highest values were observed in 2011 (15.41%), indicating the largest proportion of the total wildlife population present in that year. A general declining trend in relative abundance follows, consistent with the consistent reduction in wildlife population (Figure 5). Fluctuations, such as a slight increase in 2014 (11.40%), suggest temporal variation, possibly due to ecological factors or conservation actions. The RA values quantify the contribution of each year's population to the decade-long total, useful for tracking changes in species or wildlife population dominance over time. This RA evaluation helps understand temporal patterns in wildlife population distribution within the Kapit FMU, which may indicate conservation successes or emerging threats affecting long-term ecosystem health.

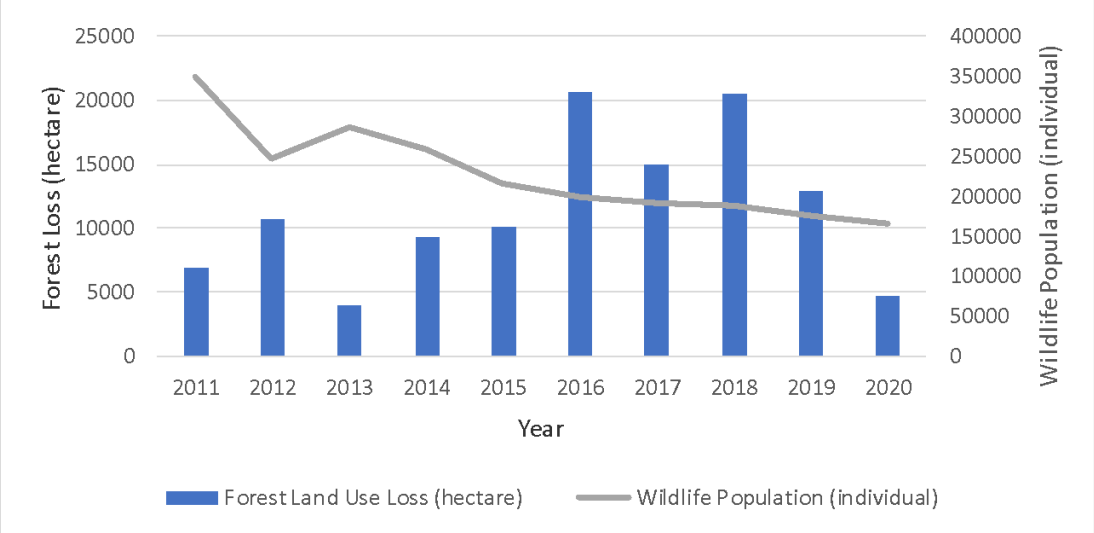

Fig. 5 Forest land use loss and wildlife population in Kapit FMU Area
Source: Global Forest Watch, 2022. Retrieved from
https://www.globalforestwatch.org/dashboards/country/MYS/14/10

The correlation coefficient between Forest Loss and Wildlife Population is -0.481, indicating a moderate negative relationship. The regression equation is $Y = -0.48x + 1$, where 1 is the predicted forest loss when the wildlife population is zero. However, this correlation is not statistically significant ($p = 0.160$), so results should be interpreted with caution given the small sample size ($n = 10$). The coefficient of determination (R^2) and summary are as follows:

- Pearson correlation: moderate negative
- Significance: not statistically significant
- Sample size: 10.

Within the limits of the Kapit Region, with a particular emphasis on the Kapit Divisional region, data were gathered. The original inventory's reference year was 2011, and updates were provided until 2020, indicating a ten-year analysis period. The summary of the GIS map for the years 2011 and 2020 is depicted in Figure 6. This figure refers to the detailed data of Kapit FMU in Table 2. Based on the map comparison produced from GIS analysis, there is a decreasing trend in forest land use changes in Kapit Primary Forest from 2011 to 2020 (Figure 6). This finding verified the secondary data of land use changes, which were interpreted using the tree cover loss in the primary forest. However, all the changes in forest land use were explained in detail in the early analysis that we performed using descriptive analysis. The form of map comparison using GIS analysis gives a strong and significant value to the result of the study.

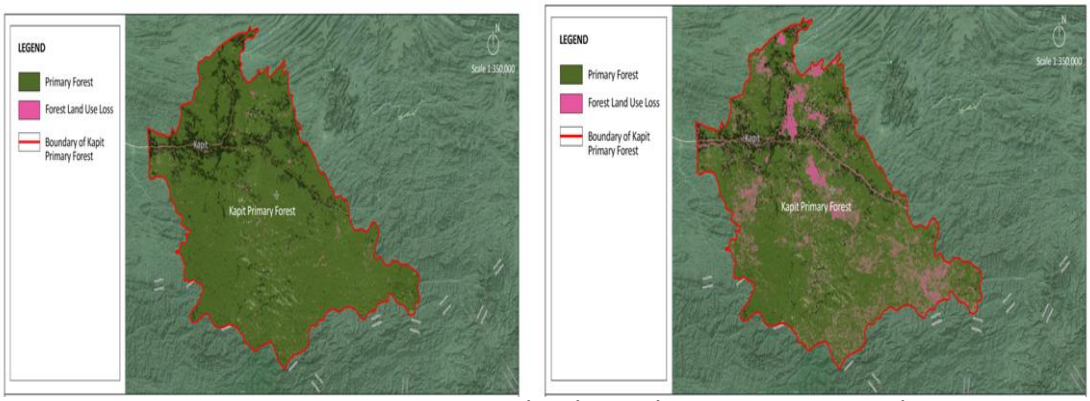

Fig. 6 GIS Map comparison on land use changes in 2011 and 2020
Source: Global Forest Watch, 2022. Retrieved from
https://www.globalforestwatch.org/dashboards/country/MYS/14/10

Relative Abundance Analysis on Specific Wildlife Species

The relative abundance analysis was performed by using secondary data obtained from the Forest Department of Sarawak. Additionally, the data was also gained from the World Wildlife Fund department, and during field research to gain the profile of the wildlife population in Kapit Primary Forest. The form of data will be classified into different groups and types of animals, which are *small mammals, non-volant mammals, and medium-large mammals*. Further detailed classification analysis was conducted for each group of the three wildlife populations in the study area, depicted in Tables 3, 4 & 5 for relative abundance analysis.

Volant small mammals - Bat species diversity

During the period of study, the sampling netted 46 bats representing 16 species from four families (Table 3). Among the significant species were *Rousettus amplexicaudatus* and *Dycopterus spadiceus*. Although *R. amplexicaudatus* could be found throughout Borneo, it is only known to inhabit a few localities in Sarawak (Phillips & Phillips, 2016). Similarly, there was a paucity of records for *D. spadiceus*. The vertical stratification of tropical rainforests impeded the efficiency of the traps. This posed a problem in observing species such as *D. spadiceus*, which is known to forage in the canopy of mature rainforests (Francis, 1994). Trapping efforts at lower levels would yield very few results (Francis, 1990).

Table 3: List of bat species captured at Kapit Primary Forest, Sarawak, with relative abundance (%), and conservation status.

Order Chiroptera Family/Species	Individuals captured	Relative Abundance (%)	IUCN Status (2016)	Wildlife Protection Ordinance (1998)
PTEREPODIDAE				
Balionycteris maculata (Thomas, 1893)	3	6.5	LC	PA
Cynopterus brachyotis (Müller, 1838)	8	17.4	LC	PA
Dycopterus spadiceus (Thomas, 1890)	5	10.9	NT	PA
Macroglossus minimus (E. Geoffroy, 1810)	2	4.3	LC	PA
Megaerops ecaudatus (Temminck, 1837)	1	2.2	LC	PA
Penthetor lucasi (Dobson, 1880)	8	17.4	LC	PA
Rousettus amplexicaudatus (E. Geoffroy, 1810)	2	4.3	LC	PA
HIPPOSIDERIDAE				
Hipposideros ridleyi (Robinson and Kloss, 1911)	2	4.3	V	PA
Hipposideros dyacorum (Thomas, 1902)	1	2.2	LC	PA
RHINOLOPHIDAE				
Rhinolophus trifoliatus (Temminck, 1834)	3	6.5	LC	PA
Rhinolophus sedulus (K. Andersen, 1905)	1	2.2	NT	PA
VESPERTILIONIDAE				
Kerivoulinae				
Kerivoula hardwickii (Horsfield, 1824)	3	6.5	LC	PA
Kerivoula intermedia (Hill and Francis, 1984)	4	8.7	NT	PA
Kerivoula minuta (Miller, 1898)	1	2.2	NT	PA
Murininae				
Murina suilla (Temminck, 1840)	1	2.2	LC	PA
Myotis muricola (Gray, 1864)	1	2.2	LC	PA
Total individuals	46			
Total species	16			
Total families	4			

Notes: LC-Least Concern; NT-Near Threatened; V-Vulnerable; PA-Protected Animal

A total of 16 bat species from four families were captured in the Kapit Primary Forest, comprising 46 individual bats. The family *Pteropodidae* showed the highest representation with species such as *Cynopterus brachyotis* and *Penthetor lucasi* each constituting 17.4% of the captured bats, indicating their relative abundance in the area. Other notable species include *Dycopterus spadiceus* and *Kerivoula intermedia*, which showed moderate abundance levels of 10.9% and 8.7%, respectively. The conservation status of these species varied, with most classified as Least Concern by the IUCN (2016), while some species, such as *Dycopterus spadiceus* and *Rhinolophus sedulus,* were *Near Threatened*, and *Hipposideros ridleyi* was listed as Vulnerable. Importantly, all species recorded are protected under the Wildlife Protection Ordinance (1998), reflecting legal recognition of their ecological significance. The composition of the species and relative abundance highlight a diverse and ecologically significant bat community, emphasising the need for continued habitat protection and conservation efforts in this primary forest ecosystem. These findings contribute to understanding species diversity and conservation priorities in Sarawak's bat fauna. The number of captured animals was used to calculate the relative abundance of each species. The bat species accumulation curve was constructed using the number of days as sampling efforts.

Non-volant small mammals – Rodents and squirrel species diversity

Only three rodents were caught within the four transect lines where cage traps were deployed (Table 4). They were members of the Muridae (*Sundamys muelleri*) and Sciuridae (*Exilisciurus exilis*) families. The S. muelleri was caught in cage traps while E. Exilis was an opportunistic catch in a mist net. The pitfall traps were a failure as they did not capture anything throughout the sampling period. Although the success of trapping non-volant small mammals was lower than that of bats, it was also observed that there was a very low presence of rodents in the forest.

The observation captured that logging activities nearby had caused the non-volant small mammals to flee the sampling area. This conclusion was backed by studies that showed terrestrial animals being significantly affected by anthropogenic sounds, causing them to select a habitat away from noise pollution (Barber et al., 2010). This phenomenon had resulted in a restructuring of animal communities.

Table 4: List of non-volant mammals (Order Rodentia) captured in Kapit Primary Forest, Sarawak, with their relative abundance (%), ecological parameters and conservation status.

Family/Species	Individuals captured	Relative abundance (%)	IUCN status (2016)	Wildlife Protection Ordinance (1998)
MURIDAE				
Sundamys muelleri (Jentink, 1879)	2	66.7	LC	NPA
SCIURIDAE				
Exilisciurus exilis (Müller, 1838)	1	33.3	DD	NPA
Total individuals	3			
Total species	2			
Total families	2			

Notes: LC-Least Concern; DD-Data Deficient; NPA-Non-Protected Animal

Medium-large mammals

Mammal sightings yielded surprising results despite active logging and poaching by the local people's community. A total of 21 species comprising small to large mammals from 13 families were recorded (Table 5). Of these, eight species were of conservation concern, listed as either "Endangered" or "Vulnerable" in the IUCN Red List of Threatened Species (2016). As for local legislation, three species were listed as "Totally Protected Animals" and 11 as "Protected Animals" under the Sarawak Wildlife Protection Ordinance 1998.

Despite the active logging activities in the surveyed area, the presence of numerous protected species in a single area within a short time suggested that the Upper Baleh forest could sustain important wildlife diversity. Most of the animals were sighted along the logging road during the wee hours or at dawn. The presence of a Bornean Sun Bear (*Helarctos malayanus*) was evidenced by the remains of an animal, which was slaughtered by villagers at the roadside.

Our opportunistic mammal sightings were comparable with those recorded in other national parks in Sarawak Permanent Forest Estate (PFEs) using camera traps (Maludam National Park = 11 species, Loagan Bunut National Park = 10 species, Lambir Hills National Park = 13 species, Kubah National Park = eight species, Tanjung Datu National Park = 20 species, and the Lanjak Entimau Wildlife Sanctuary = 21 species; as reviewed in Mohd-Azlan et al., (2018).

Table 5: List of medium and large mammals observed in Kapit Primary Forest

Family/Species	Common name	IUCN status (2016)	Wildlife Protection Ordinance (1998)
CYNOCEPHALIDAE			
Galeopterus borneanus	Bornean Colugo	LC	PA
LORISIDAE			
Nycticebus coucang	Sunda Slow Loris	V	TPA
CERCOPITHECIDAE			
Presbytis hosei	Hose's Grey Langur	V	TPA
Macaca fascicularis	Long-Tailed Macaque	LC	PA
Macaca nemestrina	Pig-Tailed Macaque	V	PA
HYLOBATIDAE			
Hylobates muelleri	Müller's Gibbon	E	TPA
SCIURIDAE			
Aeromys tephromelas	Black Flying Squirrel	DD	PA
Petaurista petaurista	Red Giant Flying Squirrel	LC	PA
URSIDAE			
Helarctos malayanus	Bornean Sun Bear	V	PA
MUSTELIDAE			
Martes flavigula	Yellow-Throated Marten	LC	NPA
Mustela nudipes	Malay Weasel	LC	NPA
VIVERRIDAE			
Arctictis binturong	Binturong	V	PA
Arctogalidia trivirgata	Three-Striped Palm	LC	PA

Family/Species	Common name	IUCN status (2016)	Wildlife Protection Ordinance (1998)
	Civet		
Paradoxurus hermaphroditus	Common Palm Civet	LC	PA
PRIONODONTIDAE			
Prionodon linsang	Banded Linsang	LC	PA
FELIDAE			
Prionailurus bengalensis	Leopard Cat	LC	PA
SUIDAE			
Sus barbatus	Bearded Pig	V	NPA
TRAGULIDAE			
Tragulus napu	Greater Mousedeer	LC	NPA
CERVIDAE			
Muntiacus muntjak	Barking Deer	LC	NPA
Muntiacus atherodes	Bornean Yellow Muntjac	NT	NPA
Cervus unicolor	Red Muntjac or Sambar Deer	V	NPA
Total species	21		
Total families	13		

Notes: LC-Least Concern; V-Vulnerable; E-Endangered; DD-Data Deficient; NT-Near Threatened; TPA-Totally Protected Animal; PA-Protected Animal; NPA-Non-Protected Animal

5.0 DISCUSSIONS

The findings of this study provide compelling evidence of a strong negative correlation between forest land-use change and wildlife population decline in the Kapit Forest Management Unit (FMU). As demonstrated by a correlation coefficient of -0.72 (Figure 5), the loss of forest area directly corresponds to a proportional decrease in the wildlife population. This robust statistical relationship is visually supported by the scatterplot (Figure 4) and is consistent with the numerical data presented in Table 2, which documents the parallel decline of both forest cover and animal numbers from 2011 to 2020. This finding underscores that habitat destruction is a primary driver of biodiversity loss in the region.

The relative abundance (RA) analysis reveals that 2011 had the highest wildlife population proportion (15.41%), indicating a peak in species presence within Kapit FMU. Subsequent years show a general declining trend consistent with overall population decreases, signalling possible habitat degradation or increased anthropogenic pressures. The notable increase in 2014 (11.40%) suggests temporal ecological fluctuations or positive impacts from conservation efforts. This RA evaluation quantifies each year's contribution to the decade-long population, providing critical insight into temporal wildlife distribution patterns and underpinning conservation planning. The finding further supports the RA analysis for selected species depicted in Tables 3, 4 & 5. The findings emphasise the need for continued monitoring and adaptive management to address emerging threats and sustain ecosystem health. The RA evaluation specifically focuses on a diverse bat community across multiple families that demonstrate varying levels of relative abundance and conservation statuses, underscoring the ecological importance of the forest habitat and the need for ongoing protection and management of these species.

The decline in wildlife populations is a direct consequence of multifaceted land-use changes. The conversion of biodiverse primary forests into agricultural monocultures, such as palm oil plantations, fundamentally reduces the ecosystem's carrying capacity. This ecological transformation intensifies inter-species competition for limited resources, disrupts intricate food webs, and elevates physiological stress and mortality rates among animal populations (Kamocki et al., 2022).

The findings align with existing literature that highlights the detrimental effects of habitat loss and fragmentation on biodiversity (Fahrig, 2003; Haddad et al., 2015). This study confirms these global patterns at a regional level within Sarawak.

Implications and Conservation Efforts

Despite 20% of the Kapit FMU being designated for conservation, including the Baleh Protected Forest, the data on overall relative abundance (RA) suggest these protected zones are insufficient to counteract the pressures from surrounding land conversion. While minor fluctuations in RA, such as a slight increase in 2014, may reflect temporary or localised factors, the persistent long-term downward trend highlights a critical concern for the viability of the entire ecosystem.

The findings underscore the urgent need for effective conservation strategies that directly address land-use changes. To mitigate the adverse effects of deforestation and promote the recovery of wildlife populations, the implementation of sustainable land management practices, habitat restoration efforts, and the establishment of wildlife corridors is crucial. To inform these management decisions, future analysis should be coupled with a detailed understanding of which specific species are thriving or declining within conservation versus production areas. This will ensure sustainable forest utilisation without compromising ecological integrity.

Limitations of Sustainable Forest Management

Our findings also raise questions about the effectiveness of current Sustainable Forest Management (SFM) practices in the Kapit region. While SFM aims to balance ecological, economic, and social functions, the persistent forest loss and wildlife decline suggest that its implementation has been insufficient. As noted by Pimid et al. (2022), the success of SFM hinges on multifaceted human involvement and adequate policy enforcement. Despite the SFM framework, unsustainable land conversion—driven by economic incentives—appears to be a more dominant force on the ground.

The case of the Environmental Sensitive Area (ESA) guidelines, while not directly applicable to Sarawak, provides a valuable lesson. Studies in Peninsular Malaysia (Munian et al., 2023) have shown that integrated planning approaches, which prioritise the protection of ecologically significant areas, can be highly effective in mitigating biodiversity loss. For Sarawak's forest governance, which operates under its own distinct regulations like the Forests Ordinance 2015, adapting and strengthening such integrated planning methods is crucial.

Further categorises landscapes, including forest reserves and wildlife protection zones, emphasising integrated planning approaches that balance developmental needs with conservation priorities. Empirical studies focused on regions such as the Kapit Primary Forest reveal a significant negative correlation between forest cover loss and wildlife species richness, underscoring the urgent need for more effective resource management strategies. Similar findings have been reported in studies of bird assemblages within selected ESA areas in Selangor, reinforcing the broader implications for biodiversity conservation (Munian et al., 2023).

6.0 CONCLUSION

The results of this study clearly indicate a moderate, inverse relationship between forest loss and wildlife population decline in the Kapit FMU. This reinforces the urgency of addressing ongoing land-use changes in the region. To mitigate this crisis, it is crucial to expand and more stringently manage existing conservation zones to create effective wildlife corridors and counteract the effects of habitat fragmentation. Second, prioritise the protection of key wildlife habitats in all land-use decisions, ensuring that economic development does not come at the expense of biodiversity. Third, continue to use GIS and remote sensing to track land-use changes and wildlife population shifts in real time.

Nonetheless, this study acknowledges several methodological limitations. The analysis primarily relied on secondary data, which may vary in accuracy or temporal consistency, and the correlation results, which are not significant. Hence, do not establish direct causation. Future research should therefore incorporate primary field surveys over a longer time, increase records of the wildlife data, longitudinal ecological monitoring, and predictive modelling to validate and deepen the understanding of land-use and biodiversity interactions. Despite these limitations, the study contributes valuable insights into the linkages between forest management and wildlife conservation in Sarawak, providing evidence-based guidance for policymakers to balance economic development with ecological resilience in the Kapit region.

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OBSERVATIONAL STUDY ON SHOPHOUSE CONFIGURATIONS ADAPTABILITY IN PENANG, MELAKA, MUAR, AND KUALA LUMPUR: DESIGN PREFERENCES, AESTHETIC APPEAL, AND SOCIAL COHESION

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ABSTRACT

Malaysian shophouses are vital cultural assets, embodying the nation's architectural and socioeconomic history. However, rapid urban development and changing lifestyles threaten their preservation, often prioritising modernisation at the expense of heritage. A critical issue is the lack of empirical research on how design alterations affect user satisfaction and social cohesion, leading to ad-hoc renovations that may erode their historical value while failing to meet contemporary needs. Many modified shophouses struggle to balance functionality, thermal comfort, and community engagement, risking their role as social hubs in urban neighbourhoods. This study investigates these challenges by analysing design adaptations, aesthetic preferences, and social impacts in shophouses across Penang, Melaka, Muar, and Kuala Lumpur. Through observational methods and matrix analysis, it assesses spatial layouts, materials, and user interactions. Findings reveal that hybrid designs—combining heritage features with modern upgrades—are most effective, strategically using double-skin façades, open spaces, and communal corridors to enhance liveability and social cohesion. The study advocates for evidence-based design strategies to ensure shophouses remain sustainable, culturally resonant, and socially inclusive.

Keywords: Shophouse adaptability, observational methods, design preferences, social cohesion.

1.0 INTRODUCTION

As a symbol of Malaysian cities, shophouses offer a distinctive fusion of architectural, historical, and cultural value. Originating in the colonial era, these structures have changed to accommodate shifting societal expectations, urban demands, and economic transformations (Rashid & Heath, 2022). As cities like Penang, Melaka, Muar, and Kuala Lumpur work to balance heritage preservation and contemporary urban growth, the flexibility of shophouses has drawn more attention in recent years (Firzan et al., 2022). Through an analysis of design choices, aesthetic appeal, and their influence on social cohesiveness, this study aims to comprehend the adaptation of shophouses in these four cities. Through observational techniques, the study provides a clear explanation of how end users engage with these areas and how such interactions influence the social and physical surroundings.

In urban studies, adapting and preserving old structures, like shophouses, has become crucial, especially in developing areas. Sustainable adaptation strategies are crucial for promoting economic growth while satisfying user expectations (Hussain & Ujang, 2020). Another finding stated by Said et al. (2021) stresses the value of conserving old shophouses since they enhance Malaysian cities' cultural character and allure for tourists. However, adapting old buildings to meet contemporary requirements without sacrificing their historical authenticity has been challenging (Balocco & Cecchi, 2020). Little research has discussed the physical attributes and social dynamic impacts on shophouses. Thus, this research will focus on how design preferences, aesthetic

appeal, and social cohesion can enhance the adaptive reuse potential of historic shophouses in tropical urban contexts, particularly in Malaysia.

2.0 LITERATURE REVIEW

In Malaysia, shophouses' adaptability has drawn increasing attention from cultural conservation, architectural studies, and urban studies (Abdul Rahman & Lim, 2024; Lim & Ismail, 2023; Phang et al., 2023). With an emphasis on their adaptability in contemporary urban development, the discussion summarises recent research on shophouses' design, preservation, and social impact. Three main areas serve as the framework for the review: (1) aesthetic appeal and design preferences (Tan & Yusof, 2022); (2) sustainable adaptation strategies (Abdul Rahman & Lim, 2024); and (3) community dynamics and social cohesiveness (Phang et al., 2023; Yusoff & Koh, 2024).

2.1 Design Preferences and Aesthetic Appeal

Malaysian shophouses are renowned for their distinctive architectural designs, which combine colonial, Chinese, Indian, and indigenous elements. Recent studies have underlined the significance of maintaining these aesthetic features while modifying shophouses to meet modern requirements. Hussain and Ujang (2020) point out that end-users like shophouses with modern interior designs and historic façades. Maintaining shophouses' aesthetic appeal and functional relevance requires balancing the old and the new. The versatility of shophouses is also greatly influenced by the colours and materials used. Research by Al-Obaidi et al. (2022) shows that double-skin façades and light-coloured exteriors in tropical climates help reduce heat absorption while improving indoor comfort. Their study also found that adding vertical blinds and shading devices enhances functionality and visual appeal in dense urban areas.

2.2 Sustainable Adaptation Techniques

Shophouse preservation requires sustainable adaptation, especially amid the fast-paced urbanisation and climate change. The role of daylighting laws, energy-efficient materials, and green building techniques in increasing shophouse flexibility has been the subject of recent studies. For instance, al-Obaidi et al. (2022) stress the value of daylighting in tropical regions, where adequate ventilation and natural light can greatly enhance indoor environment quality. According to their research, shophouses' visual appeal and usability can be improved by carefully placing windows, courtyards, and skylights. The adoption of energy-efficient materials is another essential component of sustainable adaptation. Materials like insulated roofing and double-skin façades, according to Bansal et al. (2020), can lower energy use without sacrificing the shophouse's historic character. Furthermore, it has been demonstrated that adding green spaces, like courtyards and pocket corridors, improves the urban microclimate and offers gathering places for people to socialise (Jasme et al., 2020).

2.3 Social Cohesion and Community Dynamics

Shophouse adaptation is a social issue and a concern for design and sustainability. Shophouses are frequently used as gathering places for the community, especially in old cities. The effects of shophouse adaptation on community dynamics and social cohesiveness have been the subject of recent research. For example, Said et al. (2021) discovered that shophouses featuring common areas and open courtyards strengthen social bonds between inhabitants, business owners, and guests. These areas promote social events that foster community, like markets, festivals, and unofficial get-togethers. However, social problems might also result from shophouses being modified for commercial use. Long-time residents' daily routines may be disturbed by the conversion of shophouses into hotels, cafes, and retail establishments, especially in heritage zones, according to Baillargeon (2021). This emphasises the necessity of a well-rounded strategy that considers the social ramifications of shophouse modifications to ensure they benefit the neighbourhood and the economy.

2.4 Gaps in the Literature

Even though recent research has greatly advanced our knowledge of shophouse adaptability, there are still a number of unanswered questions. First, little is known about how adaptable shophouses are in tiny cities like Muar, where economic growth and historical preservation sometimes clash. Second, how end users engage with modified shophouse environments has not been extensively studied using observational methods. In order to fill these gaps, this study will use observational methods to examine design choices, aesthetic appeal, and social cohesiveness in four cities: Penang, Melaka, Muar, and Kuala Lumpur.

3.0 METHODOLOGY

This research employs structured observational methods to analyse shophouse adaptability across four Malaysian cities (Penang, Melaka, Muar, Kuala Lumpur), conducting 240 hours of behavioural mapping in 12 case-study buildings (3 per city) representing diverse urban contexts as shown in Figure 1 below.

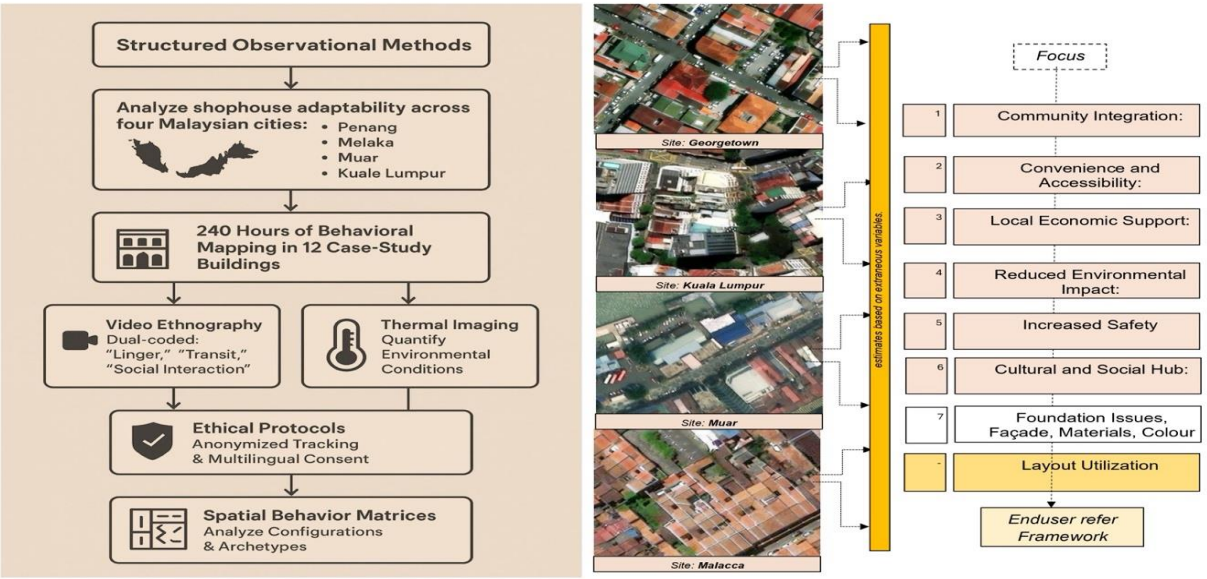


Fig. 1: Observations take into account elements like orientation, zoning, materials, and colour in Penang, Melaka, Muar, and Kuala Lumpur. (Source: Google Maps and Author).

This will consider elements like orientation, zoning, materials, and colour in varied metropolitan settings and rich architectural histories of pre-war shophouses that combine colonial, Chinese, Indian, and indigenous influences. Researchers documented user interactions with architectural elements, space utilisation patterns, and microclimate adaptations through mapping indications, where each city was independently annotated with footage using a behavioural framework ("lingering," "transit," "social interaction"). All data were synthesised into spatial behaviour matrices analysing linear configurations, colour-specific zoning, and shape/enclosure archetypes, with special attention to touristic heritage zones where design preferences and social behaviours most prominently intersect.

4.0 ANALYSIS

Design adaptation & aesthetic preferences analysis

This analysis of shophouse adaptations in Kuala Lumpur highlights contrasting responses to urban climate challenges. In KL's riverfront Lebuh Pasar district (Fig. 2), metal ventilation panels and full-length windows dominate, emphasising airflow in dense urban conditions, while varied colour sections indicate fragmented aesthetic choices. In contrast, Muar's seafront Bandar Maharani uses ornamental metal panels and north-south oriented pocket corridors to mitigate evening heat, with uniform colour stringers reflecting cohesive material planning.

KL's spatial organisation shows ad-hoc commercial adaptations, while Muar demonstrates intentional microclimate design, showing how smaller cities can apply thermally responsive strategies with fewer resources. Both rely on hybrid materials (wood-glass-metal composites), reflecting a regional blend of heritage aesthetics and modern performance needs.

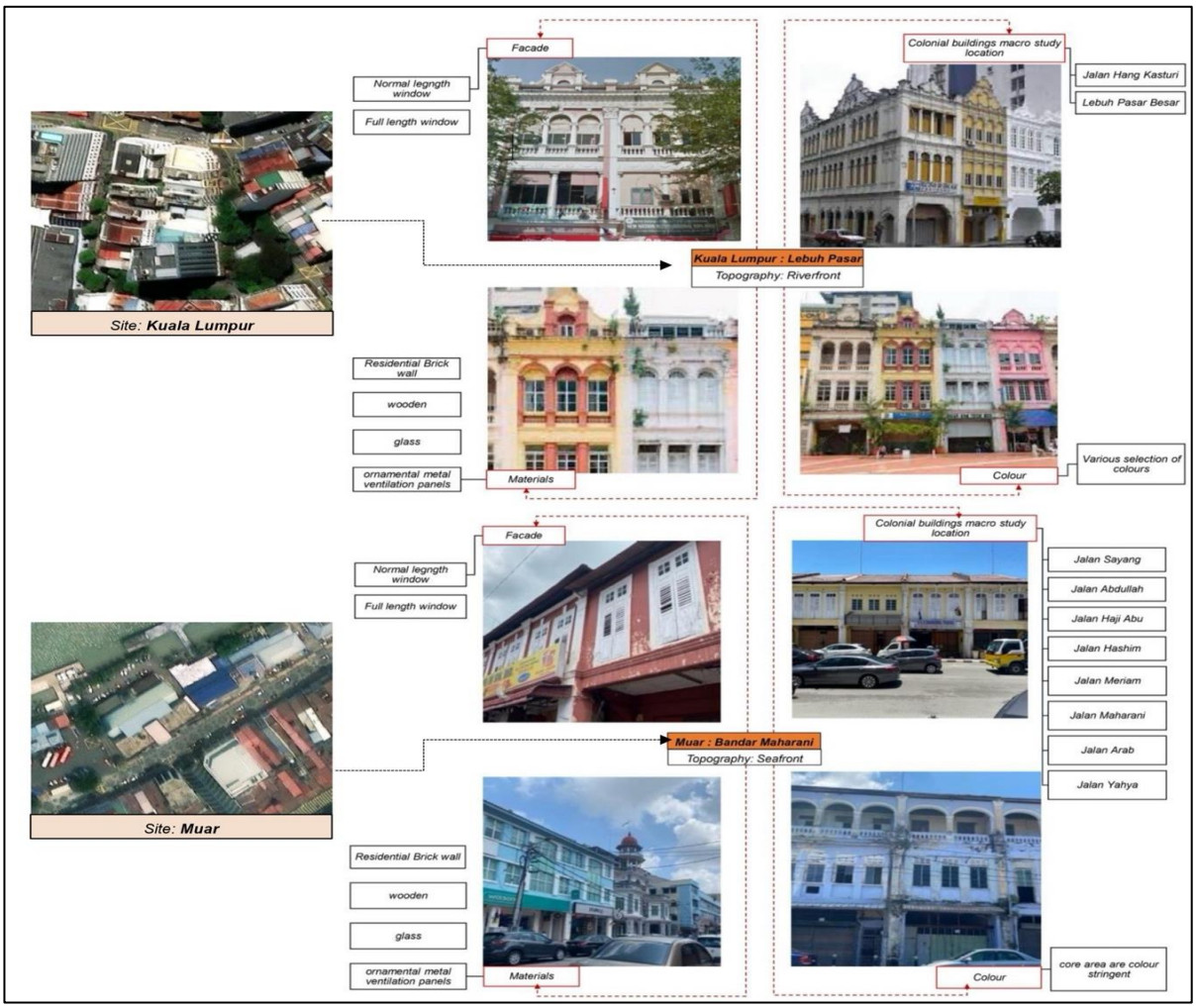


Fig. 2: The exterior and macro mapping for Muar and Kuala Lumpur.
(Source: Authors).

The analysis of shophouse adaptations below shows how historic policies and topography shape materiality and spatial organisation. In Melaka's riverfront context, constructed metal ventilation panels and partial colour-coding along Jalan Hang Jebat demonstrate a utilitarian approach to humidity control, using repetitive brick-wood compositions and standardised window proportions (normal/full-length). Contrastingly, Penang's seafront Georgetown employs ornate metal panels and full-length windows to enhance commercial visibility, with vibrant multi-chromatic façades along Lebuh King reflecting UNESCO aesthetic mandates. Both cities share hybrid climate strategies—Melaka's linear material organisation optimises river breezes, while Penang's parallel shaded/unshaded zones mitigate solar gain. Penang's small tube frames and lotted screens highlight its tourist-driven material diversity versus Melaka's functional uniformity, underscoring how regional priorities (economic vs. environmental) manifest in adaptive reuse.

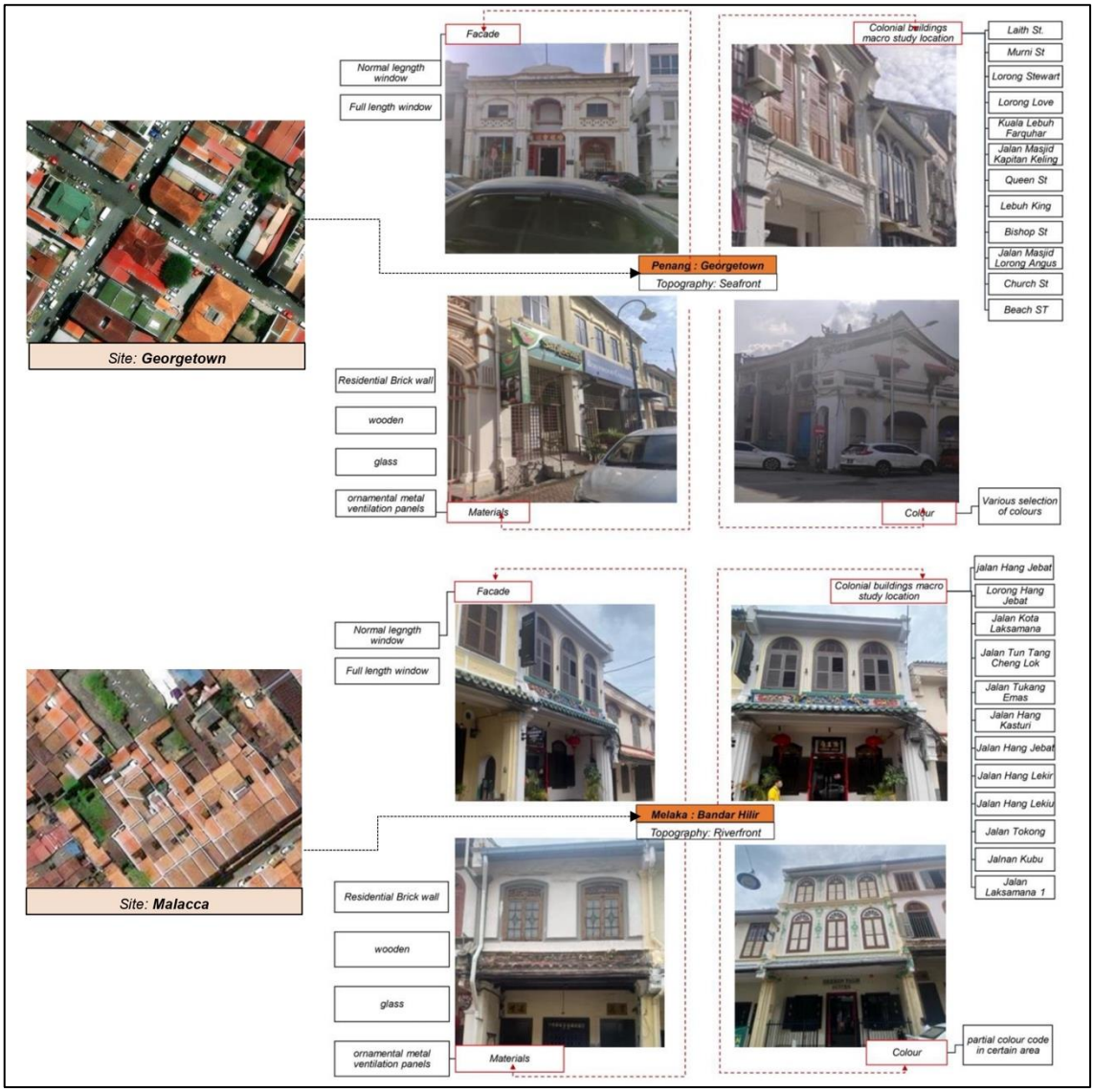


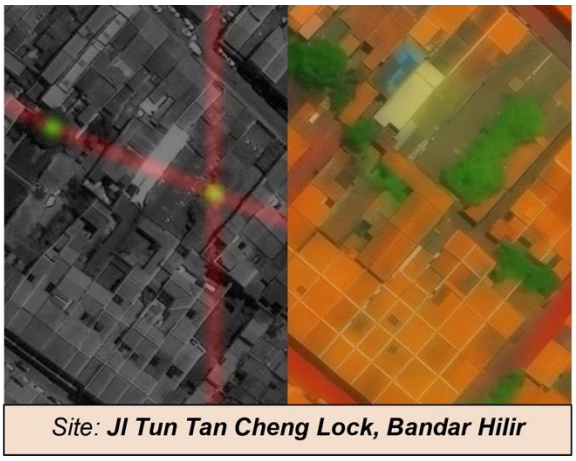
Fig. 3: The exterior and macro mapping for Bandar Hilir and Georgetown. (Source: Authors).

Social impact analysis

In Muar (Bandar Maharani), behavioural data highlights concentrated high transit activity along riverside streets and adjacent piers in Figure 1 below, reflecting the waterfront's role as a key transit and commercial hub. Streets parallel to the river connect commerce, eateries, and transport points. In contrast, social interaction zones appear near civic buildings and public lots, where people gather and linger, signalling a slower-paced rhythm within this small-town heritage fabric. A central intersection shows bright yellow from overlapping red routes, marking a hub of movement and social interaction, likely a main town square. Red linear paths radiate outward along perpendicular streets, while the surrounding blocks show limited lingering (minimal green), concentrating pedestrian activity at the centre.

The pedestrian data in Kuala Lumpur's Medan Pasar in Figure 4 reveals dense red zones concentrated at the central intersection and surrounding main roads, reflecting urban intensity and its role as a transit hub near LRT access points. Movement is fast-paced and directional. Still, green interaction zones appear near shaded trees, small plazas, and pedestrian islands—spaces that encourage rest and socialising despite dominant transit flows. This points to the multifunctional behaviour embedded in the city's historic commercial core. Pedestrian routes crisscross the dense area. Two green social hotspots—near the image centre (right) and lower left—likely represent public squares or markets. Red corridors link these: a diagonal red path from lower left to upper right intersects with another from the top centre. Their meeting near the central green hub forms a yellow zone,

suggesting vibrant overlap between transit and lingering. The pattern shows how gathering places are embedded along main pedestrian routes, enabling continuous urban activity.



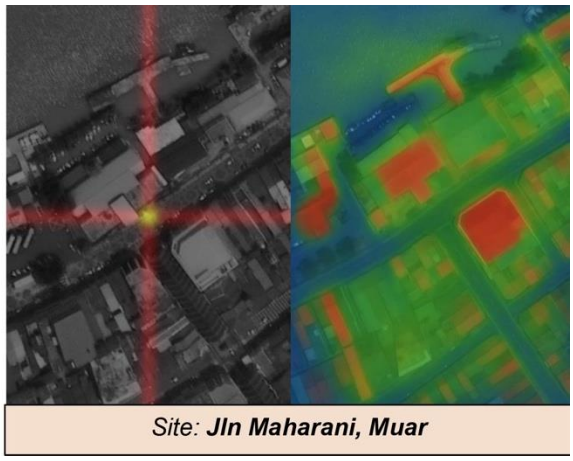
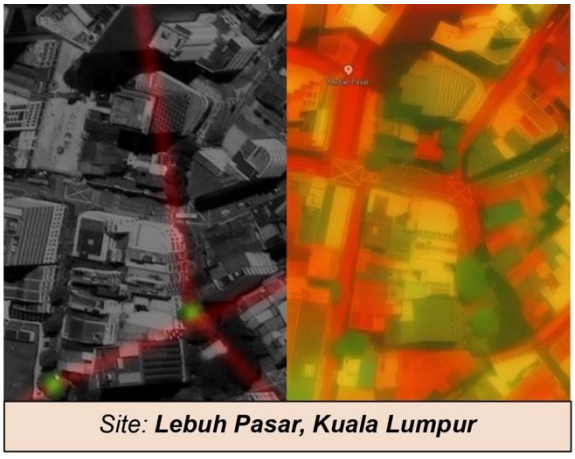


Fig. 4: Pedestrian distribution (red=high transit, green=high social interaction.
(Source: Maps).

In Georgetown, Pulau Pinang, the data in Figure 5 reveals a classic grid layout with red zones marking key pedestrian transit routes across the orthogonal network. These indicate efficient walkability and active corridors between shophouses, local businesses, and cultural landmarks. Green areas—at intersections, courtyards, and shaded sidewalks—signal high social interaction, reflecting a historical urban rhythm that blends movement with pause. Narrow alleys and mixed-use buildings support a shared public realm. A bold red vertical path on the left represents a major pedestrian thoroughfare, possibly near a park or commercial axis. Two distinct green zones—upper left and lower right—mark social hubs such as plazas or gathering spaces. The orange tint near the lower right cluster shows moderate overlap where foot traffic enters a social zone, while the upper green zone sits more isolated, reflecting a quieter congregation.

The behavioural heatmap in Bandar Hilir, Melaka, particularly along Jalan Hang Jebat, shows a dominant red corridor along the heritage main street, indicating constant pedestrian flow in this tourist-heavy zone. Attractions like souvenir shops, food stalls, and heritage sites reinforce its role as a transit spine. Social interaction zones (in green) appear in internal courtyards, shaded areas, and near cultural landmarks, offering relief and spaces for pause within the high-flow setting. The map shows several small social hubs and a linking corridor. A green zone to the left marks one gathering space, while a yellow hub to the right represents an overlap of movement and social activity. A red diagonal path connects the hubs, suggesting a popular pedestrian route. A vertical red strip on the right indicates continued foot traffic through the second hub. This pattern reflects distributed social nodes connected by active routes, where people circulate across multiple centres rather than a single core.



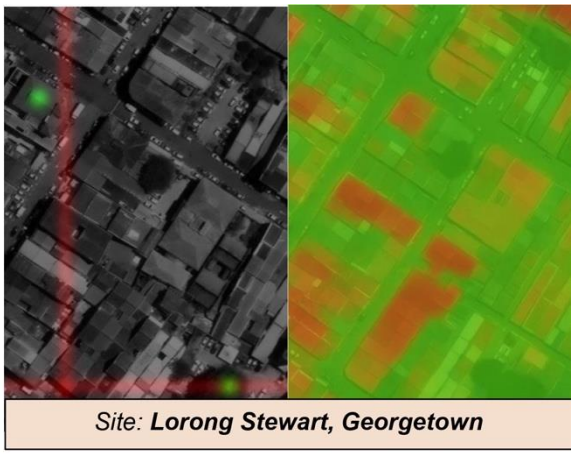
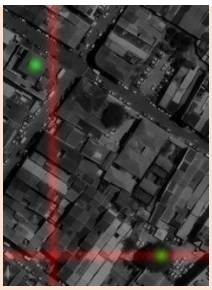
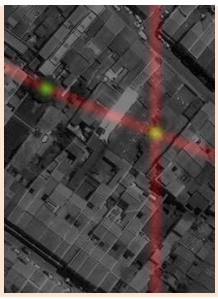


Fig. 5: Key pedestrian transit routes across Melaka & Pulau Pinang.
(Source: Authors)

Table 1: Comparative Shophouse Adaptation Metrics Across Four Malaysian Cities

Metric	**Penang** (George Town)	**Kuala Lumpur** (Lebuh Pasar)	**Melaka** (Bandar Hilir)	**Muar** (Bandar Maharani)
Façade Design	Ornate metal panels, multi-chromatic façades	Commercial metal panels, fragmented colours	Brick-wood uniformity, partial colour-coding	Ornamental panels, uniform colour stringers
Climate Features	Concurrent shaded/unshaded zones	Riverfront ventilation panels	Linear river-breeze alignment	North-south pocket corridors
Façade Retention Rate	72% (UNESCO-driven)	34% (Commercial pressure)	68% (Tourism balance)	55% (Local-scale focus)
Avg. Temp. Reduction	2.8°C (double-skin façades)	1.5°C (partial adaptations)	3.1°C (courtyards + shading)	2.3°C (pocket corridors)
Social Spaces/100m²	4.2 (open corridors)	1.1 (limited communal areas)	5.0 (pocket corridors)	3.8 (shared courtyards)
Commercial Conversion	41% (boutique hotels)	82% (retail/offices)	58% (cafes/galleries)	33% (local businesses)
Resident Displacement	22% (moderate gentrification)	67% (high gentrification)	35% (managed tourism)	15% (community-led)
		Space-Use Behaviors		
				
	Linear Corridor and Distant Nodes	Network of Crossing Flows	Multiple Hubs with Connector	Central Intersection Hub
• Lingering (min/hr)	18.2	6.5	22.4	15.3
Transit (paths/hr)	42.1	68.3	38.6	45.2
Social Interaction	8.7 conv./hr	2.1 conv./hr	12.5 conv./hr	9.3 conv./hr
Social Spaces/100m²	4.2	1.1	5.0	3.8
• % Long-term Residents	58%	29%	63%	72%
Policy Effectiveness	Tiered grants (89% uptake)	Weak enforcement (42% compliance)	Material subsidies (75% uptake)	Community workshops (63% success)

5.0 DISCUSSIONS

The findings presented through comparative spatial, thermal, and behavioural metrics provide empirical clarity on the adaptability of shophouses in Penang, Melaka, Muar, and Kuala Lumpur. By analysing aesthetic integration, climate-responsiveness, and patterns of human behaviour, the study underscores how design strategies directly impact cultural preservation, environmental comfort, and social connectivity. The cross-city matrix confirms that Melaka exhibits the most holistic model, while Kuala Lumpur reflects the most fragmented adaptation outcomes due to intense commercial pressures.

5.1 Considerations for Designing and Visual Appearance

The data indicates that Penang and Melaka lead in integrating historic façades with modern interior upgrades, supported by high façade retention rates (72% and 68%, respectively) and vibrant colour zoning aligned with policy enforcement (UNESCO in Penang, tourism incentives in Melaka). These approaches align with Hussain and Ujang (2020) and Jin & Wang (2021), affirming that a hybrid visual language—where colonial elements are preserved alongside contemporary material choices—enhances both appeal and function. Conversely, with the lowest façade retention (34%) and highly fragmented colour and material application, Kuala Lumpur exhibits a pattern where commercial expediency overrides heritage considerations. This confirms the contradiction with Said et al. (2021), who advocate preserving façade integrity in urban adaptations. As such, stronger heritage zoning and architectural control guidelines are urgently required in KL to stabilise its visual identity and cultural continuity.

5.2 Methods of Sustainability Adaptation

Thermal performance analysis reveals that Melaka achieves the highest average temperature reduction (3.1°C), followed closely by Penang (2.8°C), mainly due to implementing passive cooling strategies such as pocket corridors, courtyards, and double-skin façades. These methods echo the passive design strategies proposed by Al-Obaidi et al. (2022) and Parsaee et al. (2020), supporting enhanced microclimate performance without compromising heritage value. Muar demonstrates practical adaptability through orientation-aligned corridors and uniform material palettes, enabling 2.3°C temperature reductions with lower financial inputs. In contrast, Kuala Lumpur's minimal thermal gains (1.5°C) and inconsistent use of shading and ventilation features, particularly in high-transit areas like Jalan Kasturi, reflect weak policy enforcement and lack of targeted subsidies. Replicating Melaka's subsidy model across cities could significantly elevate environmental performance, particularly in heat-exposed urban cores.

5.3 Social Cohesion and Community Dynamics

Behavioural data (Table 1) demonstrates the influence of design on social interaction. Melaka's pocket corridors and internal courtyards yield the highest social interaction rates (12.5 conv./hr) and lingering time (22.4 min/hr), emphasising the spatial logic of informal gathering zones within touristic heritage districts. This supports the theories of Lynch (2022) and Said et al. (2021) on spatial permeability and visibility promoting community bonding. Muar also performs well, with high long-term resident retention (72%) and moderate interaction (9.3 conv./hr), affirming the role of community-led adaptive reuse in maintaining social routines. Penang's case is more nuanced—while visual appeal is high, over-commercialisation in hotspots like Love Lane reduces deep social engagement, reflected in a lower conversation rate (8.7 conv./hr). Kuala Lumpur lags, with only 2.1 conv./hr and minimal green zones, where urban intensity disrupts communal rhythms, echoing Baillargeon's (2021) critique on gentrification-induced social fragmentation.

5.4 Urban Planning and Conservation Implications

The contrasting performances across cities demonstrate the need for differentiated urban planning responses. Melaka's success stems from clear zoning, design codes, and material subsidies, balancing tourism and local identity. Penang benefits from high policy uptake (89%) but needs to mitigate tourist saturation to revive authentic community ties. Kuala Lumpur's challenge lies in weak compliance (42%) and absent social indicators in development controls. As such, urban plans must integrate social cohesion benchmarks (e.g., a minimum of 10 conv./hr interaction zones) and regulate pedestrian flow (<50 paths/hr) to protect cultural rhythms. Muar, though small-scale, offers a scalable grassroots model with strong community integration and minimal displacement.

5.5 Policy Recommendations

Behavioural analysis from the matrix reveals actionable patterns. In Penang, locations like Queen Street and Church Street achieved high orientation and visual scores but required spatial decluttering to promote lingering. Melaka excelled in interaction zones (e.g., Jalan Hang Kasturi) with high scores across all matrix dimensions, indicating a successful integration of tourist heritage zoning, façade preservation, and community-centred design. Muar presents a strong grassroots model with moderate zoning policies but strong social presence and low displacement. While scoring high in zoning and functionality, Kuala Lumpur struggled in social and visual cohesion. The evidence calls for three immediate, location-specific interventions:

i. Enforce a social interaction threshold: Heritage zones should aim for at least 10 conversations/hr, using Melaka's corridor designs as a model.
ii. Control pedestrian flow intensity: Kuala Lumpur should reduce transit saturation (<50 paths/hr) through shaded walkways and rest pockets, enhancing social permeability.
iii. Implement targeted incentives: Tiered tax benefits for thermal and social upgrades (e.g., double façades, shaded seating) as shown effective in Penang (25% increase in lingering) should be expanded across cities.

These policies should be embedded into urban governance frameworks and supported by cross-agency collaborations between local authorities, heritage boards, and resident associations. Only through behavioural-informed and climate-conscious design policies can Malaysian cities ensure the' longevity, vibrancy, and inclusiveness of their historic shophouses.

6.0 CONCLUSION

This study affirms that the adaptive reuse of Malaysian shophouses must strike a deliberate balance between heritage preservation, climate responsiveness, and social inclusivity. By employing structured observational methods, the research identifies distinct urban patterns and performance outcomes shaped by spatial design, material application, and behavioural dynamics. Melaka is the most comprehensive model, with pocket corridor configurations and strong zoning mechanisms supporting thermal comfort and vibrant social interaction (12.5 conv./hr). Penang demonstrates high visual appeal and effective passive design strategies, although tourist saturation dampens deeper community engagement. In contrast, Kuala Lumpur reflects the challenges of rapid commercialisation, where high pedestrian transit (68.3 paths/hr) coincides with weak façade retention (34%) and diminished social cohesion. Despite its smaller scale, Muar showcases promising community-driven adaptations that balance functional upgrades with high resident continuity (72%). Three core elements underpin successful shophouse adaptation:

i. Heritage-conscious design—retaining architectural character through façade preservation and material continuity.
ii. Climate-responsive solutions—such as double-skin façades, pocket corridors, and shaded walkways that improve urban comfort.
iii. Behaviorally informed planning—ensuring spatial configurations foster interaction and minimise displacement.

Urban policies must adopt city-specific strategies to operationalise these insights. These include enforcing minimum social interaction benchmarks, regulating transit intensity through public realm enhancements, and incentivising thermal and communal upgrades. Heritage adaptation cannot be treated as a uniform process; instead, it must reflect each city's unique socio-cultural and environmental fabric. Ultimately, this study offers a replicable framework for tropical cities seeking to future-proof their historical assets by aligning architectural integrity.

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THE ADOPTION OF VALUE MANAGEMENT BY QUANTITY SURVEYING FIRMS IN MALAYSIA

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ABSTRACT

Quantity Surveyors (QS) are well-positioned to promote Value Management (VM) in construction projects due to their cost expertise. However, their knowledge and awareness of VM are insufficient, and they often confuse it with cost-cutting. Despite VM's introduction in Malaysia in the early 1980s, its adoption has been limited. The technical application of VM within Quantity Surveying (QS) firms in Malaysia remains unclear, necessitating further investigation. This research aims to determine VM adoption by QS firms, identify the obstacles, and propose strategies to overcome the obstacles. Data was collected through a questionnaire survey of 32 respondents from 32 QS firms in Malaysia. The findings reveal that VM adoption by QS firms in Malaysia is generally low. The obstacles include time constraints due to VM's lengthy process, client reluctance to fund VM services, designer reluctance to adopt VM, and a shortage of trained VM professionals. Strategies to overcome these obstacles include educating clients and decision-makers about VM's importance, making VM knowledge accessible, and improving VM curricula in higher education institutions.

Keywords: Adoption, Obstacles, Strategies, Value Management (VM).

1.0 INTRODUCTION

The introduction of value management in the early 1980s in Malaysia shed an affirmative light on QS's taking the lead in developing value management as one of its niche areas (Wei & Keong, 2016). However, VM is not popularly adopted due to a lack of time to implement it (RICS, 2017). King et al. (2020) reveal that VM is frequently practised voluntarily or on the client's request. In common cases, VM is carried out in a specific project rather than being integrated into the company's management system. One of the contributing factors is the role of designers in managing other projects simultaneously. Architects often perceive VM studies as a means of criticising their work and finding shortcomings in their designs rather than as a means of improvement (Ling et al., 2020). As for QS, tight deadlines have made it difficult for them to carry out VM in a particular project while preparing other projects' requirements, because VM is a time-consuming process. Apart from that, even though VM is well-known, it is not included in the abilities that the regulatory body, RICS, requires of QS when taking their Assessment of Professional Competence (Oki & Ogunsemi, 2017; as cited in Spellacy et al., 2021).

Past research from Cheah & Ting (2005), Wei & Keong (2016), Ling et al. (2020), Li et al. (2022), etc., has discussed the benefits and challenges of VM implementation in various types of projects. However, the technical aspect of the VM application in Malaysia, especially whether it is integrated into QS firms across Malaysia, has yet to be discussed. Therefore, the objectives of this research are: (1) to determine the adoption of Value Management by Quantity Surveying firms in their practices, (2) to identify the obstacles in adopting Value Management by Quantity Surveying firms, and (3) to determine the strategies to overcome the obstacles in adopting Value Management by Quantity Surveying firms. Quantitative and qualitative data collection methods achieve this research's objectives. The quantitative method involves data collection through a questionnaire survey, while the qualitative method involves semi-structured interviews. The questions asked for data collection are formulated based on the inputs from the literature review.

The research scope for this study is the adoption of Value Management in Quantity Surveying firms. The respondents are limited to the Quantity Surveyors currently working in Consultant Quantity Surveyors companies registered with the Board of Quantity Surveyors Malaysia (BQSM) operating in Malaysia. This study is significant in providing information on adopting Value Management in the Quantity Surveying firms. This research presents the current state of Malaysian Quantity Surveying companies in adopting Value Management throughout development projects. It is crucial to learn the obstacles hindering the application of Value Management so a strategy can be formed to overcome these obstacles. The findings are the pinnacle for QS to improve its professional services to its clients further. This research is also meant to help Quantity Surveying graduates understand the overview of Value Management applications in Malaysian Quantity Surveying firms.

2.0 LITERATURE REVIEW

According to the IVMA (2019), Value Management is "a planning and review process which is distinctively different to other processes because of its structured approach using a prescribed Work Plan and an analytical focus to achieve best value or, where appropriate, best value for money". VM is essential to improve the value of a project, product, process, service or organisation by analysing functions. Exercising VM in construction is usually workshop-based, where a multidisciplinary team is involved and an independent facilitator is commonly needed. In Malaysia, it is mandatory for a government project that costs RM50 million and above to go through the process of value management (EPU, 2011).

2.1 Adoption of Value Management

The adoption of VM is studied from different aspects of its technical application. In the context of organisational practices, Li et al. (2022) find that VM was not integrated in most of the organisations surveyed, and project teams did not practice its concept. According to Lin et al. (2022), the experience of organisations and practitioners is found to have a substantial correlation with VM adoption. The author further explains that smaller project members receive fewer opportunities from their organisations to obtain VM study experience. From the aspect of VM adoption phases, Ghani et al. (2021) find that the VA study is performed after the project budget approval, which indicates the 'decision to construct' demarcation point. This study is against the VM manual, which requires VA to be conducted at the briefing stage, which took place before the project obtains approval. King et al. (2020) also discovered that VE is frequently done after the contract has been signed, once construction has started, and in cases of budget overruns or other unanticipated events. Ellis et al. (2005) also reveal that the VM process rarely goes beyond the tender stage and is seldom carried out.

Saifulnizam et al. (2011) imply that VM in Malaysia is not recognised as a consultant QS practice job structure in construction project types. However, it is considered a method to assist with decision-making in construction projects. To support this, Jaapar et al. (2012) point out that VM is adopted in infrastructure, residential, and flood irrigation projects. In client types, King et al. (2020) reveal that VM is frequently practised voluntarily or on the client's request. Consequently, Ahmad (2011) stated that VM has been adopted in 71 public projects in Malaysia. To support this, Jaapar et al. (2012) reveal that VM studies conducted by the public sector are through workshops, as the VM manual recommends. Similarly, Ling et al. (2020) find that VM is practised extensively among developers in the private sector to increase the value of their projects.

Regarding contract value, the Economic Planning Unit (EPU) of the Prime Minister's Department of the Malaysian government has mandated the use of VM in governmental programs and projects valued at RM50 million and above (EPU, 2011). However, Lin et al. (2022) argue that, regardless of project type, the adoption of VM by organisations for smaller construction projects under RM5 million is relatively low and highly dependent on the project size.

2.2 Obstacles to Adopt Value Management

The first obstacle to adopting VM is the misconception among the QS. Usman et al. (2013), Ling et al. (2020), and Wei & Keong (2016) find that the primary obstacles impeding the execution of VM are a poor understanding and experience in VM study. King et al. (2020) argue that QS are aware of the concept but often misunderstand it. Li et al. (2022) explain that the majority believe VM is rather a strategy or concept than a profession, hence they lack motivation to explore. Secondly, Lin et al. (2022) point out that one of the main obstacles to VM expansion within organisations is a shortage of VM specialists. Jaapar et al. (2009) discovered that many organisations had never participated in a VM training, and that there was a dearth of advice from relevant experts and inadequate facilitation during the workshops. While most understand VE, Kineber et al. (2022) find that only a few have formal VE training.

In addition, the obstacle to adopting VM is caused by the inefficient conduct of VM studies. Spellacy et al. (2021) found that the VM study process has not been carried out efficiently, ultimately leading to ineffective outcomes. This means VM is not conducted according to the VM manual, which shall begin as early as possible during the inception stage and involve the required participants, including the QS. Also, Usman et al. (2013) and Ling et al. (2020) agree that implementing VM in a project is a time constraint. Due to its lengthy process, Wei & Keong (2016) find that VM causes interruption to the normal work schedule. Tight deadlines have made it difficult for the QS to carry out VM in a particular project while preparing other project requirements because VM is a time-consuming process (RICS, 2017). Organisations are also less likely to adopt VM due to designers' reluctance. Ling et al. (2020) find that many designers have a vigilant mindset to avoid taking responsibility for legal issues. The misconception that VM studies reflects a designer's incompetence and integrity, which is why designers are unwilling to consider alternative approaches and revisions to their designs (Rad & Yamini, 2016).

Furthermore, Othman et al. (2019) and Kineber et al. (2023) find that the decision-makers are often absent during the VM study. Low participation of decision-makers in VM workshops has created a communication gap between the clients and other consultants. Additionally, organisations are less likely to adopt VM due to the client's reluctance to fund VM services. Although VM requires an experienced facilitator to ensure the exercise is conducted systematically, convincing the client to pay for one can be challenging, as Bennett & Mayouf (2021) claimed. Moreover, Othman et al. (2019) and Kim et al. (2016) claim that the current VM guidelines are impractical. The guidelines for implementing VM are not comprehensive and contain ambiguous procedure wording. As a result, the guidelines have confused VM participants about their roles and responsibilities, including the QS themselves, who are arguably one of the most important participants of a VM team (Spellacy et al., 2021). Finally, organisations are less likely to adopt VM due to the fear of a reduction in professional service fees. This decision is predicated on the idea that professional fees for construction are determined by taking into account the project's expected total cost.

2.3 Strategies to overcome the obstacles to adopting Value Management

The first strategy to overcome the obstacles to adopting VM is to make VM knowledge accessible. Wei & Keong (2016) suggest that VM reference materials and information should be made publicly available to industry participants. Furthermore, Kim et al. (2016) emphasise the necessity of introducing the VM methodology in organisations by providing VM seminars and a sample VM implementation in some projects. Ling et al. (2020) also stress that the government or professional organisations like IVMM should actively promote the benefits and achievements of VM by exhibiting successful case studies to the general audience. Secondly, there should be mandatory VM training in the organisation. Kineber et al. (2022) and Li et al. (2022) suggest that construction professionals should receive formal training on VM principles, concepts, and methodologies from their organisations. Likewise, Lin et al. (2022) stress that organisations provide regular training and practices for participants of smaller projects on VM principles, techniques, and facilitation skills. Bowen et al. (2009) agree and recommend integrating contemporary VM theory and the application of VM in practice, including VM facilitator training and simulation workshops.

In addition, establishing a professional VM team is recommended for organisations (Li et al., 2022). Bowen et al. (2009) stress the importance of establishing a clear definition of the roles and responsibilities of the members in conducting a VM study. Having a certified VM facilitator pays, but the expert does not necessarily need to be a qualified VM specialist because of limitations in experience and resources (Jaapar et al., 2012). Also, there is no reason why someone with a surveying background cannot be an excellent VM facilitator (RICS, 2017). Moreover, it is critical to educate the clients about VM as one of the ways to minimise cost overrun. Ellis et al. (2005) find that educated clients most likely allow a series of interventions. Since QSs are in a good position to recommend that VM is used during briefing and feasibility studies (RICS, 2018), Ojo et al. (2023) suggest that holding a meeting could serve as an effective means of educating clients about the costs associated with running VM workshops as well as the substantial cost savings that can be realised by doing so.

Furthermore, the authorities should improvise law and contract provisions to accommodate VM implementation (King et al., 2020). Li et al. (2022) also recommend that the government facilitate the application of VM by formulating policies, regulations, and guidelines. Several documents related to the local context should be published in the construction industry (Kim et al., 2016). In addition, the government should improve the VM syllabus at higher educational levels. Tutesigensi et al. (2021) suggest that VM techniques and applications should be taught to undergraduate students in construction-related fields. Furthermore, postgraduate construction-majoring students should be able to practically implement the phases of VM on construction projects and receive theoretical instruction from academic institutions (Ojo et al., 2023).

Besides, the organisation should establish rules of adoption phases for VM, including the effort to regulate a standard reference, so VM studies are carried out efficiently. The VM Standard Reference will assist managers, value program managers, practitioners, and trainers in applying VM in their organisations in a consistent, standard manner (SAVE International, 2020). In Malaysia's context, guidelines for adopting VM have been established by the Economic Planning Unit of Malaysia (EPU, 2011). Wei & Keong (2016) and Saifulnizam et al. (2011) suggest that clients provide additional fees for VM services to those consultancy firms, as VM could be considered a new scope of work for them.

3.0 METHODOLOGY

This study employs a quantitative approach to achieve the research objectives. A total of 32 respondents participated in the survey, providing insights regarding the adoption of VM in their organisations. The survey responses were subjected to statistical analysis to identify trends and patterns. The questionnaire consists of four (4) sections: Section A, Section B, Section C, and Section D. The Statistical Package for Social Sciences (SPSS) software serves a significant function in analysing the data collected from the questionnaire survey. The questionnaire survey data for this study are summarised as descriptive statistics, where the frequencies or percentage distributions of the samples are described using tables. The researcher chooses the median as the measure of central tendency for this study because it is resilient to extreme values or outliers. Besides, for non-normally distributed data, the median provides a better central measure because it accurately reflects the centre of the dataset without being influenced by the shape of the distribution (Newbold et al., 2012).

4.0 RESULTS

The questionnaire survey was distributed to 128 QS firms registered under the BQSM through email, LinkedIn, and hand delivery. Out of the 128 questionnaires distributed, 32 were answered.

4.1 Adoption of Value Management

There are 12 items under five aspects of VM adoption listed in this section. The respondents were required to state their stance on the listed practice options (yes, no, or not sure) based on their experience. Table 1 shows the results of the VM adoption by their organisations. In the context of organisational practices, many respondents (59.4%) rarely practice VM in their organisation's projects. A significant number of respondents (81.3%) agree that others normally organise VM practices in construction projects with their organisation's participation.

Regarding VM phases, it is significant (65.6%) that the Value Assessment workshop is normally conducted during the initial stage of a project. Most respondents (81.3%) agree that a Value Engineering workshop is normally conducted during the design stage of a project. Half of the respondents (50%) indicated that the Value Review workshop rarely occurs after project completion. According to the type of construction projects, it is significant (81.3%) that VM is normally practised in building projects. The majority (59.4%) normally practice VM in civil engineering projects. A considerable proportion of respondents (46.9%) normally practice VM in specialised projects. Looking at the type of clients, most respondents (68.8%) practice VM in the public sector projects. Many respondents (81.3%) practice VM upon the client’s request under private sector projects. From the aspect of contract value, a considerable portion (40.6%) rarely practice VM in the projects with a contract value below RM50 million. Most (78.1%) practice VM in projects with a contract value exceeding RM50 million.

Table 1: Value Management Adoption by Quantity Surveying Firms in Malaysia

No.	Value Management Adoption by Quantity Surveying Firms in Malaysia	Not sure		Yes		No	
		Qty	%	Qty	%	Qty	%
	Organisation practices						
1.	Value management is normally practised in the projects your organisation undertakes.	0	0	13	40.6	19	59.4
2.	Others normally organise Value Management practices in construction projects with the participation of your organisation.	1	3.1	26	81.3	5	15.6
	Phases of Value Management study						
3.	Value Assessment workshop is normally conducted during the initial stage of a project.	3	9.4	21	65.6	8	25.0
4.	Value Engineering workshop is normally conducted during the design stage of a project.	2	6.3	26	81.3	4	12.5
5.	Value Review workshop is normally conducted after project completion.	10	31.3	6	18.8	16	50.0
	Type of construction projects						
6.	Value Management is normally practised in building projects.	1	3.1	26	81.3	5	15.6
7.	Value Management is normally practised in civil engineering projects.	8	25.0	19	59.4	5	15.6
8.	Value Management is normally practised in specialised projects.	12	37.5	15	46.9	5	15.6
	Type of clients						
9.	Value Management is normally practised in the public sector sector projects.	9	28.1	22	68.8	1	3.1
10.	Value Management is normally practised on the client's request in the private sector projects.	2	6.3	26	81.3	4	12.5
	Contract value						
11.	Value Management is normally practised in the projects with a contract value below RM50 million.	9	28.1	10	31.3	13	40.6
12.	Value Management is normally practised in projects with a contract value exceeding RM50 million.	5	15.6	25	78.1	2	6.3

4.2 Obstacles to Adopt Value Management

Table 2 shows the obstacles to adopting VM by Quantity Surveying firms in Malaysia. There are eight obstacles listed in the table. The respondents were required to rate their level of agreement for each problem listed in the questionnaire using a six-point Likert scale consisting of (not sure, strongly disagree, disagree, neutral, agree, and strongly agree). The research results summarised that 7 of the listed obstacles received more than 50% vote of agreement.

The majority of respondents (75%) agree that there is a time constraint due to the lengthy process of VM. Over half of the respondents (59.4%) agree that clients are reluctant to fund VM services. Many (56.2%) respondents agree that designers are reluctant to adopt VM in the projects and that there is a shortage of trained professionals in VM. 53.1% of the respondents agree that they fear the reduction in professionals' fees due to lower contract value after the VM workshop and inefficient conduct of VM workshops. These obstacles obtain a median score of 5, which indicates that respondents generally agree on these as a major problem.

Half of the respondents (50%) agree that decision-makers participate poorly in VM workshops. This obstacle obtains a median score of 4.5, which implies that respondents are leaning towards an agreement or a neutral stance.

Table 2: Obstacles in Adopting Value Management by Quantity Surveying Firms in Malaysia

No.	Obstacles in Adopting Value Management by Quantity Surveying Firms in Malaysia	Agree + Strongly Agree		Median Score (Scale)	Likert Scale
		Qty	%		
1.	Time constraint due to the lengthy process of Value Management	24	75.0	5	Agree
2.	Client's reluctance to fund Value Management services	19	59.4	5	Agree
3.	Shortage of trained professionals in Value Management	18	56.3	5	Agree
4.	Reluctance of designers to adopt Value Management	18	56.3	5	Agree
5.	Fear of a reduction in professional fees due to a lower contract value after the Value Management workshop	17	53.2	5	Agree
6.	Inefficient conduct of Value Management workshops	17	53.2	5	Agree
7.	Low participation of decision-makers in Value Management workshops	16	50.0	4.5	Neutral-Agree
8.	Misconception about Value Management by industrial practitioners	13	40.6	4	Neutral

4.3 Strategies to overcome the obstacles to adopting Value Management

Table 3 shows the strategies quantity surveying firms use in Malaysia to overcome the obstacles to adopting VM. Eight strategies are listed in the table. The respondents were required to rate their level of agreement for each problem listed in the questionnaire using a six-point Likert scale consisting of (not sure, strongly disagree, disagree, neutral, agree, and strongly agree).

The research results summarised that almost all the listed obstacles received more than 50% of the vote of agreement.

The most significant strategy is to educate the clients and decision-makers about the importance of VM, which receives the highest agreement vote (96.9%). The second most prominent strategy (90.7%) is to make VM knowledge accessible, followed by the next (84.4%) to improve the VM syllabus in higher education institutions. The strategy to establish a VM team in the organisation received 78.2% agreement, while 75% of the respondents agreed on mandatory VM training. Subsequently, 68.8% of the respondents agree that providing additional fees for VM services is an effective strategy. These strategies obtain a median score of 5, which indicates that respondents generally agree on these as potentially effective strategies.

Table 3: Strategies to Overcome the Obstacles in Adopting Value Management by Quantity Surveying Firms in Malaysia

No.	Strategies to Overcome the Obstacles in Adopting Value Management by Quantity Surveying Firms in Malaysia	Agree + Strongly Agree		Median Score (Scale)	Likert Scale
		Qty	%		
1.	Educate the clients and decision-makers about the Importance of Value Management	31	96.9	5	Agree
2.	Make Value Management knowledge accessible	29	90.7	5	Agree
3.	Improve the Value Management syllabus in a higher education institution	27	84.4	5	Agree
4.	Establish a Value Management team in the organisation	25	78.2	5	Agree
5.	Mandatory Value Management training in the organisation	24	75.0	5	Agree
6.	Provide additional fees for Value Management services	22	68.8	5	Agree
7.	Establish rules of adoption phases for Value Management	16	50.0	4.5	Neutral – Agree
8.	Improvise law and contract provisions	13	40.7	4	Neutral

Only half of the respondents (50%) agree with the strategy to establish rules of adoption phases for VM, revealing a median score of 4.5, which implies that respondents are leaning towards an agreement or a neutral stance. Lastly, the strategy to improvise law and contract provisions receives the least vote (40.7%), obtaining a median score of 4, indicating that respondents have a neutral opinion.

5.0 DISCUSSIONS

5.1 Adoption of Value Management

The findings reveal that the adoption of VM by Quantity Surveying firms in Malaysia is still low, as Li et al. (2022) suggested, as the VM services are not provided by and integrated into most organisations. In addition, although Wei & Keong (2016) claim that VM is best implemented through the project management services rather than utilising it as a mere option towards a particular project, VM is still proven to be adopted based on the type of projects. The selective adoption of VM is similar to what Jaapar et al. (2012) have studied, where VM is adopted in infrastructure, residential, and flood irrigation projects. The findings also reveal that the adoption of VM by the QS firms in Malaysia is moderate, as many organisations abide by the standard phases of VM from the initial stage up to the design stage of the projects. This contradicts what Ghani et al. (2021) suggested, where a VA study is performed after the project budget approval, and opposed to what King et al. (2020) claimed, where VE is frequently done only after the contract has been signed and upon the commencement of the construction. However, most organisations seldom carry out VR after project completion, as Ellis et al. (2005) supported, where they find that the VM process rarely goes beyond the tender stage.

However, the findings reveal that the adoption of VM by the QS firms in Malaysia is relatively high based on the type of clients served. This proves that VM is frequently adopted voluntarily or on the client's request, as revealed by King et al. (2020) and Usman et al. (2013). From the aspect of contract value, it is proven that regardless of project type, the adoption of VM by organisations for smaller construction projects is relatively low and highly dependent on the project size, as supported by Lin et al. (2022). However, it has been proven that VM is widely adopted in projects valued at RM50 million to achieve higher cost savings, increase project quality, and foster innovation.

5.2 Obstacles to adopting Value Management

The findings reveal that the most significant obstacles in adopting VM by Quantity Surveying firms in Malaysia are time constraints due to the lengthy process of Value Management, with the highest vote from 75% of respondents. It is undeniable that VM is a time-consuming process, as suggested by the RICS (2017); hence, many organisations admit that VM's lengthy process hinders them from making VM one of the core services in their organisations. The second obstacle ranked the highest is the client's reluctance to fund VM services. It aligns with Bennett & Mayouf (2021), who stated that convincing the client to pay for a certified facilitator for VM practice can be challenging. The following obstacle is the reluctance of designers to adopt VM. This result is consistent with the study by Ling et al. (2020), which proves that resistance from designers is one of the hindrances to implementing VM by the QS organisations. Certainly, the misconception that VM studies reflect a designer's incompetence and integrity is why designers are unwilling to consider alternative approaches and revisions to their designs, as suggested by Rad & Yamini (2016).

Besides, the shortage of trained professionals in VM is also a concerning problem. Not only does the construction industry lack VM specialists, but many organisations do not provide VM training for their staff, as claimed by Kineber et al. (2022) and Lin et al. (2022). This finding proves that the chance of a QS being the second-best candidate for VM facilitation in Malaysia is a missed opportunity due to a lack of formal training in VM. Another obstacle is the fear of reduced professional fees due to lower contract value after the VM workshop. The finding proves that many organisations are predicated on the idea that professional fees for construction are determined by taking into account the project's expected total cost, as Ojo et al. (2023) supported. They are afraid that the output of conducting VM will reduce the contract value, resulting in earning lower consultation fees. Lastly, the findings from the obstacle of inefficient conduct of VM studies reveal that many QS firms participating in VM workshops conducted by other consultants carry out the process informally, disregarding the existing VM manual. This is supported by Spellacy et al. (2021), who found that the VM study process has not been carried out efficiently, ultimately leading to ineffective outcomes.

5.3 Strategies to overcome the obstacles in adopting Value Management

The most significant strategy to overcome the obstacles in adopting Value Management is to educate the clients and decision-makers about the importance of VM. This strategy aligns with a study by Ellis et al. (2005), where they found that educated clients would most probably allow a series of interventions throughout the contract period, especially during briefing and feasibility studies. The second strategy, ranked the highest, is to make VM knowledge accessible. Instead of limiting the purchase power to acquire the knowledge of VM, the regulating bodies should make VM reference materials and information publicly accessible to industry practitioners. This is consistent with what Kim et al. (2016) have emphasised, where it is also essential to introduce the VM methodology in the organisations by providing VM seminars and a sample implementation of VM in some projects. The following strategy is to improve the VM syllabus in higher education institutions. This strategy aligns with the studies conducted by Tutesigensi et al. (2021), suggesting that VM techniques and applications should be taught to undergraduate students in construction-related fields such as the Department of Quantity Surveying, Building Surveying, Building, and Construction. By preparing the students with the necessary skills and knowledge about VM, this strategy might overcome the obstacles to the adoption of VM by the QS firms in Malaysia.

In addition, establishing a VM team in the organisation may be an effective strategy to overcome the obstacles to adopting VM by the QS firms in Malaysia. This strategy is consistent with what Li et al. (2022) have suggested in their study, where it is recommended for organisations to establish a professional VM team and develop a management model with a defined subject. Besides, RICS (2017) acknowledges that the QS should become an excellent VM facilitator representing their own organisations. Also, it is important to enforce mandatory VM training in the organisation. This strategy is emphasised by Kineber et al. (2022), Li et al. (2022) and Lin et al. (2022) in their studies, and it also applies to all QS in any organisation. Hence, QS firms should provide their employees with regular training and practices, including VM facilitator training and simulation workshops, as suggested by Bowen et al. (2009). Finally, the respondents suggest that the clients provide additional fees for VM services to the QS firms. Although some QS consultant companies do not officially offer VM services to the client, they must participate in the VM studies of selected projects in collaboration with other clients' consultants. Therefore, the regulating bodies must serve justice for the QS firms and consider the additional fees to those consultancy firms, as VM could be considered as a new scope of work for them, as supported by Wei & Keong (2016) and Saifulnizam et al. (2011).

6.0 CONCLUSION

The adoption of VM by Quantity Surveying firms in Malaysia is currently quite low. Several obstacles are holding back wider implementation. These include time constraints due to the lengthy process of Value Management, the client's reluctance to fund Value Management services, the reluctance of designers to adopt Value Management, and the shortage of trained professionals in Value Management. To overcome these challenges, several strategies can be employed: to educate the clients and decision-makers about the importance of Value Management, make Value Management knowledge accessible, and improve the Value Management syllabus in higher education institutions.

In conclusion, while the adoption of VM among Quantity Surveying firms in Malaysia is currently limited, addressing the identified obstacles through strategic initiatives can significantly enhance its implementation. This can lead to improved project outcomes and greater efficiency in the construction industry. Future research should focus on the current state of training and education in VM within Malaysia. This includes assessing the availability and quality of training programs and exploring ways to enhance the skills and knowledge of professionals in the field. By addressing this recommendation, future research can contribute to a deeper and more comprehensive understanding of VM practices in Malaysia, ultimately leading to improved implementation and outcomes in various industries.

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A SYSTEMATIC LITERATURE REVIEW ON CITY BRANDING AND IMAGE FOR AGRO-TOURISM AND BUNG KARNO MEMORABILIA DEVELOPMENT IN BLITAR

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ABSTRACT

This study aims to conduct a systematic literature review on the concepts of city branding, city image, and city identity, and how these three elements can support the development of the image of agro-tourism areas in Blitar City. With the increasing interest in agro-based tourism, it is essential to understand how effective branding can enhance the attractiveness and identity of the region. The methodology employed in this research involves a comprehensive literature analysis, gathering and evaluating various relevant studies. This review encompasses multiple aspects, including successful branding strategies, public perceptions of city image, and the factors that shape city identity. The findings indicate that the integration of city branding and the development of agro-tourism image can create positive synergies, enhance tourist appeal, and strengthen local identity. The results of this study are expected to provide recommendations for stakeholders in Blitar City in designing more effective branding strategies and developing policies that support the growth of the agro-tourism sector. Thus, this research not only contributes to academic literature but also offers practical guidance for sustainable tourism development in the region.

Keywords: agro-tourism, city branding, city identity, city image, sustainable tourism

1.0 INTRODUCTION

In an increasingly competitive global landscape, cities worldwide are actively cultivating unique identities to attract investment, tourism, and recognition (Kowaas, Syamsia, & Mandagi, 2023). This pursuit of distinctiveness involves strategic city branding efforts, aimed at shaping both the city's image and its inherent identity. City branding, at its core, is about highlighting a city's uniqueness to differentiate it from others. However, many promotional endeavors risk overlooking the genuine character of the city they seek to promote (Hidayat, Ismariati, & Apriliandini, 2019). This creates a tension between constructed image and authentic identity, a critical challenge for urban development.

Prior research emphasises the interplay between a city's physical attributes, cultural values, and technological advancements in shaping its image (Ghafar, Ghani, & Adam, 2022). The public's perception, or "city image," is the culmination of these characteristics as understood by its inhabitants and visitors (Chan, Suryadipura, & Kostini, 2021; Al-ghamdi & Al-Harigi, 2015). A cohesive city identity arises when branding and image resonate with the affective and emotional connections that people have with the place and are reinforced by cognitive understanding of its unique qualities (Peng, Strijker, & Wu, 2020; Sönmez, 2020).

While the literature extensively covers city branding, city image, and city identity separately, less attention has been paid to how these concepts can be integrated to support specific regional development goals. This study addresses this gap by examining the potential of city branding, city image, and city identity to foster the development of agro-tourism in Blitar City.

Blitar, renowned for its star fruit production, presents a unique opportunity to capitalise on its agricultural heritage, thereby boosting tourism and enhancing the regional economy.

This systematic literature review aims to:

1. Synthesise existing knowledge on city branding, city image, and city identity;
2. Analyse how these concepts interact and contribute to a cohesive city identity; and
3. Explore how these elements can support the development of Blitar's star fruit agro-tourism sector.

The review thereby provides a comprehensive understanding of how strategic branding is grounded in a deep understanding of city image and identity, which can contribute to sustainable tourism development and enhance Blitar's unique position in both regional and global contexts. It also offers practical insights for policymakers and stakeholders seeking to leverage the city's unique assets for economic and cultural growth.

2.0 LITERATURE REVIEW

2.1 City Branding

City branding has emerged as a critical strategy for urban development, aimed at enhancing a city's identity, attracting tourism, and improving the quality of life for its residents. It involves the promotion of a city's unique characteristics, including cultural diversity, historical significance, and natural resources. Recent studies emphasise the importance of integrating community engagement and effective governance in city branding efforts to ensure that the branding resonates with both residents and visitors. As cities compete for recognition and investment in an increasingly globalised environment, successful branding requires a comprehensive approach that addresses various dimensions such as public services, safety, and infrastructure.

Bung Karno's tomb complex

Homeland Defenders Struggle Museum (PETA)

Gebang Palace

Several ornaments found in Blitar city

Raden Wijaya Heroes Cemetery (TMP)

Fig. 1: National Tourism Attractions in The City of Blitar
(Source: Research Team Field Survey, 2025)

2.2 City Image

The concept of city image encompasses the perceptions and impressions that individuals construct about a city based on their direct experiences, interactions, and exposure to external information.. This image is influenced by various factors, including media representation, cultural events, and the overall atmosphere of the city. A positive city image can significantly impact tourism and economic development, as it shapes potential visitors' decisions to explore a destination. Research highlights that effective management of city image involves not only promoting attractions but also ensuring that the actual experiences align with the marketed image. This alignment is crucial for fostering long-term relationships with tourists and enhancing community pride.

2.3 The Attraction of Bung Karno's Tomb Blitar City

Blitar has significant potential for tourism development that focuses on historical attractions. The city of Blitar is closely related to Ir. Soekarno, the first president of the Republic of Indonesia. Soekarno was born in Blitar on June 6, 1901. Around 1917 - 1919, Soekarno's family lived in Blitar, precisely in a house called the Gebang Palace. The map museum is evidence of the history and identity of the PETA event, where Blitar City was once the center of the PETA army rebellion against the Japanese army. In addition, Soekarno was buried in the Raden Wijaya Heroes Cemetery (TMP) in Blitar. As Bumi Bung Karno, the city is known for the Bung Karno Tomb, which functions as a major national tourist destination, attracting visitors from various regions. Apart from that, there is the Blitar city square, Bung Karno's tomb complex, and Kebon Rojo which add to the impression of Blitar as a national tourist destination. As a form of city identity from Blitar, it has depicted several contexts of Blitar as a national city through several ornaments spread throughout the city of Blitar. See Fig. 1 for all National Tourism Attractions in The City of Blitar.

2.4 Starfruit Agrotourism Blitar City

The origin of Karangsari Starfruit Agrotourism began in 1985 whereby, Mr. Slamet planted the first starfruit tree in Karangsari Village. The story began when Mr. Suswanto, as the head of Karangsari Village, visited Mr. Slamet's house. He was treated to large, sweet, and fresh starfruit. Then the village head suggested increasing the number of starfruit seedlings. Then Mr. Suswanto held a meeting with several Karangsari residents, with the result that every house was required to plant a tree. In 2007, development was carried out by utilising the village land (tanah bengkok) with an area of 5.5 hectares with up to 2200 starfruit trees and the construction of a giant starfruit replica as an icon. In 2018 it was opened as an agro and continues to be managed by an agro manager consisting of 13 people including advisors, persons in charge, chairman, vice chairman, secretary, treasurer and sections. In addition, it is also managed by a community group of 35 people domiciled in Karangsari who also manage it as farmers, with 1 farmer taking care of 20-24 trees. However, in 2020 the number of trees decreased to 1933 trees. Due to the conversion of land use for facility development. Blitar has significant potential for tourism development at agrotourism. Additionally, Blitar boasts considerable agrotourism potential through the *belimbing* (star fruit) farms in Karangsari Urban Village (Fig. 2), offering a unique agricultural experience.

Karangsari Starfruit Agrotourism

Fig. 2: Karangsari Starfruit Agrotourism in The City of Blitar
(Source: Research Team Field Survey, 2025)

3.0 METHODOLOGY

The research conducted aims to study a literature review that can be utilised in descriptive and explanatory research. This study employs a systematic review approach that is narrative in nature, specifically utilising the Systematic Literature Review (SLR) method with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. The researchers identified and analysed relevant research topics within descriptive studies and discussed contemporary and engaging issues. Through the Systematic Literature Review using the PRISMA method, the researchers were able to comprehensively search for and filter relevant publication articles. To find publication articles that align with the research objectives, various inclusion and exclusion criteria established by the researchers were strictly applied.

The research consisted of 29 published articles, and the findings were organised methodologically and presented in accordance with PRISMA criteria. The PRISMA technique was used to assist in the methodological organisation and presentation of study findings. A comprehensive strategy was implemented to enhance knowledge about the subject by integrating information from 29 published articles that met the established criteria set by the research team. This study contributes to the advancement of knowledge in this field by employing a narrative systematic review technique while adhering to the principles outlined in the PRISMA guidelines, thereby providing results that can be useful for future descriptive and explanatory research. Fig 3 below shows the PRISMA methodology techniques employed by the researchers:

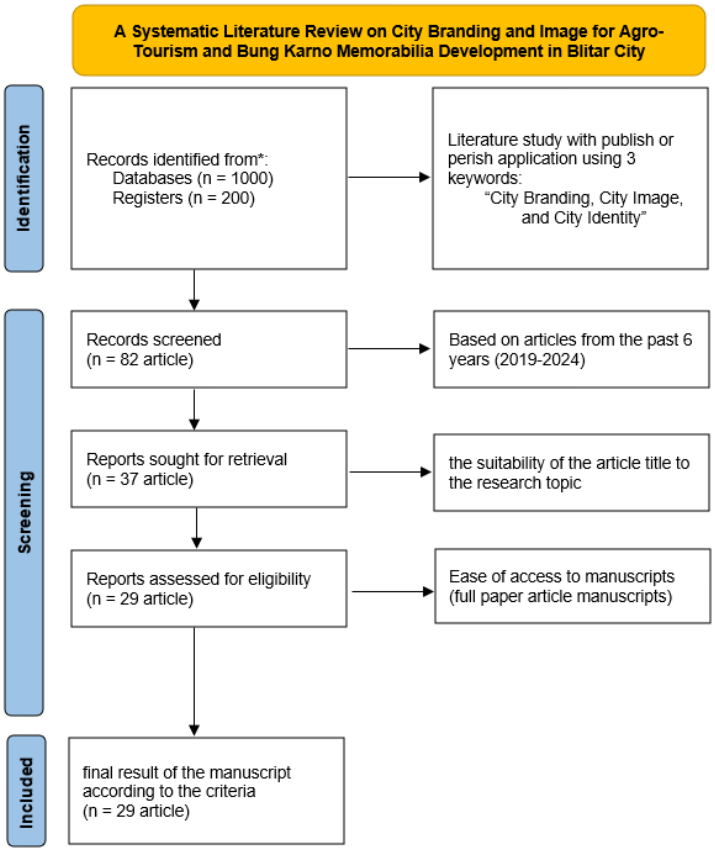

Fig. 3: Stages of SLR Analysis with the PRISMA Technique
(Source: PRISMA analysis, 2025)

4.0 RESULTS

4.1 Number and Type of Publication Articles

Based on the systematic literature review of 29 selected journal articles, information was obtained regarding the number and type of publications reviewed, as follows:

1. Journal Title and Code
   To facilitate the review conducted by the researchers, the reviewed journals were codified as shown in the Table 1.

Table 1: List of Journals Reviewed

Code	Title	Year	Country	Affiliation
[1]	Social Representations Of The European Capitals And Destination E-Branding Via Multi-Channel Web Communication	2019	Italy	Sapienza University of Rome
[2]	Boosting City Image For Creation Of A Certain City Brand	2019	Italy	School of Urban and Regional Planning, University of Florence
[3]	Planning Cities4People–A Body And Soul Analysis Of Urban Neighbourhoods	2020	Poland	KTH Royal Institute of Technology
[4]	History, Modernity, And City Branding In China: A Multimodal Critical Discourse Analysis Of Xi'an's Promotional Videos On Social Media	2023	China	The Hong Kong Polytechnic University
[5]	Branding China Through The Internationalization Of Higher Education Sector: An International Students' Perspective From China	2020	China	Kean University Wenzhou Campus
[6]	Art-Event Image In City Brand Equity: Mediating Role Of City Brand Attachment	2020	India	Cochin University of Science and Technology
[7]	Comparing City Image And Brand Identity In Polycentric Regions Using Network Analysis	2020	Netherland	Delft University of Technology
[8]	Leveraging Tokyo 2020 To Re-Image Japan And The Olympic City, Post-Fukushima	2021	England	University of Surrey
[9]	Informality And The Branding Of Creative Places: The Case Of Suci Screen-Printing Kampong In Bandung, Indonesia	2021	Indonesia	Institut Teknologi Bandung
[10]	Place Branding And Growth Machines: Implications For Spatial Planning And Urban Development	2022	Canada	Ryerson University dan University of Western Ontario
[11]	Place Branding (R)Evolution: The Management Of The Smart City's Brand	2021	Poland	Lodz University of Technology
[12]	The Sense Of Place And Its Influence On Place Branding: A Case Study Of Sanandaj Natural Landscape In Iran	2020	Iran	University of Tehran
[13]	Ningbo City Branding And Public Diplomacy Under The Belt And Road Initiative In China	2021	China	University of Nottingham Ningbo China
[14]	Architecture And City Branding: Role Of Iconic Buildings	2019	Egypt	October University for Modern Sciences and Arts (MSA) University
[15]	Tourism As An Aspect Of City Branding In Functional Urban Areas	2021	Poland	Bialystok University of Technology
[16]	Sullana City Brand: Opportunity And Challenges In Piura, Peru	2022	Peru	Universidad Nacional de Frontera (UNF)
[17]	Connecting Identity And Image Of City Branding In Kota Tua (Old City) Jakarta	2019	Indonesia	State University of Jakarta
[18]	Systematic Creation Of A City's Visual Communication: Logo Design Based On The Phoenix Flower In Tainan City, Taiwan	2022	China	City University of Macau
[19]	A Review Of The Essence Of City Branding In Enhancing Image And Identity Of A City	2022	Malaysia	UNIVERSITI MALAYA
[20]	The Adaptive Reuse Of Cultural And Historical Heritage As An Asset In City Of Riga Branding. Case Of Hanzas Perons	2022	Latvia	Latvian Academy of Culture
[21]	City And Festival: Spaces Of "Site" Identity, Territorial Development And Branding	2021	Russia	Irkutsk National Research Technical University
[22]	The Design Of City Brand Visual Image Recognition System	2021	Korea	Seoul National University
[23]	Media Technologies In Shaping Urban Identity	2020	Russia	Samara State Technical University
[24]	Between Branding And Being: How Are Inclusive City Branding And Inclusive City Practices Related?	2024	Netherland	Erasmus University Rotterdam
[25]	How Can Cities Build Their Brand Through Arts And Culture? An Analysis Of Ecoc Bidbooks From 2020	2024	Rumania	Transilvania University of Brasov

Code	Title	Year	Country	Affiliation
	To 2026			
[26]	A Critical Typology Of "Good Place Branding" Lessons From Place-Branding Expertise	2023	Sweden	Lund University
[27]	Place Attachment And The Expression Of Thematic Imageries In An Urban Kampung In Surakarta, Indonesia	2023	Indonesia	University of 17 Agustus 1945 (UNTAG) Semarang
[28]	Public Squares As Catalysts For City Brand	2023	Iraq	Architectural Engineering Department, Al Nahrain University
[29]	Temporary Identification Style Of Urban Areas	2021	Russia	Kazan State University of Architecture and Engineering

2. Distribution of Publication Years
   Literature studies on various academic publications regarding city branding, city image, and city identity are conducted by researchers, considering the increasingly dynamic and innovative developments of cities. Based on the classification by publication year, many studies indicate developments in research on city branding, city image, and city identity within the last five years. The studies conducted during the last five years are as follows: 2018 (13.79%), 2019 (20.69%), 2020 (27.59%), 2021 (16.24%), 2022 (13.79%), and 2024 (6.90%), as shown in Table 2:

Table 2 : Distribution of Publication Year

Years	Total	Percentage
2019	4	13,79
2020	6	20,69
2021	8	27,59
2022	5	16,24
2023	4	13,79
2024	2	6,90
Total	29	100,00

3. Distribution of Affiliations and Country of Origin of Publication Authors
   The classification of authors, as depicted by their affiliations, reveals that in the overall literature review of the 29 articles reviewed, all are affiliated with academic institutions, namely universities and colleges (See Fig. 4). This indicates that the scientific development regarding city branding, city image, and city identity is progressing dynamically and rapidly, so that research on this theme continues to develop both substantially and practically. Academic affiliations from various universities, spread across countries both developed and developing, demonstrate a collaborative effort in developing a future city identity.

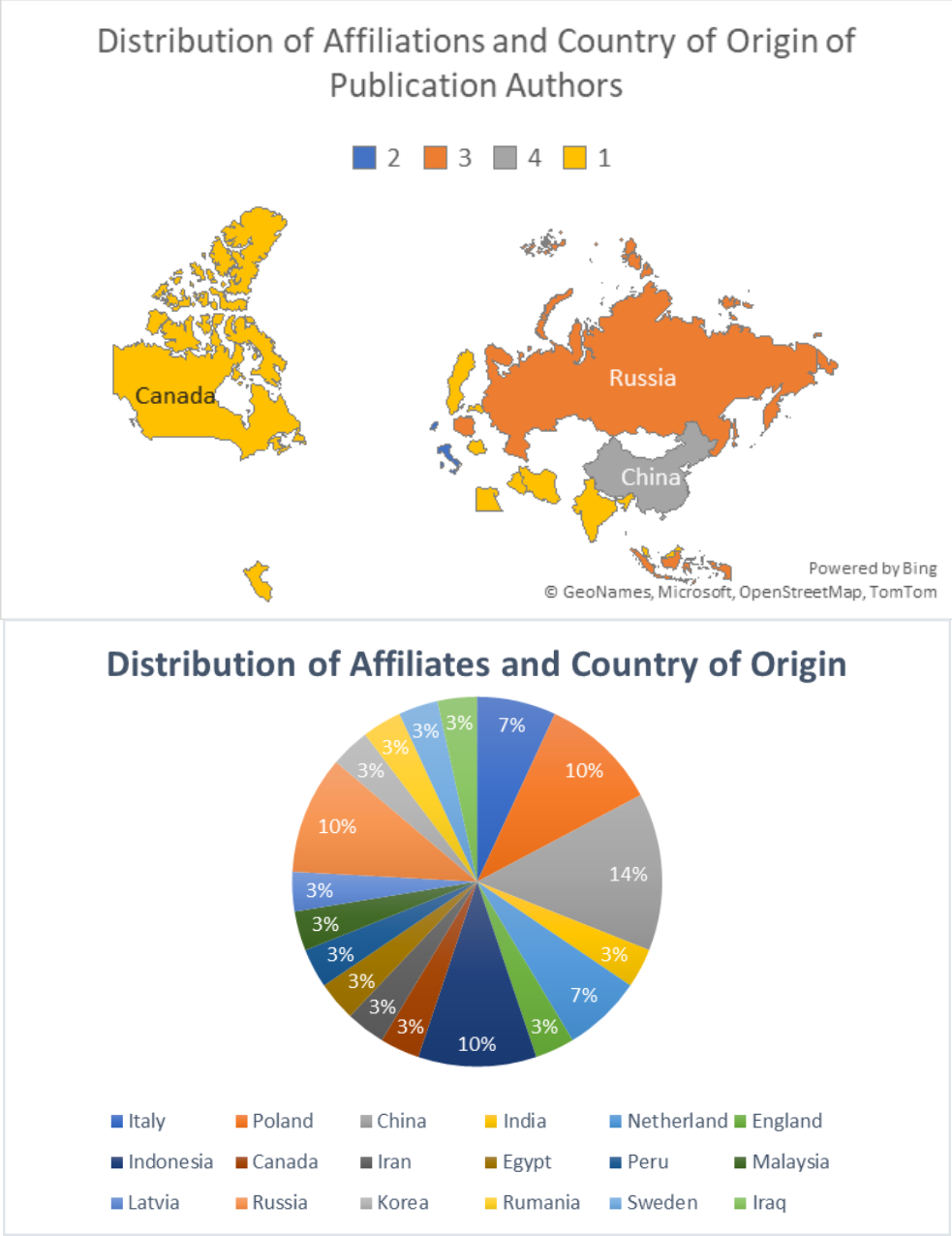

Fig. 4: Author Affiliation Distribution
(Source: Data Illustration with Microsoft Excel, 2025)

2.2 Important Substances of Publication Articles

Based on the results of a systematic literature review of 29 selected journal articles, the important substance of each article was obtained descriptively as shown in Table 3.

Table 3 : Review of Literature and Emerging Variables

No	Author	Research Theory	Methodology	Variable Research
1	A.S. de Rosa	Brand Identity (Aaker, 1996); Brand Image (Baloglu and McCleary, 1999)	Content Analysis	Institutional places, geographical places, social recreation places, urban places, architectural places; Best performance, good performance, medium performance, medium performance, lower performance; Updating, reability, content
2	A. Shirvani	Systematic approach	(Grounded Theory)	Economic Performance, Media and

	Dastgerdi	(Strauss & Corbin, 1994); Emerging approaches (Glaser, 1994); Constructivist approach (Charmaz, 2006)	Purposive Sampling dan Content Analysis	Advertising, Cultural Activities, Policy, Spatial Planning
3	M. Hårsman Wahlström	Place identity, place attachment	quantitative (Urban Neighbourhood analysis)	Body: Meeting place, public service, commercial service, connectivity; Love: pride, satisfaction, loyalty; Soul: cultural diversity, beauty, imagery, security, symbolic, experience, accessible nature, walkability, loyalty, identification
4	Y. Wang	Urban imaginary, city branding	Multimodal Critical Discourse Analysis	modernity: Style, Youth, Fantasy city, Popularity, internationality; historical: Reshaping and revitalizing folk arts
5	S. Yousaf	Nation Branding, customer-oriented perspectives (Lomer, Papatsiba, & Naidoo, 2018)	Snowball Sampling	country distance, national image, brand equity, behavioural intention
6	D. Jawahar	Event Image, city brand equity, city attachment	Sampling (kuisioner), SEM	Demographics and travel habits
7	N. Wäckerlin	Place Branding	Quantitative Network Analysis	People's Views on the City; Cognitive and affective attention
8	D.M.B. Duignan	Place Branding (Keller, 2003)	Qualitative and Multimethod	Branding strategies and initiatives, innovation functions and representatives, management challenges
9	F.Z. Fahmi	City Branding (Kavaratzis, 2004; Dinnie, 2011)	Qualitative (Content Analysis)	Village potential, development framework, development components, respect and self-esteem
10	E. Cleave	Place branding	semi-structured interviews	Central Partners, peripheral partners, cycles of place
11	M. Grebosz-Krawczyk	Smart City	direct or indirect communication with respondents through questionnaire surveys by phone or online	Emotional Values, Functional values, smart values
12	H. Falahatkar	Sense of Place	Qualitative	Social and cultural (ethnicity and religious background)
13	S.I. Zhang	city branding	Qualitative	Stakeholder perception: Official, residents, business, expatriates
14	R. El Messeidy	City Branding	Qualitative	Landmark, spot truism, perspective
15	E. Glińska	City Branding	Content Analysis	Atmosphere, attraction, amenities, access
16	A.P.C. Milagros	City Branding	Quantitative, descriptive (Random Probability Sampling)	Colour Association, Banyangan Association, Slogan, Pride
17	R. Hidayat	City Branding, City Image, Image Building	Qualitative	Symbols, Slogans, logos, brands, and other attributes
18	W.P. Hsun	Bergstrom (2008) contends that two aspects make up a sign: form and content.	Content Analysis and Morphology Analysis	Symbols, cultural elements, Typeface design, Industrial embodiments, meaning of the human body
19	N.A. Ghafar	City Image and City Identity, Kavaratzis (2009) and Oguztimur and Akturan (2015).	Content Analysis	Emotional value, identity, city assets

20	L. Ozoliņa	cultural heritage, city identity, city branding, sense of belonging	Qualitative	architecture and cultural heritage, adaptive reuse as a process of preservation, architecture, and opportunity
21	O. Ye Zheleznyak	Authentic image space and traditional festival cultural archetypes	Descriptive	Regional uniqueness, Vital activities, Meetings between traditions
22	Y. Wu	City visual image	Response Surface Method Experiment (RSM and ANN)	Urban Planning and Demography
23	T.V. Karakova	Urban Image	Qualitative	Communion, Deterritorialization, attitude
24	R. Zhao	city branding	Qualitative (content analysis)	Practice and Demographics
25	E.L. Ciuculescu	City branding	Qualitative	Cultural programs that can be a branding strategy
26	J. Bertilsson	Good Place Branding (Weber, 1922)	Grounded Theory	Totemic, Artistic, Platformic, Mimetic
27	Krismawanti	Place attachment	Qualitative	People, Culture, and Place
28	S.M. Jameel	Kevin Lynch 1960 (City Image)	Descriptive Approach with Questionnaires	Dimensions and Images of Public Spaces; Quality of Public Space; City Image; City Identity
29	D. Koshkin	Urban Temporary Identification Style	Typology and classification approach	Cultural Event, Sport event, Design

From the preceding steps, it was observed that there are several similarities in research variables, theories, and methodologies used across the journals. Subsequently, an interpretation of the variables was conducted to determine the number of shared variables used by the identified journals. Table 4 shows the distribution of research variables.

Table 4 : Distribution of Research Variables

No	Variable Research	Research Paper	Total
1	Economics	Shirvani Dastgerdi & De Luca, (2019) ; Jameel & Hussien (2023)	2
2	Culture	Shirvani Dastgerdi & De Luca, (2019) ; Falahatkar & Aminzadeh (2020) ; Ozolina, (2022) ; Zheleznyak & Korelina (2021) ; Ciuculescu & Luca (2024) ; Krismawanti, K., & Nursanty, E. (2023) ; (Jameel & Hussien, 2023) ; Koskhin (2021) ;	8
3	Policy and Government	Shirvani Dastgerdi & De Luca, (2019) ; Jameel & Hussien, (2023)	2
4	Spatial Planning	Shirvani Dastgerdi & De Luca, (2019) ; |Wu, Y., & Shen, M. (2021)	2
5	Habits or activities	Yousaf (2020) ; Jawahar (2020) ; Zheleznyak & Korelina (2021) ; Jameel & Hussien (2023) ;	4
6	Demography	Jawahar (2020) ; |Wu, Y., & Shen, M. (2021) ; Zhao et al., (2024)	3
7	Functions and Representatives of Innovation	Duignan (2021) ; Grebosz-Krawczyk (2021) ; (Jameel & Hussien, 2023) ;	3
8	Place	Cleave & Arku, (2022) ; Krismawanti, K., & Nursanty, E. (2023) ;	2
9	Emosional value	Grebosz-Krawczyk (2021) ; Ghafar et al. (2022)	2
10	Social	(Falahatkar & Aminzadeh, 2020) ; (Jameel & Hussien, 2023);	2
11	Identity	Hidayat (2019) ; Ghafar et al. (2022)	2

5.0 DISCUSSIONS

5.1 City Branding and Strategy for Blitar City

The multifaceted concept of City Branding emerges as a prominent theme in a significant portion of the reviewed literature (Shirvani Dastgerdi & De Luca, 2019), (Wang & Feng, 2023), (Yousaf et al., 2020), (Jawahar et al., 2020), (Wäckerlin et al., 2020), (Duignan, 2021), (Fahmi et al., 2021), (Cleave & Arku, 2022), (Falahatkar & Aminzadeh, 2020), (Zhang et al., 2021), (El Messeidy, 2019), (Glińska, 2021) , (Milagros, 2022), (Hidayat et al., 2019), (Ozolina, 2022), (Zhao et al., 2024), (Ciuculescu & Luca, 2024), and (Jameel & Hussien, 2023), with 18 out of 29 articles directly addressing it. These studies collectively highlight a range of key variables that intricately shape a city's brand identity. The preceding analysis identifies 11 key components that shape city branding. For Blitar to effectively position itself as a national tourism destination centered on its unique historical and cultural assets—namely, the Tomb of Bung Karno (Indonesia's first president), the Proclamators of Indonesian Independence, and starfruit agrotourism in Karangsari —these components must be strategically leveraged:

1. **Economic Landscape**: As Bumi Bung Karno, Blitar can leverage tourism centred on its historical significance and agrotourism in Karangsari. Supporting local businesses that offer Bung Karno-themed memorabilia and star fruit-based products boosts the local economy and enhances the city's brand. Highlighting these unique economic drives attracts tourists seeking cultural experiences and agricultural products, solidifying Blitar's economic landscape as a blend of history and nature.
2. **Historical Context and Modernity**: Blending historical narratives with contemporary innovation, Blitar can connect its legacy as Bumi Bung Karno with modern attractions. Interactive exhibits at the Bung Karno Museum and virtual tours of star fruit farms create a unique experience. This approach celebrates Blitar's past while offering engaging, modern tourism opportunities.
3. **Urban Activities and Events**: Organising events and festivals that celebrate Blitar's historical and agricultural heritage enhances its brand. Commemorations of Bung Karno's life and star fruit harvest festivals create a vibrant atmosphere. These activities attract tourists and highlight the city's unique blend of history and agriculture.
4. **Demographic Diversity**: Promoting inclusivity while showcasing Blitar's rich history related to Bung Karno and the star fruit agro-industry helps attract visitors. Supporting cultural exchange programs and community-based tourism initiatives further enriches the visitor experience. Engaging diverse community members in tourism efforts enhances the environment for both residents and visitors.
5. **Perceptual Impressions**: By ensuring positive experiences and promoting what Blitar offers, effective management of these elements can grow tourism for Bumi Bung Karno and star fruit. Addressing concerns and promoting what Blitar has to offer strengthens Blitar's reputation and attracts tourists. Showcasing these unique facets enhances Blitar's appeal.
6. **Functional Innovation**: Functional innovation improves tourist experiences, as innovation can help tourists get around historical sites or star fruit farms. By implementing user-friendly mobile apps for the city that help guide people around, this makes the city becomes more memorable for tourists. It would also positively shape the image of the city.
7. **Development Potential and Awareness**: Capitalising on Blitar's historical assets and Karangsari's star fruit agro-industry drives tourism. Developing themed accommodations and cultural experiences centered around Bung Karno and star fruit enhances the city's appeal. Highlighting these aspects draws tourists and strengthens Blitar's brand.
8. **Policy and Governance**: Developing policies that support tourism development while preserving Blitar's cultural heritage and star fruit agro-industry is essential for long-term success. Protecting sites, promoting sustainable tourism, and encouraging local involvement are key. These measures create a collaborative environment, enabling active participation in

shaping Blitar's brand identity.

9. **Iconic Landmarks**: Leveraging the Tomb of Bung Karno and star fruit farms as iconic landmarks defines Blitar's identity. Promoting these landmarks through targeted marketing campaigns makes them recognisable to visitors. These recognisable locations draw visitors in and shape Blitar's identity.
10. **Tourism & Tourism Infrastructure**: Improving accommodations and the visitor center enhances tourist experiences, especially for Bumi Bung Karno and star fruit. By providing high-quality services and amenities, this increases the city's image as a prime location. Doing so will create a unique experience.
11. **Identity & City Slogan**: Developing a slogan that represents the legacies of Bumi Bung Karno and star fruit is paramount for Blitar. A good city slogan can attract more tourists by showcasing both those aspects of the city and setting it apart from others. This will entice those looking for an authentic cultural experience.

5.2 City Image and Strategy for Blitar City

The discussion of city image is covered in detail in Journals (Shirvani Dastgerdi & De Luca, 2019), (Hårsman Wahlström et al., 2020), (Jawahar et al., 2020), (Grebosz-Krawczyk, 2021), (Ghafar et al., 2022), (Wu & Shen, 2021) and (Karakova et al., 2020). Based on the systematic review of 7 out of 29 journals, the topic of city image is discussed. Within the discussion of city image, it is known that several variables are discussed in several journals and are key to seeing how a city image can be formed:

1. **Media and Advertising**: Media and advertising play a crucial role in shaping the image of a city. In Blitar, effective communication strategies that promote its identity as Bumi Bung Karno and highlight the agrotourism potential of star fruit can significantly enhance public perception. Utilising various media channels to disseminate information about historical sites and agricultural attractions will help create a favorable impression. As discussed in Journals (Shirvani Dastgerdi & De Luca, 2019) and (Karakova et al., 2020), targeted advertising campaigns can effectively communicate Blitar's unique offerings to potential visitors.
2. **Spatial Planning**: Spatial planning is essential for developing a coherent city image that reflects its historical significance and agricultural assets. In Blitar, well-structured urban planning can facilitate access to key attractions like the Tomb of Bung Karno and star fruit farms in Karangsari. By integrating these elements into policy documents, the city can create an inviting environment that enhances its image as a tourist destination. This aspect is emphasised in Journals (Shirvani Dastgerdi & De Luca, 2019) and (Wu & Shen, 2021), which highlight the importance of strategic planning in shaping a city's identity.
3. **Product Perception**: The perception of products associated with a city contributes significantly to its overall image. In Blitar, promoting local products such as star fruit and Bung Karno memorabilia can enhance the city's branding efforts. By emphasising the quality and uniqueness of these products, Blitar can foster a strong connection between its agricultural heritage and historical significance. This connection is explored in Journals (Hårsman Wahlström et al., 2020) and (Jawahar et al., 2020), which discuss how product perception influences city branding.
4. **Event Image**: Events play a vital role in shaping the character of a city's image. For Blitar, hosting events that celebrate its historical legacy and agricultural heritage—such as star fruit festivals or commemorations of Bung Karno—can create memorable experiences for visitors. These events not only attract tourists but also foster community pride and engagement. The significance of the event image is discussed in Journal (Jawahar et al., 2020), highlighting how such activities contribute to a city's overall branding strategy.
5. **Value**: The concept of value encompasses both emotional and practical aspects that shape a city's image. In Blitar, promoting the emotional value associated with its historical sites and agricultural experiences can enhance visitor engagement. By highlighting the unique stories behind Bung Karno's legacy and the cultural significance of star fruit, Blitar can create a compelling narrative that resonates with tourists. This aspect is explored in Journals (Grebosz-Krawczyk, 2021) and (Ghafar et al., 2022), which emphasise the importance of value in city branding.
6. **City Assets**: The assets possessed by a city are fundamental in forming its image. In Blitar, leveraging iconic landmarks like the Tomb of Bung Karno alongside agricultural assets such as star fruit farms creates a distinctive identity for the city. These assets not only provide cultural significance but also serve as attractions that attract visitors. The importance of urban assets in shaping city image is highlighted in Journal (Ghafar et al., 2022), underscoring their role in branding efforts.

6.0 CONCLUSION

In conclusion, the development of city branding for Blitar as Bumi Bung Karno and its agrotourism potential through Karangsari's star fruit farms is essential for enhancing its identity and attracting visitors. By strategically leveraging various components such as media and advertising, spatial planning, product perception, event image, and urban assets, Blitar can create a compelling narrative that resonates with both tourists and residents. These elements work synergistically to shape a positive city image that reflects Blitar's rich historical legacy and agricultural heritage.

Furthermore, effective policy and governance are critical to support these branding efforts. Implementing regulations that promote sustainable tourism practices while preserving cultural heritage will ensure long-term success. By fostering community involvement and enhancing infrastructure, Blitar can create an inviting environment that not only attracts tourists but also instills pride among its residents. Ultimately, a well-executed city branding strategy will position Blitar as a premier destination for cultural and agrotourism, celebrating its unique offerings while contributing to the local economy.

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CULTURAL PRESERVATION MEETS MODERN DESIGN: INVESTIGATING THE IMPACT OF TRADITIONAL WOODCARVINGS ON NATURAL VENTILATION IN HUNGARY

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ABSTRACT

This study investigates the integration of traditional woodcarving panels to enhance natural ventilation (NV) and thermal comfort in modern architecture. Focusing on Szombathely, Hungary, the research employs wind analysis, microclimate assessment, and Computational Fluid Dynamics (CFD) simulations to assess the effect of woodcarving designs on airflow and indoor comfort. The panels derived from Hungarian cultural motifs were analysed using Free Area Ratio (FAR) values of 46.57% and 44.85%. Simulation results revealed air velocity improvements of up to 2.2 m/s inside living spaces, indicating significant passive cooling benefits. The findings highlighted the potential of integrating cultural craftsmanship with contemporary architectural design to promote sustainable, energy-efficient buildings honouring local heritage.

Keywords: Natural Ventilation, Thermal Comfort, Cultural Heritage, Woodcarving panel, Computational Fluid Dynamics (CFD)

1.0 INTRODUCTION

Integrating traditional elements like woodcarving into modern architecture has gained attention for aesthetic and functional benefits (Zhang, 2024; Xu, 2024). Woodcarving, especially in the form of ventilation panels, has been used across cultures, including Hungarian architecture, to enhance natural ventilation (NV) and improve indoor air quality (IAQ) (Callegari, 2024). With the growing impact of climate change, particularly in temperate regions like Szombathely, Hungary, effective NV strategies are increasingly critical to maintaining indoor comfort, especially during hot summers (Oleiwi, Sulaiman, & Mohamed, 2023). Szombathely experiences a temperate climate characterised by warm to hot summers and cold winters. As an inland city in western Hungary, it lies far from large bodies of water such as the Adriatic or Black Sea, limiting maritime influence and contributing to more extreme temperature fluctuations. Urban areas like Szombathely are also affected by the Urban Heat Island (UHI) effect, where temperatures are higher than in surrounding rural areas due to surface materials and anthropogenic heat sources (Zsolt, 2009). This phenomenon intensifies summer heat stress, making passive cooling solutions particularly important. Uncomfortable summer conditions typically last from late June to early September, with daytime temperatures frequently exceeding 30°C. Due to the city's inland topography and absence of coastal ventilation, localised strategies such as passive NV are crucial for heat mitigation. Historical data from Hungary's 2007 heatwaves indicated significant health impacts, reinforcing the urgency of thermal comfort interventions in urban environments (Paldy & Bobvos, 2010).

Buildings consume a substantial amount of energy, with Heating, Ventilation, and Air Conditioning (HVAC) systems accounting for approximately 50% of total use (Cho, Woo, Park, & Shin, 2013). While active systems

such as heat pumps and intelligent energy management have improved efficiency (Nguyen & Nassif, 2016), reducing dependency on mechanical cooling remains a key goal of sustainable architecture. Natural ventilation (NV) offers a passive, energy-saving alternative that improves air quality and reduces environmental impact. However, in climates experiencing extreme summer heat, passive solutions alone may be insufficient for maintaining thermal comfort.

This study examines how woodcarving ventilation panels can improve NV and thermal comfort in Szombathely's climate. The hypothesis is that while woodcarving panels enhance airflow, their ability to regulate temperature during extreme heat may be limited, requiring additional cooling methods. Computational fluid dynamics (CFD) simulations assess airflow and temperature within a building, considering Szombathely's wind speeds of up to 14 m/s and summer temperatures reaching 34°C. The study also analyses the panels' Free Area Ratio (FAR) for its impact on NV efficiency.

This research also draws parallels to the Malaysian context, where the decline of traditional Malay architecture elements such as woodcarvings and passive ventilation systems has similarly raised concerns about cultural erosion and environmental inefficiency in modern construction, particularly in states like Kelantan (Abdul Razak & Sabil, 2024; Harun, Mohd Ariffin, & Abdullah, 2017). The research aims to contribute to understanding how traditional elements like woodcarving can be adapted to modern architecture for better energy efficiency and comfort, particularly in climates experiencing extreme summer heat. The findings suggest the benefits of combining passive and active cooling methods for improved thermal comfort.

2.0 LITERATURE REVIEW

2.1 Natural Ventilation and Thermal Comfort Standards

Natural ventilation (NV) uses natural airflow to enhance indoor air quality (IAQ) and thermal comfort while reducing energy consumption. It adapts to local climates, using techniques such as cross-ventilation and windcatchers to regulate temperatures (Ahmed, Kumar, & Mottet, 2021). While NV performs well in temperate climates, it may not be sufficient during heatwaves or extreme summer temperatures, requiring hybrid strategies combining passive and mechanical methods.

The ASHRAE Standard 55 adaptive model is often referenced to define thermal comfort benchmarks in NV-based designs. This model accounts for temperature, humidity, airspeed, and metabolic rate in non-mechanically cooled environments. Table 1 presents key adaptive comfort parameters relevant to NV-based design.

Table 1: Adaptive Comfort Model from ASHRAE Standard 55

Parameter	Value	Unit
Summer Clothing Indoors	0.5	Clo
Activity Level Daytime	1.1	Met
Predicted Percent of People Satisfied	90.0	%
Comfort Highest Summer Temperature	26.7	°C
Maximum Humidity	84.6	%
Minimum Dry Bulb Temperature for Sun Shading	23.8	°C
Minimum Global Horizontal Radiation for Sun Shading	315.5	Wh/sq.m
Maximum Wet Bulb Temperature (Direct Evaporative Cooling)	20.0	°C
Minimum Indoor Air Velocity for Comfort	0.2	m/s
Maximum Comfortable Air Velocity	1.5	m/s
Maximum Mechanical Ventilation Velocity	0.8	m/s
Maximum Perceived Temperature Reduction (Fan-Forced Ventilation)	3.0	°C

Table 2 presents climate-specific comfort parameters for Szombathely, Hungary. These highlight local wind, temperature, and humidity patterns crucial for evaluating passive NV systems' performance during summer.

Table 2: Summer-specific temperature, humidity, wind speed, and comfort conditions in Szombathely, Hungary.

Parameter	**Details for summer (June – September)**
Temperature Range	Morning Low: 18°C Afternoon High: 34°C
Adaptive comfort zone	Temperature: 20°C - 27°C Humidity: 30% - 70%
Predominant Wind Directions	North-Northwest (NNW), North (N), Northwest (NW)
Common Wind Speeds	Frequently between 2 - 6 m/s (7 - 22 km/h)
Maximum Observed Wind Speed	Up to 14 m/s (50 km/h), primarily from northern directions
Calm Periods	Few, with speeds below 2 m/s (7 km/h)
Humidity Range	Generally, falls between 30% to 70%
Percentage of Time in Comfort Zone	Approximately 8.1% of the summer season fits within the Adaptive Comfort Zone

2.2 Székely Gate woodcarving and its relation to Hungarian culture

Székely woodcarving, seen in the traditional Székely gate (Figure 1), is a key element of Hungarian cultural heritage. These carvings, featuring floral and geometric motifs, serve aesthetic and symbolic purposes, often representing life and continuity. The intricate design of Székely woodcarving could be adapted for modern use, such as in architectural ventilation panels, to improve airflow and cooling in contemporary buildings (Bárth, 2023)

Fig. 1: Hungarian Székely Gate.
(Source: https://www.hungarikum.hu/en/content/sz%C3%A9kely-gate).

2.3 Integration of ventilation panel into modern buildings

Incorporating NV into modern design, including through woodcarving panels, has gained attention in sustainable architecture. Vernacular buildings have long employed bioclimatic design to optimise airflow, with examples like Mediterranean timber projections offering passive cooling (Thravalou, Michael, Neophytou, & Philokyprou, 2023). Similarly, a study in Malaysia comparing Mashrabiya and Malay carved window panels found that these traditional perforated designs significantly enhance internal air velocity up to three times the base wind speed, demonstrating the airflow potential of carved openings in passive ventilation systems (Baydoun & Sapian, 2022a).

Recent innovations, such as semi-transparent photovoltaic façades, integrate NV with energy efficiency (Ni, Shi, Lei, Wang, & Xu, 2022). However, NV's success depends on local, historical, and economic factors, requiring

careful design adjustments to ensure effectiveness across diverse environments (Yin & Qi, 2022). In the context of Hungary, adapting Székely carving techniques into functional panels may offer a unique opportunity to blend cultural heritage with climate-responsive design.

3.0 METHODOLOGY

3.1 Site-specific microclimate analysis

Microclimate analysis is crucial for optimising architectural design to improve occupant comfort and energy efficiency. Architects can refine NV strategies and reduce reliance on mechanical cooling by assessing factors like temperature, humidity, wind patterns, and solar radiation (Graham, Berardi, Turnbull, & McKaye, 2020). This study uses Climate Consultant 6.0 to analyse Szombathely's summer climate, ensuring that traditional woodcarving panels are effectively adapted to modern contexts. The adaptive comfort model from ASHRAE Standard 55 defines thermal conditions for naturally ventilated spaces, relevant in the absence of mechanical cooling.

As shown earlier in Table 2 (section 2.1), Szombathely's summer climate (June-September) features temperatures ranging from 18°C in the morning to 34°C in the afternoon, with an adaptive comfort zone between 20°C and 27°C. The dominant wind directions are NNW, N, and NW, with speeds between 2-6 m/s (7-22 km/h), occasionally reaching 14 m/s (50 km/h). Relative humidity generally falls between 30-70%, with ideal NV conditions occurring only 8.1% of the time. Szombathely was chosen due to its distinct summer climate and available EPW data, offering insights into passive cooling strategies in Hungary's warm summer conditions and the potential of woodcarving panels to enhance airflow and comfort.

3.2 Geometry setup

A basic room model 10m x 6m x 3.5m was developed in Autodesk Revit to explore the integration of traditional woodcarving elements in modern architecture (Figure 2). Woodcarving panels were positioned above windows and the main door to assess their impact on NV, shown in Figure 3. Two human figures were included in the bedroom and kitchen (Figure 4), with interior doors left open (Figure 5) to simulate realistic thermal comfort conditions under peak summer temperatures and maximum wind speeds. The model was simplified for seamless CFD integration, ensuring accurate airflow analysis and ease of interpretation.

The base model was developed as a simplified representation of a compact residential unit, rather than being modelled after an existing building. Its rectangular form and dimensions reflect common housing typologies in low-rise urban settings. The orientation of the building aligns with the prevailing wind directions in Szombathely, primarily from the NNW, ensuring optimal conditions for cross-ventilation studies. While the design is hypothetical, it was informed by climatic data and vernacular spatial layouts. Figure 2 shows the floor plan and window-door arrangements selected to simulate real-world passive cooling scenarios.

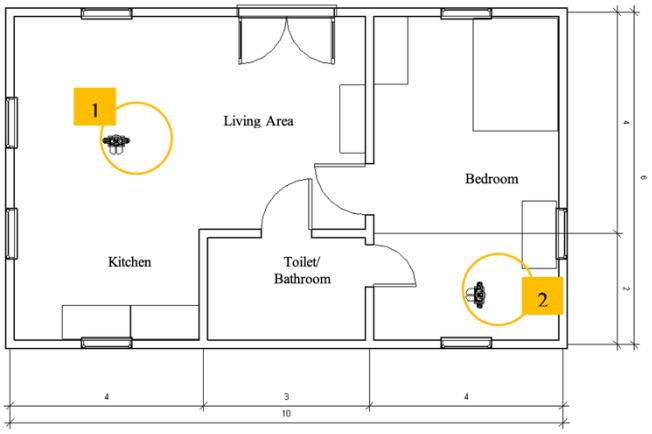

Fig. 2: Floor plan.

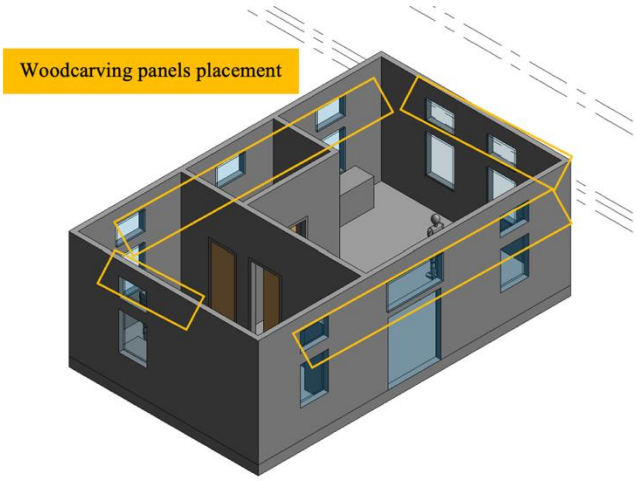

Fig. 3: Woodcarving panels placement.

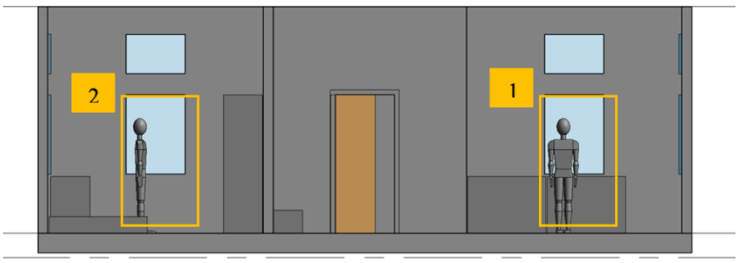

Fig. 4: Human figure placement.

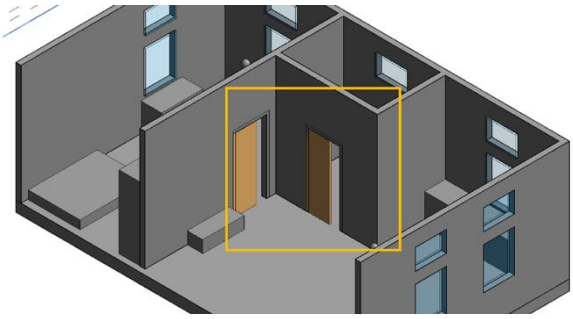

Fig. 5: Interior doors condition.

3.3 Woodcarving design analysis

The kaputükör or gate mirror is a traditional decorative element from the Székely gates of Hungary, known for its intricate and symbolic patterns. These gate mirrors are essential to Hungarian cultural heritage, often representing values and beliefs deeply rooted in the region's folklore (Preda et al., 2018). Figure 6 shows a traditional kaputükör design, which inspires the reinterpretation used in this study.

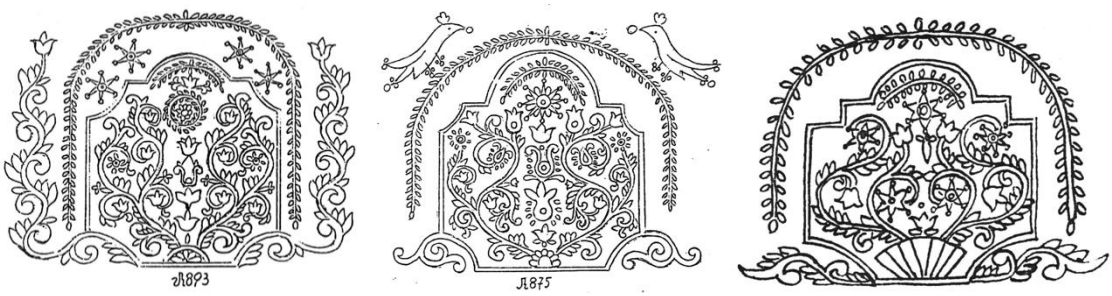

Fig. 6: Kaputükör minták (Source: Kovács, 2005)

To support airflow analysis, the design was simplified into a black-and-white representation (Figure 7), where white indicates solid (positive) space and black represents void (negative space. This approach improves the clarity of FAR calculations and the accuracy of airflow simulation in CFD models.

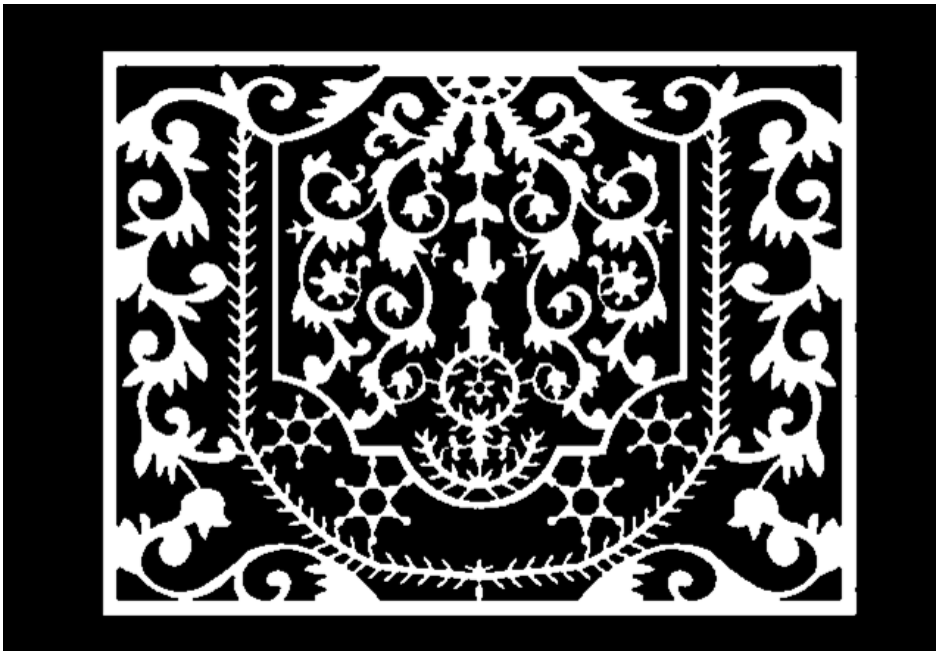

Fig. 7: Reinterpreted woodcarving panel for ventilation use.

The motif is a harmonious blend of floral motifs, celestial elements such as the sun and stars, and nature-inspired designs. The floral motifs symbolise growth and vitality, while the sun and stars evoke timelessness and a connection to the cosmos. These patterns are not merely decorative; they embody cultural and symbolic meanings, reflecting the values and beliefs of the Székely people. The meticulous craftsmanship of the kaputükör significantly enhances the aesthetic and cultural value of Székely gates.

Table 3: Woodcarving panel type for Szombathely.

Location	Code	Panel	Description
Above the windows & toilet wall	WC3		• QTY: 8 Nos • Size: 609.6 mm x 914.4 mm
Above the main entrance	WC4		• QTY: 1 Nos • Size: 800 mm x 1800 mm

Table 3 shows the installation locations of the woodcarving panels at two critical points within the building: above the windows (WC3), toilet wall (WC3), and main entrance (WC4). The total of 9 units was placed at these locations. These panels maintain consistent design and functionality, supporting cross ventilation within the structure while enhancing its aesthetic appeal.

3.4 Parameter setup for CFD simulation

The external air volume for the CFD simulations shown in Figure 8 was carefully defined to reflect realistic environmental conditions specific to Szombathely, Hungary. Its dimensions were 1289.112 mm (H), 3412.6 mm (W), and 6700.589 mm (D), adhering to the proportional guidelines outlined in the Autodesk tutorial. These proportions ensured that the air volume extended sufficiently beyond the building geometry to accurately model airflow interactions without boundary interference. Combined at -22.5 degrees, this setup simulated the natural wind flow conditions that are rarely perpendicular to the building façade. Materials were assigned as specified in Figure 8.

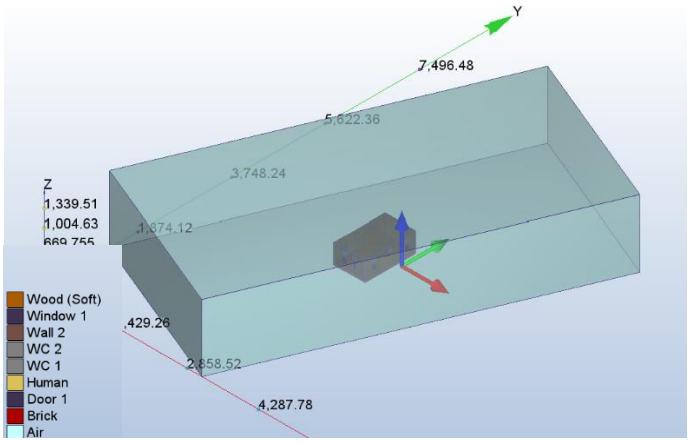

Figure 8: CFD external air volume & materials setup.

With the external air volume and parameters for the ventilation systems established, the simulation then analyses the airflow and thermal conditions based on distinct temperatures and wind speeds. The boundary conditions applied are summarised in Table 4 below:

Table 4: Boundary conditions for Szombathely.

Boundary condition	**Value (Szombathely)**	**Surface/Volume**
Temperature	34°C	-Northwest facing (Szombathely) external air volume
Velocity	14m/s	North-Northwest facing (Szombathely) external air volume to simulate wind flow
Pressure	0 Pa	South-Southeast facing (Szombathely) external air volume, acting as the outlet.
Film coefficient	20 W/m²K	The entire outer surface of the building
Human	60 W/m²K	Two human figures are positioned within the building to assess thermal comfort

Materials settings:

- Walls: hardwood, thermal conductivity: 0.065 W/mK. Saved as Wall 1.
- Windows: Solar window material, thermal conductivity: 0.2 W/mK. Saved as Window 1.
- Entrance door: solar window material, thermal conductivity: 0.23 W/mK. Saved as Door 1.

These updates ensure accurate thermal properties for walls, windows and doors, supporting a realistic simulation of airflow and thermal performance based on Szombathely's climate.

3.4.1 Justification for Using Free Area Ratio (FAR) Instead of Window-to-Wall Ratio (WWR)

The window-to-wall ratio (WWR) is a commonly used metric in building design to assess the proportion of glazed openings relative to wall surface area. However, WWR is limited in its applicability to non-glazed, perforated elements such as traditional woodcarving panels. WWR does not capture the airflow elements, such as conventional woodcarving panels. It does not account for airflow behaviour or permeability, which are essential for accurate simulation of NV performance (Rana, Hasan, Sobuz, & Tam, 2022).

In contrast, the FAR provides a more appropriate metric, specifically quantifying the percentage of open (void) area in a perforated panel relative to its total area. This makes FAR particularly effective for evaluating the airflow performance of carved wood panels used in passive cooling applications. Studies have shown that perforated architectural elements, such as Mashrabiya and traditional Malay carving windows, can significantly enhance indoor air velocity and thermal comfort by facilitating controlled cross-ventilation (Baydoun & Sapian, 2022b).

FAR directly correlates to airflow resistance and pressure drop, critical for realistic CFD simulations. Its adoption in simulation modelling helps guide design strategies in climates where passive ventilation is necessary to reduce reliance on mechanical systems.

FAR formula: $$FAR = \frac{Void\ Area}{Total\ Area}\ x\ 100$$

Table 5: FAR for woodcarving panels.

Woodcarving Panel	FAR
WC3	0.4657 or 46.57%
WC4	0.4485 or 44.85%

The FAR analysis shows varying balances of solid and void areas. WC3 (46.57%) is highly effective for maximising airflow while retaining sufficient material for support, and WC4 (44.85%), balancing ventilation and decorative appeal, is optimal for enhancing NV. Using boundary conditions based on Szombathely's climate, the CFD simulation was validated by comparing the results with local data. An unstructured grid mesh ensured accurate airflow capture, particularly around the woodcarving panels.

4.0 RESULTS

4.1 Flow and temperature distribution

This section presents a comparative analysis of airflow and temperature distribution patterns in Szombathely, as depicted in the CFD simulation in Figure 9. The simulation is based on a wind speed of 14 m/s and an ambient temperature of 34 °C. Szombathely ranges from 34 °C to 36.8 °C, with more pronounced temperature gradients observed between the cooler incoming airflow and the warmer air downstream of the building. Inside, the temperature ranges from 34 °C to 35.2°C, while the external temperature fluctuates between 34°C and 36.8°C, contributing to significant temperature fluctuations.

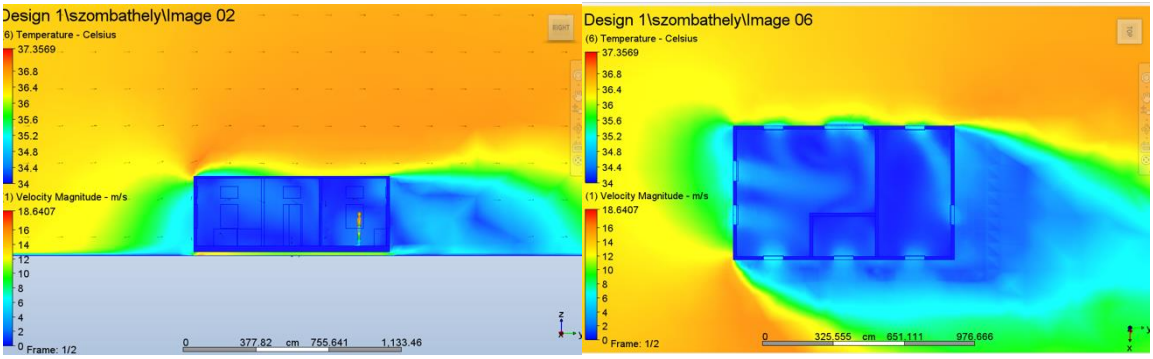

Figure 9: Flow and temperature distribution.

The airflow inside the building is shown with colour contours ranging from blue to light blue, indicating wind velocities between 9 and 14 m/s. The simulation shows a dynamic airflow pattern in Szombathely, with stronger winds creating turbulence and noticeable variations in wind direction and intensity throughout the building. These higher wind speeds make the woodcarving panels more effective in promoting cross-ventilation, resulting in more efficient cooling and better temperature regulation. The stronger winds enhance the exchange of indoor and outdoor air, increasing the building's NV capacity and providing more effective cooling during warmer months.

4.1.1 Air volume flow rate comparison

The volumetric airflow rate ($Q = \mathrm{A} \times v$) was calculated based on the surface area and mean perpendicular air velocity for WC3 and WC4 to provide a more accurate comparison between the two panel types. The surface areas of the panels are approximately 0.56m^2 (WC3) and 1.44 m^2 (WC4), with mean air velocities of 1.8m/s and 2.5m/s, respectively. The resulting volumetric flow rates are:

- WC3: 1.8 m/s x 0.56m^2 = 1.0m^3/s
- WC4: 2.5m/s x 1.44m^2 = 3.6m^3/s

This shows that WC4 facilitates 3.6 times more airflow than WC3. Although WC4's velocity is only 1.4 times higher than WC3's, its significantly larger surface area contributes to a much higher volumetric air flow, confirming that opening size must be considered alongside airspeed when assessing NV effectiveness.

4.2 Predicted mean vote (PMV)

PMV (Table 6) evaluates thermal comfort by considering factors like airflow velocity, temperature, clothing, metabolic rate, humidity, and radiant heat. Autodesk CFD calculates PMV to predict a group's mean thermal sensation on a seven-point scale, from -3 (cold) to +3 (hot), with 0 indicating neutral comfort.Table 6: Predicted mean vote values

Value	Sensation
-3	cold
-2	cool
-1	slightly cool
0	neutral
+1	slightly warm
+2	warm
+3	hot

The PMV value reaches 3, as shown in Figure 10, indicating extreme discomfort due to persistently high temperatures despite the strong natural airflow from the north-northwest. This highlights the limitations of relying solely on passive ventilation during extreme heat. Figure 10 further shows varying PMV values across the human figure, with light blue and green areas (values between 0.4 and 1.6) on the legs, knees, and arms indicating mild discomfort. As the PMV increases, it reaches 2.4 in the abdominal area (yellow), signifying noticeable thermal discomfort. These values represent the varying discomfort levels experienced by different body parts due to Szombathely's environmental conditions. The surrounding air's PMV values, shown in the

hollow human figure (Figure 11), range from 0 to 1.2, with most values between 0 and 1, suggesting that the surrounding air is neutral to slightly warm, causing minimal discomfort.

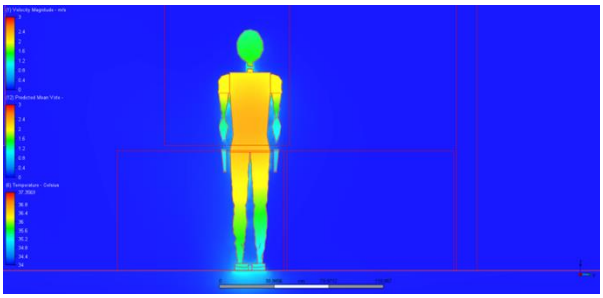

Figure 10: PMV value for human.

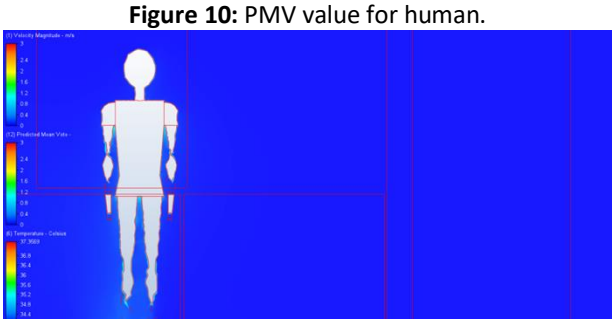

Figure 11: PMV of the surrounding air.

5.0 DISCUSSIONS

This study aimed to evaluate the effectiveness of woodcarving panels in enhancing NV and thermal comfort in Szombathely, Hungary. The primary hypothesis suggested that woodcarving panels with higher FAR would improve airflow and indoor comfort, which was partially supported.

CFD simulation results showed that panels WC3 (46.57%) and WC4 (44.85%) enhanced airflow, with wind velocities reaching up to 14m/s in internal zones near openings. While both panel types facilitated ventilation, their effects were not directly proportional due to differences in panel area. WC4 was nearly three times larger than WC3, which implies that simply comparing FAR percentages without accounting for airflow volume (Q A x v) could lead to misleading conclusions.

The volumetric airflow calculation further clarifies the performance difference between the panels. Despite WC4 having only 1.4 times higher velocity than WC3, its larger surface area results in 3.6 times greater air volume flow. This confirms that evaluating NV effectiveness requires considering both panel design and dimension. Larger perforated panels like WC4 enhance aesthetic value and substantially improve indoor airflow performance.

The boundary conditions in the simulation reflected realistic summer scenarios in Szombathely, including a 14 m/s NNW wind, ambient temperature of 34 °C, and appropriate material settings for walls and openings. An unstructured mesh was applied to ensure fine-grained airflow resolution, particularly around the carved panel geometries.

Despite increased airflow, the panels did not significantly reduce internal temperatures during extreme heat, resulting in discomfort (PMV value of 3). This suggests that passive ventilation, although effective in improving airflow, is insufficient for maintaining thermal comfort in extreme conditions (Abdullah et al., 2021). These findings support a hybrid ventilation approach, especially for climates with high solar gain and limited nighttime cooling.

The validity of the CFD results was supported by comparing them with microclimate data, adherence to ASHRAE standards, and the use of industry-standard tools (Autodesk CFD and Climate Consultant 6.0). While

experimental validation was beyond the scope of this study, future work may include wind tunnel testing or on-site monitoring to verify simulation results.

In summary, airflow performance depends not only on FAR, but also on panel area, orientation, and distribution. Effective NV design should balance these factors for cultural integration and environmental performance.

6.0 CONCLUSION

This study explored the integration of woodcarving ventilation panels into a modern building to improve NV and thermal comfort in Szombathely. Using Szombathely, Hungary, as the case study, CFD simulations revealed that woodcarving panels with FAR of 46.57% (WC3) and 44.85% (WC4) significantly improved indoor airflow, with peak internal velocities reaching up to 14 m/s in alignment with outdoor wind speeds.

The ventilation rates exceeded the ASHRAE Standard 55 minimum threshold of 0.2 m/s for occupant comfort in naturally ventilated spaces. However, thermal comfort was not achieved, with PMV values reaching +3, indicating discomfort due to elevated internal temperatures. This outcome highlights the limitation of relying solely on passive ventilation under extreme heat conditions.

Design comparisons between WC3 and WC4 showed that although WC3 had a higher FAR, WC4's larger panel size allowed greater air volume intake. Therefore, NV effectiveness is influenced by both FAR and total panel area. To optimise performance, designers may consider:

- Increasing the number of smaller, high-FAR panels distributed along prevailing wind paths
- Combining perforated panels with shading elements or thermal mass
- Exploring directional carvings to guide the flow

In conclusion, carved wood panels with FAR values above 45% can significantly enhance passive airflow. While they contribute to improved ventilation, their extreme thermal impact remains limited. For achieving full thermal comfort, a hybrid system integrating culturally significant ventilation elements with adaptive cooling strategies (e.g., operable panels, evaporative cooling) is recommended.

The study supports the strategic integration of traditional craftsmanship into sustainable and climate-responsive architecture. Future research may further refine airflow dynamics through experimental validation and explore how pattern geometry or material thermal conductivity variations influence long-term comfort and energy performance.

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MAPPING TYPOLOGY OF OUTDOOR PLAYSCAPE FOR PRESCHOOL: CASE STUDY OF GOVERNMENT AND PRIVATE KINDERGARTENS IN KLANG VALLEY

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ABSTRACT

The research maps the typology of outdoor playscapes in preschools, with an explicit focus on government and private kindergartens in the Klang Valley. The present study develops a map of the design and quality of outdoor playscapes in government and private kindergartens located in the Klang Valley, exploring how regulatory and economic factors influence the quality of play. Through a secondary resources approach, the research investigates the outdoor spatial layouts, relevant layout plans, and the types of play equipment supplied. The research explores how these design elements influence the functionality and overall character of the playscapes. Results show that most government kindergartens adhere to local authority guidelines, and their outdoor spaces are well-planned to facilitate active play, socialisation, and child development. In contrast, private kindergartens focus more on financial benefits, usually resulting in less thoughtful spatial arrangements and play equipment choices. Investing in outdoor facilities that appeal to children may not be the best practice for child development. The study develops a design framework that ensures well-organised outdoor settings, integrates different play equipment, and facilitates holistic development. It advocates more informed design practices beyond financial considerations, paving the way for public and private institutions to create nurturing, developmentally appropriate outdoor play spaces for young children.

Keywords: Landscape Design, Outdoor Play Environment, Preschool Playscape Typology, Spatial Layouts, Early Childhood Development

1.0 INTRODUCTION

Outdoor playscapes in preschool settings are vital in fostering holistic child development by offering avenues for physical engagement, social connection, and cognitive development. A well-designed outdoor environment contributes to children's physical and social development and emotional well-being. Hasim et al. (2023) highlight that outdoor play allows children to release stress, build resilience, and experience emotional stability, making it a crucial aspect of early learning environments. Similarly, Candiracci (2025) underscores that play should not be limited to designated playgrounds but should be integrated into broader public and learning spaces to support emotional, social, cognitive, and physical development. These perspectives emphasise that the design of outdoor spaces is fundamental to supporting children's comprehensive developmental needs.

In Malaysian preschool contexts, significant variability exists in the design and quality of outdoor playscapes. Public kindergartens generally adhere to local authority regulations that ensure the safety, accessibility, and developmental appropriateness of their outdoor environments. Their designs typically incorporate natural features and diverse play zones that encourage active, social, and imaginative play. Conversely, private kindergartens tend to prioritise aesthetic appeal or commercial competitiveness, resulting in spaces that may

appear visually attractive but offer limited developmental opportunities due to rigid layouts, restricted play equipment, and reduced integration of natural elements.

Public kindergartens' alignment with regulatory guidelines strongly emphasises developmental outcomes, particularly outdoor environments that encourage exploratory and risk-based play. Smedsrud et al. (2024) note that nature-based outdoor environments, which promote risk-taking, social collaboration, and problem-solving, are the key components of early childhood development. On the other hand, financial constraints and profit-driven decision-making often influence the design of private preschool environments, limiting their developmental effectiveness. Morgenthaler et al. (2023) point out that children are most engaged in play settings that offer challenge, autonomy, and opportunities to interact with familiar peers and animals. When such environmental qualities are compromised, the richness of play experiences diminishes.

To better understand how regulatory and financial considerations influence playscape quality, the present study investigates the typology of outdoor playscapes across public and private kindergartens in Klang Valley. It examines the spatial organisation, play equipment, and design characteristics that define children's outdoor play environments to identify how these elements collectively contribute to early childhood development, and the following objectives direct it:

1. To map and categorise outdoor playscapes in government and private kindergartens across Klang Valley, focusing on play equipment, layout, accessibility, safety, and natural features.
2. To compare outdoor playscape design and spatial layout between government and private kindergartens.
3. To examine how regulatory guidelines and financial factors influence the quality and functionality of outdoor playscapes.

The study examines the typology of outdoor playscapes in preschools, focusing on government and private kindergartens in the Klang Valley, Malaysia. It explores how research on spatial layouts, play equipment, and design elements establishes functionality and developmental outcomes through a secondary resources approach. This research examines the design characteristics of both institutions to determine how adherence to regulatory guidelines versus market-driven approaches affects the quality of the outdoor play environment. It is guided by the hypothesis that government-run kindergartens provide more developmentally appropriate and well-organised outdoor spaces since guidelines stipulated by the local authority would bind them. At the same time, monetary considerations govern private kindergartens. Hence, they are less child-centred in design.

While national and local regulatory frameworks formally govern public and private kindergartens in Malaysia, government-run institutions are typically more strictly monitored and demonstrate higher compliance with standardised design requirements. In contrast, private kindergartens exhibit greater design flexibility and inconsistent adherence to these regulations, often influenced by market demands or financial considerations. The World Bank (2023) reported that despite comprehensive early childhood education standards, regulatory enforcement and compliance across Malaysia's private preschool sector remain uneven, particularly in spatial and safety provisions. Similarly, Abdul Mutalib (2022) emphasised that while legal frameworks outline minimum requirements for the physical environment of preschools, implementation gaps persist due to limited inspection and oversight mechanisms in privately operated centres.

Building on these insights, this study investigates the theoretical and practical implications of the observed disparities, focusing on how outdoor play environments influence children's physical, social, and cognitive development. By examining variations in design quality between public and private kindergartens, the study seeks to develop informed design recommendations that promote equitable access to developmentally supportive and enriching playscapes for all preschool-aged children.

2.0 LITERATURE REVIEW

In early childhood education, outdoor playscapes were intentionally created to contribute significantly to children's overall development. This review explores the critical role of outdoor environments in preschool settings, focusing on how spatial organisation and design features shape multiple dimensions of children's developmental progress. The review is organised into four main subtopics: the definition and developmental needs of children, the role of kindergarten in early education, the importance of outdoor playscapes in learning,

and the influence of spatial layout on children's play and social interaction. These subtopics establish how preschool outdoor environments can foster holistic child development.

2.1 Definition of Children and Their Developmental Needs

Children in Malaysia are legally defined as individuals under 18 years old, as stipulated in the *Child Act 2001*, emphasising their right to protection, care, and holistic development (Siraj, 2019). Child development involves the physical, cognitive, emotional, and social domains, each influenced by the environments where children live and learn. According to the National Association for the Education of Young Children (NAEYC, 2017), outdoor play is essential for nurturing the "whole child," underscoring the need for thoughtfully designed outdoor spaces that encourage various play experiences and social interactions.

Although indoor and outdoor play contribute to early learning, their range of experiences and developmental benefits differ. Indoor play often occurs within structured, controlled environments that promote fine motor coordination, concentration, and problem-solving through guided, manipulative-based activities. In contrast, outdoor play exposes children to more open, dynamic, and unpredictable settings that stimulate physical activity, sensory exploration, creativity, and social cooperation (Dankiw et al., 2020). Such environments encourage movement diversity and risk-taking, essential for developing resilience, spatial awareness, and self-confidence (Sando et al., 2021). Integrating outdoor play within early childhood education thus extends learning beyond classroom boundaries and fosters holistic growth through direct engagement with natural and social surroundings.

2.2 The Role of Kindergarten in Early Childhood Development

Kindergarten in Malaysia is formally recognised as an early educational setting for children aged four to six, emphasising holistic development through play-based learning and early childhood education principles (Radzi et al., 2023). From an educational perspective, kindergartens serve as childcare centres and structured environments designed to foster learning, creativity, social competence, and emotional growth. Maitland et al. (2020) emphasise that developmentally appropriate environments promote physical activity and overall child well-being, providing exploration, interaction, and experiential learning opportunities.

Public kindergartens in Malaysia are typically governed by local authority regulations, ensuring that spatial and educational provisions meet standards conducive to children's developmental needs (Shaari et al., 2020). In contrast, private kindergartens often operate with greater autonomy, leading to variability in quality and developmental focus due to differing financial capacities and institutional priorities. Research by Jeavons, Jameson, and Elliott (2017) indicates that publicly governed kindergartens tend to adhere more closely to national guidelines and prioritise safe, educational outdoor environments that support active learning. Meanwhile, Baker and McGinnis (2019) argue that privately managed institutions frequently emphasise aesthetic appeal and parental market expectations, occasionally at the expense of developmental functionality.

Overall, the kindergarten setting plays a pivotal role in shaping children's early learning experiences, serving as the bridge between home and formal education while providing the foundation for lifelong growth and development.

2.3 Importance and Function of Outdoor Playscapes in Early Learning

An outdoor playscape is a purposefully designed environment that combines natural elements and play structures to encourage children's exploration, social interaction, and experiential learning. Dankiw et al. (2020) emphasise that engaging in nature-based play greatly supports the development of children's cognitive flexibility, creativity, and social skills, highlighting the crucial role of interaction with natural settings in fostering overall development. Playscapes, therefore, serve as essential extensions of the classroom, offering spaces for active, imaginative, and cooperative play that foster holistic growth.

Research by the Children's Nature Network (2021) further demonstrates that play in natural schoolyards promotes higher levels of physical activity, calmer behaviour, and richer social engagement, reinforcing that outdoor environments contribute to multiple developmental domains. Similarly, Nobre et al. (2022) argue that well-designed play environments should provide opportunities for movement, creativity, and social interaction, emphasising the need for diverse and dynamic spatial elements that support children's physical, social, and cognitive development.

2.4 Influence of Spatial Layout on Children's Play and Interaction

The spatial arrangement of outdoor playscapes shapes how children interact, explore, and engage with their surroundings. Kamal and Gabr (2024) emphasise that integrating natural, elevated, and customised play elements within children's environments improves the quality of play and promotes the development of social and cognitive abilities. A well-planned spatial layout supports functional use and promotes inclusivity, accessibility, and active engagement.

Zhao et al. (2023) explain that the physical environment of a neighbourhood is influenced by several social and environmental factors, such as parental safety concerns, community design, accessibility to open spaces, and cultural preferences for play, which collectively affect how and where children engage in outdoor activities. Although Zhao et al.'s study focuses on neighbourhoods rather than kindergarten settings, these insights are transferable to early childhood environments where contextual elements such as parental expectations, safety regulations, and socio-economic conditions also shape the design and organisation of outdoor play areas. These influences determine how spaces are zoned, the level of openness for exploration, and the degree of supervision integrated into play settings.

According to KOMPAN (2024), effective outdoor environments include open areas that allow children to run, invent games, and interact flexibly and dynamically. Similarly, Park N Play Design (2023) emphasises that nature-inspired playgrounds foster cooperation, communication, and shared play experiences. Reinforcing this idea, the National Program for Playground Safety (NPPS, 2024) advises that playgrounds be designed according to children's age groups, ensuring that equipment and spaces are safe, accessible, and proportionately scaled to support their developmental stages.

Overall, thoughtful spatial design in outdoor playscapes enables diverse modes of play—active, imaginative, and social- while addressing safety, accessibility, and inclusivity. These design considerations are crucial for environments that physically engage children while nurturing their creativity, social competence, and cognitive growth.

This literature review integrates perspectives on children's developmental needs, the role of kindergarten environments, the significance of outdoor playscapes, and the influence of spatial layout design in creating effective preschool environments. Scholars consistently emphasise that well-planned outdoor spaces enhance holistic development. Government kindergartens adhere more to design and regulatory standards, while private institutions show broader variability due to differing priorities and financial capacities. The present research extends these insights by mapping the typology of kindergarten outdoor playscapes in the Klang Valley, Malaysia, to examine how regulatory compliance and market-driven design decisions influence preschool outdoor environments.

3.0 METHODOLOGY

The present research adopts a secondary data analysis approach integrating Google Earth (GE) and Google Street View (GSV) to investigate the typology of outdoor playscapes in public and private kindergartens across Klang Valley. The integration of GE and GSV enables a comprehensive spatial understanding, with GE providing aerial perspectives for mapping and GSV offering ground-level imagery to assess playscape quality, accessibility, and design characteristics. This dual-method digital observation strategy supports a systematic analysis of multiple geographically dispersed sites while maintaining data consistency and accessibility.

3.1 Research Approach

The present study employs a descriptive–comparative research design to map, categorise, and assess outdoor playscapes according to their spatial organisation and design quality. Using secondary visual data enables systematic spatial documentation while minimising the logistical constraints associated with on-site fieldwork. GE imagery was utilised to assess site layouts, open spaces, and vegetation patterns, while GSV was employed to examine play equipment, accessibility features, and surface conditions. Combining both tools ensures that macro-level spatial configurations and micro-level design details are captured comprehensively.

3.2 Sampling Strategy and Case Selection

A total of 15 kindergartens were selected using a purposive sampling approach to represent various institutional types and spatial contexts within the Klang Valley. The sample comprises five (5) government and ten (10) private kindergartens. This distribution reflects the actual institutional composition in urban and suburban areas of Klang Valley, where private kindergartens outnumber public ones (Ministry of Education Malaysia, 2023).

Selected sites were in Ampang, Pandan Indah, Taman Dagang, Sri Petaling, Bangsar, and Klang, providing a cross-section of urban and suburban neighbourhood typologies. The selection prioritised kindergartens with observable outdoor areas and accessible imagery through GE and GSV to ensure adequate visual documentation.

Selection criteria for inclusion were as follows:

1. The kindergarten must be clearly identifiable through signage or listing.
2. The site must have a visible outdoor playscape area that is observable via GE or GSV.
3. The location must fall within the Klang Valley administrative boundary.
4. Public kindergartens were verified using the Ministry of Education Malaysia Preschool Directory (2023).
5. Private kindergartens were verified through Google listings, visible signage, or institutional websites confirming private ownership.

This selection ensured diversity in site typology, institutional governance, and spatial quality, while maintaining a feasible scope for visual assessment. The list presented in Table 1 represents a mix of government and private kindergartens distributed across the Klang Valley. Institutional classification was verified through the Ministry of Education Malaysia directory (2023) for government kindergartens, while private institutions were verified through visible on-site signage, verified online listings, and official institutional websites. This classification ensured the accuracy and legitimacy of each kindergarten included in the study.

Table 1: **List of Kindergartens Involved in the Study**

Institution	Name	Location
Government	G1	Pandan Mewah
	G2	Taman Mulia Jaya
	G3	Kampung Tasik Tambahan
	G4	Taman Dagang Jaya
	G5	Pandan Indah 6/8
Private	P1	Pandan Indah
	P2	Taman Dagang Jaya
	P3	Taman Dagang
	P4	Taman Pandan Mewah
	P5	Taman Cempaka
	P6	Ampang Utama
	P7	Bangsar
	P8	Sri Petaling
	P9	Bangsar
	P10	Klang

Figure 1 illustrates the spatial distribution of the selected kindergarten sites across the Klang Valley, highlighting the geographical spread between government and private institutions to ensure representational coverage of urban and suburban contexts.

Figure 1: Distribution Map of Selected Kindergarten Sites in Klang Valley

3.3 Data Collection Process

Data were collected between January and April 2025 using a structured visual observation procedure via Google Earth (GE) and Google Street View (GSV)—the process aimed to ensure consistent, accurate, and comprehensive evaluation across all sites.

1. Site Identification—Kindergartens were located using verified names and addresses on Google Maps. Each institution was cross-checked with official directories and online sources to confirm its classification as public or private.
2. Aerial Mapping (Google Earth): GE imagery assessed the overall layout, outdoor space distribution, surrounding context, and vegetation coverage. Parameters such as site boundaries, play area proportions, and adjacency to built structures were recorded.
3. Ground-Level Observation (Google Street View): GSV provided ground-level imagery to examine visible design features, including entrance design, surfacing, shading, accessibility, fencing, and play equipment.
4. Data Recording and Verification – Observations were documented in a structured site profile matrix capturing layout type, surface material, safety elements, and equipment diversity. Institutional verification was further confirmed via signage on GSV or institutional web data.

Using such digital platforms enables a comprehensive preliminary examination of sites without requiring physical visits. GE provides high-resolution satellite imagery for spatial assessment, while GSV offers reliable ground-level perspectives of outdoor design details. Although these tools cannot fully substitute field observation, studies have demonstrated that GE and GSV yield high spatial accuracy and valid visual data for urban and landscape research when field validation is impractical (Booth & Lam, 2018). Their integration ensures consistent data collection and allows visual comparison across dispersed sites.

This digital approach ensures efficiency in data collection in terms of time, cost, and logistical feasibility, reducing the need for travel while maintaining systematic documentation. It minimises disruptions to school operations, allowing for ethical and resource-efficient analysis of 15 kindergartens' outdoor environments.

3.4 Data Analysis

The collected data were analysed using a spatial and typological mapping framework to identify patterns and variations in playscape design. Each site was evaluated based on:

1. Spatial layout – including zoning, circulation, and proportion of open areas.
2. Design Features – encompassing types of play structures, surfacing, and vegetation.
3. Safety and Accessibility – presence of fences, supervision visibility, and age-appropriate scaling.
4. Play Functionality – opportunities for physical, social, and imaginative play.

Comparative analysis was then conducted to identify similarities and differences between government and private kindergartens, focusing on how spatial design reflects regulatory compliance or market-driven considerations. This analytical approach enables the identification of design typologies and their implications for children's physical, cognitive, and social development.

3.5 Summary

This methodological framework integrates secondary spatial observation tools to ensure systematic, cost-effective, and verifiable data collection. The combination of Google Earth and Google Street View provides dual perspectives: macro-scale spatial mapping and micro-scale visual analysis, enhancing reliability and replicability. The approach is particularly suitable for large-scale typological studies where physical access is constrained but detailed visual information remains available through digital platforms.

3.6 Data Verification and Reliability

Several verification strategies were applied during observation and data recording to ensure the reliability of spatial interpretations derived from Google Earth (GE) and Google Street View (GSV).

First, cross-validation between GE and GSV imagery was carried out for each site. GE provided aerial perspectives useful for understanding the spatial organisation and roof coverage, while GSV enabled ground-level viewing of façades, fencing, entrances, and visible play equipment. For instance, in cases such as P5, where the play area was located beneath a semi-transparent sunroof, GSV provided clear side views of the integrated play structure and surfaced through street-level imagery captured at pedestrian height, complementing the limited aerial visibility.

Second, functional inferences in identifying a structure as a storage room were made based on multiple observable cues, such as location within the compound, size, access restriction, locked doors or lack of openings, and absence of play signage or child-scale features. These visual indicators are consistent with spatial reading techniques used in remote sensing and environmental observation studies (Booth & Lam, 2018; Li et al., 2022).

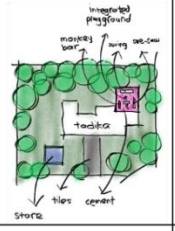
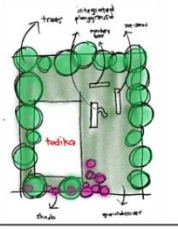
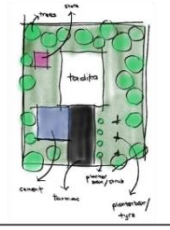
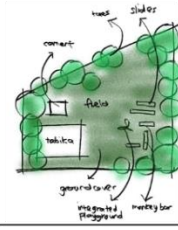
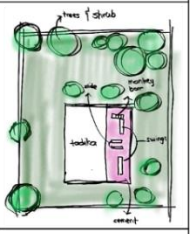
Third, to confirm image clarity and accuracy, several sites with different lighting and angles were compared across available GSV years (2019–2024). Locations such as G1 (Pandan Mewah) and P8 (Sri Petaling) provided high-resolution visuals where playground equipment, shade structures, and fencing materials could be clearly identified. Only kindergartens with sufficiently clear imagery were included in the final analysis, ensuring that ambiguous or obscured visuals did not bias interpretation.

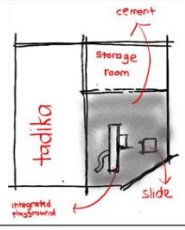
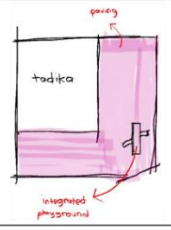
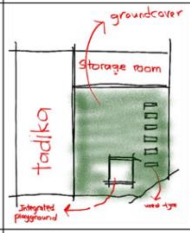
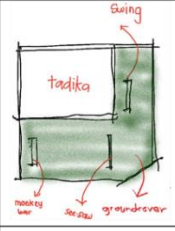
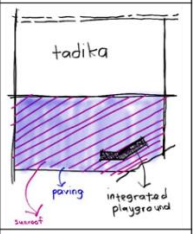
Prior literature supports GE and GSV's high positional and visual accuracy for spatial documentation, reporting error margins within 1–3 meters for building footprints and consistent image resolution suitable for urban design assessment (Potere, 2008; Hu et al., 2020). These validations reinforce the reliability of the visual interpretations used in this study.

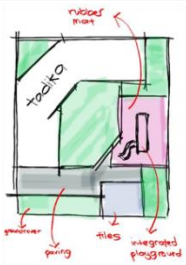
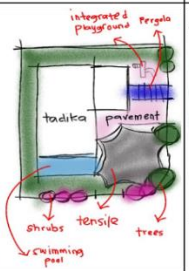
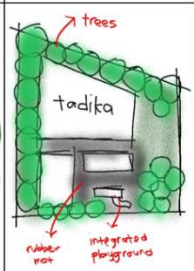
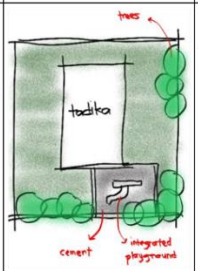
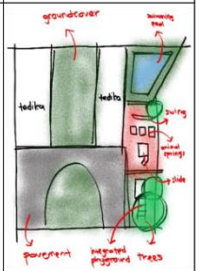
4.0 RESULTS

The following table summarises the study's inventory, detailing the outdoor playscapes of selected preschools in Klang Valley. Each entry includes the kindergarten's name, location, Google Maps view, overall space and character, and types of play equipment provided.

Table 2: Inventory on the outdoor playscape of government and private kindergartens in Klang Valley

Location	Pandan mewah	Taman Mulia Jaya	Kampung Tasik Tambahan	Taman Dagang Jaya	Pandan Indah 6/8
Kindergarten	G1	G2	G3	G4	G5
View through Google Earth					
Sketch of equipment					
Space and characters	Bungalow Lot	Bungalow Lot	Bungalow Lot	Bungalow Lot	Bungalow Lot
Facilities	-Integrated playground -Monkey bar -Swing -See-saw	-Integrated playground -Monkey bar -See-saw		-Integrated playground -Monkey bar -Slides -See-saw	-Slides -Monkey bar -Swing

Location	Pandan Indah	Taman Dagang Jaya	Taman Dagang	Taman Pandan Mewah	Taman Cempaka
Kindergarten	P1	P2	P3	P4	P5
View through Google Earth					
Sketch of equipment					
Space and characters	Corner Lot	Corner Lot	Corner Lot	Corner Lot	Corner Lot
Facilities	-Integrated playground -Slide	-Integrated playground	-Integrated playground -Recycle tyre	-Monkey bar -See-saw -Swing	-Integrated playground -Paving -Sunroof

Location	Ampang Utama	Bangsar	Sri Petaling	Bangsar	Klang
Kindergarten	P6	P7	P8	P9	P10
View through Google Earth					
Sketch of equipment					
Space and characters	Flag Lot	Bungalow Lot/Corner Lot	Flag Lot	Bungalow Lot	Corner Lot
Facilities	-Integrated playground -Rubber mat -Paving	-Integrated playground -Swimming pool -Paving -Tensile	-Integrated playground -Rubber mat -Paving	-Integrated playground	-Integrated playground -Swimming pool -Paving -Sunroof -Swing -Animal spring

This section summarises the key findings from the spatial analysis of 15 kindergartens, organised according to the three research objectives outlined in the introduction. The study follows the framework established in the literature review, focusing on how outdoor playscapes support children's holistic development, particularly regarding socialisation, cognitive growth, and physical activity.

Each site was analysed using imagery from Google Earth (GE) and Google Street View (GSV) to identify design characteristics such as layout organisation, play-equipment variety, accessibility, and natural elements. Observations were recorded using a playscape analysis matrix, where features were coded according to functional and developmental affordances. GE provided macro-level information such as site boundaries, layout proportions, and shade coverage, while GSV provided micro-level details such as child-scale features, surfacing, and play-equipment visibility.

Table 3: Inventory on the outdoor playscape of government and private kindergartens in Klang Valley

Objective	**Key Findings**	**Government Kindergartens**	**Private Kindergartens**
1. To map and categorise outdoor playscapes in government and private kindergartens across Klang Valley, focusing on play equipment, layout, accessibility, safety, and natural features.	Classification of outdoor playscapes in government and private kindergartens based on play equipment, layout, accessibility, and safety features.	a) Well-organised outdoor spaces designed to meet local regulatory guidelines. b) Variety of play equipment, including climbing structures and swings. c) Integrating natural elements such as trees, grass, and shaded areas. d) Child-centred design with accessible spaces for varied developmental activities.	a) Design emphasises aesthetic appeal and visual branding over functionality. b) Limited diversity of play equipment centred on a few large structures. c) Less integration of natural features. d) Spatial layouts appear fragmented, offering reduced accessibility.
2. To compare outdoor playscape design and spatial layout between government and private kindergartens.	Comparison of spatial organisation, design features, and play-environment layout.	a) Outdoor spaces promote active play, social interaction, and cognitive engagement. b) Clear zoning for physical, cognitive, and social play. c) Multi-functional spaces allow varied play experiences.	a) Design prioritises aesthetics over developmental function. b) Rigid spatial organisation with limited play-zone diversity. c) Fragmented layouts emphasising isolated play areas.
3. To examine how regulatory guidelines and financial factors influence the quality and functionality of outdoor playscapes.	Examination of how regulations (public) and financial motivations (private) affect playscape functionality.	a) Government kindergartens comply with local authority guidelines and meet developmental needs. b) Spaces are well-maintained and developmentally appropriate.	a) a) Private kindergartens focus on market appeal. b) Visually appealing spaces often lack support for holistic child development. c) Financial priorities limit the range of play structures.

4.1 Interpretation of Findings

The findings in Table 2 were derived from a systematic visual-comparison approach, in which observable features were categorised into four analytic criteria:

1. Layout organisation – spatial zoning, circulation flow, and visual connectivity.
2. Play diversity – number and variety of structures enabling physical, imaginative, and social play.
3. Natural integration – degree of vegetation, shade, and natural surface inclusion.
4. Accessibility and child-centeredness – visible access routes, safety boundaries, and appropriately scaled play elements.

Well-organised outdoor spaces displayed clear play-zone separation, connected circulation paths, and open sightlines for supervision. These traits were evident in G2 (Taman Mulia Jaya) and G4 (Taman Dagang Jaya), where GE imagery showed structured layouts and shaded play zones.

Regulatory compliance was evaluated using visible indicators consistent with the Garis Panduan Prasekolah (Ministry of Education Malaysia, 2023) and the Garis Panduan Perancangan Tadika dan Taska (PLANMalaysia, 2021). Government kindergartens exhibited fencing, shaded rest areas, and play-zone ratios proportional to these standards. Private kindergartens showed wider variation, often emphasising decorative landscaping and bright façades over functional zoning.

GSV's ground-level images interpreted child-centred design, revealing child-scale furniture, accessible surfacing, and age-appropriate play structures. For example, P5 (Taman Cempaka) featured low-height slides and visible access routes adjacent to classrooms.
Aesthetic-driven designs were apparent in private kindergartens such as P3 (Taman Dagang) and P7 (Bangsar), which displayed colourful façades and ornamental features but limited spatial variety for play. Such contrasts illustrate a division between regulation-driven functional and market-driven aesthetic designs across the two institutional types.

Although the observed trends correspond with prior literature (Shaari et al., 2020), the conclusions stem from empirical visual evidence obtained via structured GE–GSV analysis. This analysis supports the credibility of the typological distinctions between government and private kindergarten playscapes.

4.2 Key Insights & Implications

The comparative findings highlight a consistent difference between the design priorities of government and private kindergartens. Government-run kindergartens, guided by regulatory frameworks such as the *Garis Panduan Prasekolah* (Ministry of Education Malaysia, 2023) and *Garis Panduan Perancangan Tadika dan Taska* (PLANMalaysia, 2021), demonstrate more organised and developmentally supportive playscapes. These environments integrate diverse play opportunities that promote physical coordination, social interaction, and cognitive exploration, aligning with the principles of holistic child development emphasised in the literature (Moore, 2024).

In contrast, while often aesthetically attractive, private kindergartens prioritise financial and marketing factors over developmental functionality. The emphasis on visually appealing yet spatially limited designs restricts the richness of children's play experiences. This imbalance indicates that financial motivations can inadvertently undermine the developmental quality of outdoor environments, especially where regulatory oversight is less stringent.

4.3 Conclusion of Results

The findings confirm that government-run kindergartens provide outdoor playscapes that are more developmentally appropriate and spatially coherent, owing to their adherence to national guidelines and structured design standards. Conversely, private kindergartens show greater variability and often limited developmental depth, shaped mainly by economic and aesthetic priorities.
These outcomes reinforce the need for policy harmonisation and design regulation that extends beyond government institutions. Equal emphasis on child-centred and developmentally sound outdoor design across all kindergarten types would ensure that early learning environments in Malaysia holistically support children's physical, cognitive, and social growth.

5.0 DISCUSSIONS

This section interprets the study's findings concerning its objectives, theoretical context, and previous literature. It highlights how outdoor playscape typologies in public and private kindergartens across the Klang Valley reflect differences in spatial design, regulatory adherence, and developmental quality.

5.1 Linking Findings to Research Objectives

The mapping and typological analysis demonstrate that government-run kindergartens consistently exhibit superior spatial organisation, safety features, and developmental affordances. These findings substantiate the first two research objectives, confirming that adherence to national and local guidelines (PLANMalaysia, 2021; Ministry of Education Malaysia, 2023) produces playscapes that promote active, social, and imaginative play.

In contrast, private kindergartens emphasise branding, visual aesthetics, and compact layouts influenced by economic constraints and market demand rather than developmental value. This statement supports the third objective, showing that financial considerations significantly shape the design and quality of private preschool environments.

5.2 Interpretation in Relation to Literature

The findings align strongly with prior studies emphasising outdoor play enhances physical, cognitive, and social development (Raval, 2023). Government institutions translate these developmental principles into physical design outcomes such as distinct play zones, shaded rest areas, and child-scaled play structures.

This pattern supports Jeavons, Jameson, and Elliott (2017) and Shaari, Mohd Isa, and Hamzah (2020), who observed that systematic regulatory governance improves inclusivity, safety, and developmental outcomes in preschool environments. Conversely, the market-oriented tendencies in private kindergartens mirror Baker and McGinnis (2019), who noted that privatised educational settings may reduce pedagogical value when design choices prioritise consumer appeal.

5.3 Spatial and Developmental Implications

Holistic development requires an interplay between physical, social, and cognitive opportunities. Government-run kindergartens typically integrate open movement spaces, collaborative play zones, and quiet areas, promoting active learning and peer interaction.

Private kindergartens, by contrast, often limit unstructured play due to smaller site footprints and emphasis on ornamental or indoor-focused facilities. This imbalance supports findings by the Children's Nature Network (2021) and Smedsrud et al. (2024), who demonstrated that naturalised and flexible play environments enhance social cooperation, creativity, and emotional well-being in early childhood.

5.4 Policy and Design Implications

The contrast between regulation-driven and market-driven environments underscores the importance of unified enforcement across preschool types. Policymakers should extend government design guidelines to all early-childhood providers, ensuring that developmental priorities outweigh financial or aesthetic motivations.

This study offers a typological framework for practitioners to evaluate or redesign playscapes. It emphasises open-ended, inclusive spaces that foster exploration, collaboration, and physical activity. Embedding child-centred design within Malaysia's preschool landscape architecture could improve developmental equity nationwide.

5.5 Limitations and Future Research

This study relied on secondary spatial data, which are Google Earth and Google Street View, which limit behavioural observation of children's real-time play interactions. Nonetheless, the reliability of visual interpretation was strengthened through cross-validation across imagery years (2019–2024).

Future research could employ mixed methods, combining spatial typology with field observation, interviews with educators, or post-occupancy evaluations, to deepen understanding of how playscape design directly influences developmental outcomes. Comparative studies across states or international contexts could enrich the framework's applicability.

6.0 CONCLUSION

Using geospatial secondary data, this study mapped and analysed the typology of outdoor playscapes in public and private kindergartens across the Klang Valley. The comparative analysis revealed clear institutional differences that significantly affect early-childhood development.

6.1 Summary of Findings

The comparative analysis between government-run and private kindergartens revealed distinct patterns in spatial organisation, play diversity, and developmental affordances. Government-run kindergartens, which operate under national and local regulatory frameworks, demonstrated well-organised spatial layouts, diverse play equipment, and strong integration of natural elements. These characteristics align closely with developmental objectives, supporting children's physical, social, and cognitive growth through intentional spatial design and material provision.

In contrast, private kindergartens, often influenced by financial constraints and aesthetic priorities, tended to exhibit limited spatial diversity and fragmented layouts. Although these environments may appear visually appealing, they frequently lack the functional and developmental affordances observed in their government counterparts.

The findings underscore that regulatory compliance is crucial to developmentally appropriate playscape design. Where such standards are enforced, environments promote inclusivity, engagement, and holistic development. Conversely, unregulated financial motivations in private institutions may compromise the functionality and inclusiveness of outdoor play environments.

6.2 Contribution to Knowledge

This study contributes substantially to early childhood design and policy literature by introducing a typological mapping framework that classifies preschool outdoor playscapes through remote spatial data. This methodological approach provides a replicable means of assessing and comparing playscape characteristics across diverse institutional settings.

Furthermore, the study offers empirical evidence that regulatory enforcement is critical in enhancing design quality and maximising developmental potential within early childhood environments. It also underscores how economic pressures influence private preschool settings' spatial form and functional quality, often leading to disparities in play affordances. These insights provide valuable guidance for landscape architects, educators, and policymakers in designing and managing outdoor learning environments that authentically support holistic child development.

6.3 Recommendations

Based on the study findings, several recommendations are proposed to enhance the design and regulation of early childhood outdoor environments. First, policy integration should be prioritised by extending existing government design guidelines, such as those outlined by PLANMalaysia (2021) and the Ministry of Education (2023), to encompass private kindergartens. This policy would ensure that all institutions adhere to consistent quality and safety benchmarks.

Second, in design practice, landscape architects and educators are encouraged to incorporate natural play zones, flexible equipment, and accessible spatial layouts that foster exploration, creativity, and social collaboration among children.

Third, periodic audits across public and private preschools should strengthen monitoring and evaluation mechanisms to assess spatial quality, developmental support, and regulatory compliance.

Lastly, for future research, it is recommended that digital mapping techniques be integrated with qualitative methods, such as teacher interviews and direct observations of children's play, to validate spatial–behavioural relationships and further enrich the understanding of playscape affordances in early childhood education.

6.4 Overall conclusion

The study affirms that spatial design quality is a developmental determinant in early-childhood environments. Public kindergartens demonstrate that outdoor playscapes naturally promote children's physical, social, and cognitive well-being when they follow regulatory and pedagogical standards.

To achieve educational equity, Malaysia must ensure that public and private kindergartens provide safe, inclusive, and stimulating outdoor spaces. Creating such environments is not merely a design concern but a commitment to nurturing the next generation's capacity to learn, collaborate, and thrive through play.

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EXPLORING STUDENT EXPERIENCES WITH PRODUCT LINE-UP ANALYSIS IN INDUSTRIAL DESIGN CURRICULUM

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ABSTRACT

Product Line-Up Analysis (PLA), a traditional marketing tool used to evaluate and optimise product portfolios, offers a systematic approach to identifying consumer preferences and market trends. This study examines the integration of an enhanced, quantitative PLA method into the International Islamic University Malaysia (IIUM) industrial design curriculum, framed within the context of the New Product Development (NPD) process. The research involved 14 final-year Industrial Design students from the AAD Department, KAED, enrolled in the BAAD 4201 Final Year Project (Industrial Design), Semester 2, 2024/2025. The study employed two methods: a studio-based PLA conducted during Weeks 1–3, where students analysed 50–80 product samples to extract key design features and quantify their prevalence using percentages, and a survey to gather students' experiences and feedback. A three-part questionnaire addressed students' backgrounds, PLA experiences, and reflections, with responses analysed using data analysis software to generate descriptive statistics. The findings indicate that students found PLA valuable for enhancing analytical thinking, understanding product variations, and aligning design decisions with market insights. However, challenges such as unfamiliarity with the method and the need for additional instructional support were also noted. This study highlights the potential of PLA as a quantitative pedagogical tool that bridges academic learning and real-world design practice.

Keywords: Product Line-Up Analysis, Industrial Design Education, Curriculum Development, Quantitative Design Method, Design Pedagogy

1.0 INTRODUCTION

In the evolving landscape of industrial design education, there is increasing emphasis on aligning academic curricula with industry practices to better prepare students for real-world challenges. One such practice is the adaptation of Product Line-Up Analysis (PLA), a strategic tool traditionally used in marketing to evaluate and optimize product portfolios. By analysing variations within a product line, businesses can discern consumer preferences, identify market trends, and make informed decisions regarding product offerings.

The integration of PLA into industrial design education offers a systematic approach for students to analyse product variations, identify key features, and comprehend market trends early in the design process. This methodology deepens students' understanding of how design decisions correlate with market demands and consumer preferences, bridging the gap between theoretical knowledge and practical application.

Product development in industrial design is often guided by structured frameworks such as the New Product Development (NPD) model, which outline stages from idea generation and research to concept development, prototyping, and product launch. PLA can be positioned within the research and analysis phase of NPD, providing empirical insights into product features, market trends, and consumer preferences. By integrating PLA into this

stage, students can make informed design decisions grounded in both quantitative data and qualitative understanding, thereby linking systematic analysis with creative intuition.

Despite its potential benefits, the application of PLA in design education remains underexplored. Current pedagogical approaches often rely on qualitative analyses, which may not provide students the quantitative insights to fully understand market dynamics. This gap underscores the need for research into effective methods of incorporating PLA into design curricula to enhance students' analytical capabilities and market awareness.

This study aims to address this gap by examining the implementation of PLA within industrial design education. The research assesses how PLA can improve students' understanding of market trends and inform their design proposals. By exploring the methodological integration of PLA into the curriculum, the study seeks to highlight the potential outcomes of this educational strategy and its implications for theoretical knowledge and practical skills development.

The paper is structured as follows: the subsequent section reviews relevant literature on PLA and its applications in marketing and design education. Following this, the research methodology is outlined, detailing the approach taken to investigate the integration of PLA into the curriculum. The findings are then presented and discussed, highlighting the impact of PLA on students' design processes. Finally, the paper concludes with reflections on the study's implications for design education and suggestions for future research.

2.0 LITERATURE REVIEW

2.1 Product Line-Up Analysis in Marketing

Product Line-Up Analysis (PLA) has long been used in marketing to evaluate and optimise product portfolios. By analysing variations within a product line, businesses can understand consumer preferences, identify market trends, and make informed product decisions. Thomadsen (2011) highlights how product-line expansion affects market dynamics and profitability, while the U.S. Small Business Administration emphasises the importance of competitive analysis for understanding market segments. Recent studies reinforce PLA's relevance: Product Portfolio Optimisation Using MCDA (2024) demonstrates structured prioritization of product variants, Product Portfolio Optimisation for LTV Maximisation (2023) shows how selecting the right products enhances customer lifetime value, and McKinsey (2024) illustrates how cost, complexity, and performance data help refine portfolios. Additionally, Simon-Kucher (2023) outlines current drivers, such as sustainability and AI, for adjusting product lines. Beyond marketing, systematic feature analysis in design contexts (Rahman et al., 2018) parallels PLA's structured approach, guiding informed decision-making in product assessment.

2.2 Application of PLA in Industrial Design Education

The integration of PLA into industrial design education offers a systematic approach for students to analyze product variations, identify key features, and comprehend market trends early in the design process. This methodology facilitates a deeper understanding of how design decisions correlate with market demands and consumer preferences. A study by Asia University and National Cheng Kung University provides insights into how industrial design students evaluate products, emphasising the importance of comprehensive product analysis in educational settings. Research by Liu et al. (2021) discusses the implementation of innovative enterprise product design models for industrial design students, highlighting the benefits of integrating real-world analysis tools, such as PLA, into the curriculum. More recent studies further support this trend: Product Portfolio Strategies in Product Design Education (Tsai Lu Liu et al., 2023–2024) proposes curriculum frameworks that require students to consider product portfolios, not just individual products, fostering a broader strategic perspective. Design Project Classroom (Razali, Zulkifli & Mohamad, 2024) shows how industry-academic collaboration in project-based learning helps students confront real market constraints and feature trade-offs. The empirical work on Inclusive Design Capabilities (Razali et al., 2024) adds that students can better manage product variation when inclusive design principles are integrated early. Finally, Research on Teaching Mode in Local Universities (2023) indicates that teaching modes combining classroom involvement, interdisciplinary awareness, and industry engagement significantly enhance students' professional abilities—skills aligned with what PLA seeks to build.

2.3 Quantitative Analysis in Design Education

Quantitative analysis methods are increasingly incorporated into design education to enhance students' analytical capabilities and decision-making skills. These methods enable students to objectively assess design elements and their alignment with market trends using measurable tools. For example, Yao, Zhang, and Li (2023) introduced a decision-making approach based on product family architecture and systematic evaluation to enhance industrial design competitiveness. Studies such as Abd. Jalil, Yunus, Said, and Iqbal (2016) demonstrate how perceptual responses, like physiological reactions to color in stimulating environments, can be systematically quantified, highlighting the value of objective, data-driven evaluation of design elements. Furthermore, the development of quantitative design ability assessment tools, as discussed in MDPI's Sustainability journal, underscores the growing emphasis on measurable outcomes in design education. Recent studies continue this trend: Fuertes-Camacho, García-Rodríguez, and López-López (2025) developed and validated a multidimensional assessment tool for evaluating eco-social competences; Akpınarlı, Yılmaz, and Demir (2025) created the Plant Perception Scale to quantify students' awareness of ecological and cultural significance; and Bataleblu (2024) highlighted the integration of sustainability-driven regulations into higher education, emphasising systematic evaluation and quantitative assessment in educational practices. Together, these studies demonstrate the expanding role of quantitative methods in equipping design students with robust analytical and decision-making skills, including the ability to measure perceptual and sensory responses.

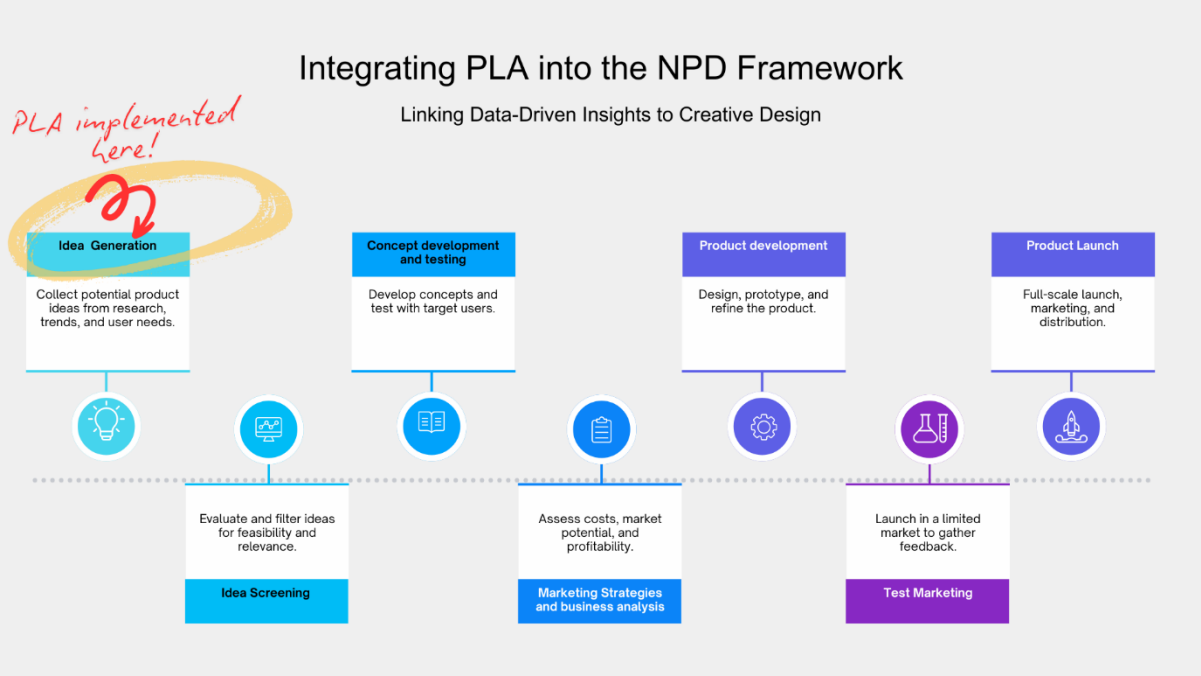

Fig. 1: PLA in the NPD Framework

2.4 Integrating PLA into the Studio-Based Design Process and NPD Framework

Studio-based design education mirrors real-world product development through a structured, iterative process that aligns with the New Product Development (NPD) framework. The NPD process is commonly structured into seven stages: (1) idea generation, (2) idea screening, (3) concept development and testing, (4) business analysis, (5) product development, (6) market testing, and (7) commercialisation. Within this sequence, Product Line-Up Analysis (PLA) can be effectively integrated into the idea generation stage, enabling students to examine existing product portfolios, identify market gaps, and anticipate consumer preferences before concept development. Studies by Liu et al. (2021) and Yao et al. (2023) demonstrate that data-driven tools such as PLA enhance students' ability to generate informed, market-relevant ideas. Grounding ideation in PLA insights supports the creation of concepts that are both innovative and user oriented. As students' progress through subsequent stages—such as mock-ups, modelling, presentations, and portfolio assessments—the early integration of PLA fosters market-oriented thinking and strengthens the connection between academic learning and industry practice.

3.0 METHODOLOGY

This study investigates the experiences of 14 final-year Industrial Design students from the AAD Department, KAED, IIUM, enrolled in the BAAD 4201 Final Year Project (Semester 2, 2024/2025), with a focus on their engagement with Product Line-Up Analysis (PLA). Over 14 weeks, students conducted background studies, including PLA activities during Weeks 1–3, integrating quantitative data into their design process. Following this, a three-part questionnaire was administered to gather information on students' backgrounds, experience their experiences with PLA, and their reflections. The collected data were analysed using Microsoft Excel to generate descriptive statistics (percentages), providing insights into student perceptions of PLA's role in their learning and design development.

4.0 RESULTS

Product Line-Up Analysis (PLA), conducted during the idea generation stage of the New Product Development (NPD) process, was performed out on 50–80 product samples selected by students in the studio (Figures 2–4). Although compiling and analysing all 80 products initially seemed challenging, this process provided substantial long-term benefits. Traditional PLA involved comparison tables to evaluate products across elements such as features, form, shape, materials, function, target audience, and price (Figure 2). Product mapping highlighted market clustering using X–Y axes to compare positioning and identify potential directions for future research (Figure 3). An enhanced quantitative approach incorporated percentage-based analysis of product elements—including shape, features, plant integration, plant size, and materials—showing, for example, that 55.7% of products had rectangular or square shapes, 36.6% were round, and 9.8% were irregular shaped (Figure 4).

These insights helped students better understand design trends, informed their decision-making, and guided the development of innovative concepts for their final-year projects. In addition, the PLA process improved students' analytical and critical thinking skills, enhanced their ability to identify market gaps, and provided a structured reference for ideation when they encountered design challenges. It also fostered awareness of user preferences, product positioning, and strategic design opportunities, enabling students to approach concept development more confidently and strategically. By completing this detailed analysis early, students gained a valuable resource they could refer to throughout the ideation and development process.

Figure 2. Sample of Product Line Up – Table

Figure 3. Sample of Products Mapping

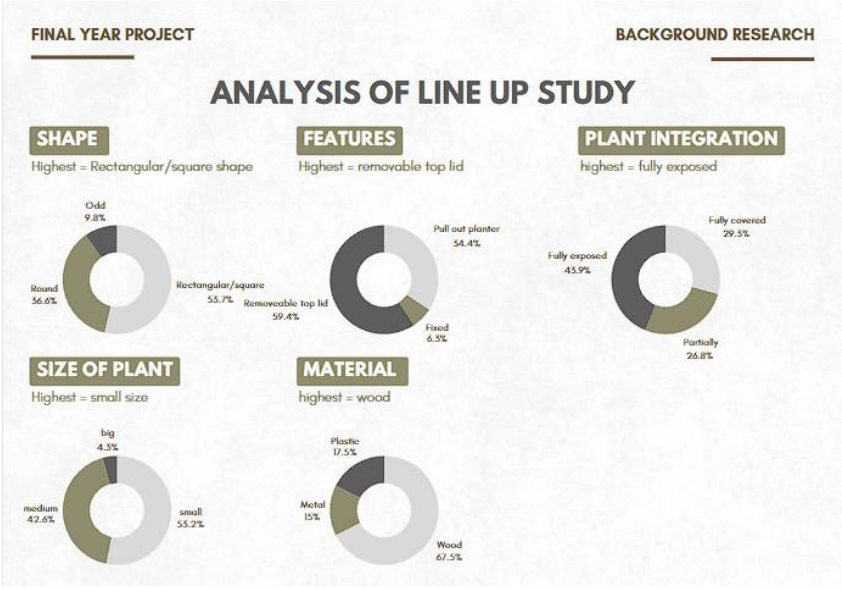

Figure 4: Sample of Enhanced Product Line-Up Analysis (PLA) Incorporating Quantitative Percentage-Based Feature

The survey, consisting of 14 questions, was organised into four key themes to better understand students' experiences with the manual Product Line-Up Analysis. Table 1 focuses on the perceived effectiveness of the method and how it compares with newer approaches. Table 2 explores how students understood product features, particularly in identifying functional and aesthetic differences. Table 3 summarises their suggestions for improving the activity, such as clearer instructions, standardised templates, and incorporating real-world observations. Lastly, Table 4 captures additional insights and reflections that reveal deeper learning outcomes and challenges encountered during the process. These categories provide a structured view of the feedback and point toward meaningful enhancements for future studio-based learning.

Table 1: Method Effectiveness

Question	Related Survey Items	Key Findings
Effectiveness of manual approach	B1: "How effective did you find this approach?"	60% found it "Very effective" or "Somewhat effective"
Usefulness of manual feature extraction	B2: "How useful was it to manually extract and list product features?"	47% found it "Moderately useful" or "Very useful"
Comparison of methods	B4: "Compared to the new method... how do you feel about the previous manual method...?"	40% felt "Both methods were equally helpful"
Value of percentage-based analysis	B7: "Do you think incorporating percentage-based feature occurrence would have made your analysis more insightful?"	67% answered "Probably yes" or "Definitely yes"

The survey results indicate that the manual approach was generally well received, with 60% of the participants finding it very or somewhat effective. Nearly half of the participants (47%) also found manual feature extraction moderately to very useful. When comparing methods, 40% felt both the manual and newer approaches were equally helpful, suggesting the manual method still holds value. Additionally, 67% of the participants believed incorporating percentage-based feature occurrence would have made their analysis more insightful, highlighting interest in combining manual methods with quantitative insights. (see Table 1). This highlights the potential of integrating traditional manual evaluation with data-driven PLA methods to strengthen ideation in the NPD process.

Table 2: Most Valuable Benefits (3 Questions)

Question	Related Survey Items	Key Findings
Understanding product variations	B3: "How did the manual extraction of features help you understand product variations and differences?"	47% said it "Helped identify key differences, but without deeper trend analysis"
Identifying functional and aesthetic differences	B6: "How did the previous method affect your ability to identify functional and aesthetic differences...?"	53% said it "Helped identify functional differences but not aesthetic ones"
Most valuable aspect	C1: "What was the most valuable part of using Product Line-Up Analysis for your design process?"	Common themes: understanding features, dimensions, mechanisms, market trends

The survey also explored the participants' views on the insights provided by the manual feature extraction process. Regarding the understanding of product variations, 47% stated that it *"helped identify key differences, but without deeper trend analysis"*. When it came to identifying functional and aesthetic differences, 53% felt the manual method *"helped identify functional differences but not aesthetic ones"*. Lastly, when asked about the most valuable aspect of using Product Line-Up Analysis for the design process, common themes emerged, such as understanding features, dimensions, mechanisms, and market trends (see Table 2).

Table 3: Impact on Design Process (11 Questions)

Question	Related Survey Items	Key Findings
Understanding product features	B8: "The line-up activity helped me understand differences in product features and aesthetics."	100% "Agree" or "Strongly agree"
Insight into consumer trends	B9: "I gained insight into consumer trends by analysing product variations."	93% "Agree" or "Strongly agree"
Identifying market preferences	B10: "I was able to identify market preferences using percentage or feature mapping."	100% "Agree" or "Strongly agree"
Deepening product understanding	B11: "The quantitative analysis deepened my product understanding."	93% "Agree" or "Strongly agree"
Strategic design direction	B12: "This method helped me develop a more strategic and informed design direction."	100% "Agree" or "Strongly agree"
Confidence in comparison	B13: "I feel more confident comparing existing products using structured visual methods."	100% "Agree" or "Strongly agree"
Improved decision-making	B14: "The approach improved my decision-making during concept development."	100% "Agree" or "Strongly agree"
Real-world relevance	B15: "The studio activity reflects how designers work in real-world industry settings."	100% "Agree" or "Strongly agree"
Awareness of global trends	B16: "I became more aware of global trends and market diversity through this activity."	87% "Agree" or "Strongly agree"
Recommendation for future use	B17: "I would recommend using Product Line-Up Analysis in future studio projects."	100% "Agree" or "Strongly agree"
Influence on concept development	C2: "How did this method influence your concept development or final mock-up?"	Common themes: informing measurements, identifying gaps in market, justifying design decisions

The survey also examined participants' perspectives on the impact of Product Line-Up Analysis on their design process. When asked how the manual extraction of features helped understand product variations, 47% of respondents indicated it *"helped identify key differences, but without deeper trend analysis"*. Regarding identifying functional and aesthetic differences, 53% mentioned it *"helped identify functional differences but not aesthetic ones"*. The most valuable aspect of using Product Line-Up Analysis was understanding key features, dimensions, mechanisms, and market trends, which were common themes across responses (see Table 3).

Table 4: Suggestions for Improvement (1 Question)

Question	Related Survey Items	Key Findings
Improvement suggestions	C3: "Do you have any suggestions for improving this studio activity in the future?"	Key recommendations: - Collaborative ground analysis - Clearer instructions from lecturers - Standardized content in tables - More hands-on activities - Site visits for real-life observation

The survey also collected feedback on potential improvements for the studio activity. Participants provided several key recommendations for future sessions, including the need for collaborative ground analysis, clearer lecturer instructions, and standardised table content. Many suggested incorporating more hands-on activities and emphasised the importance of site visits for real-life observation of product line-ups in actual situations, rather than relying solely on digital content from platforms such as Google.

5.0 DISCUSSIONS

The findings indicate that while the manual Product Line-Up Analysis method is generally effective, it has notable limitations. Most students found it helpful for identifying product features and functional differences, but less for analysing trends or aesthetic qualities. This reflects the method's strength in foundational observation and its lack of analytical depth.

Many respondents suggested that incorporating percentage-based analysis would provide clearer insights. This supports the idea that blending manual and data-driven methods could enrich students' understanding. Additionally, students highlighted the need for real-life observation, clearer guidance, and more hands-on activities, pointing to the value of experiential learning in design education.

The study suggests that although manual analysis remains a useful learning tool, its impact can be significantly enhanced through real-world engagement and structured analytical approaches.

6.0 CONCLUSION

This study has shown that manual Product Line-Up Analysis provides foundational value in helping design students observe and compare product features. However, its effectiveness is limited when deeper analysis or aesthetic evaluation is required. Students appreciated the method's clarity and structure but expressed a strong need for complementary tools, particularly those that incorporate data-driven analysis and real-world experiences.

The feedback highlights the importance of evolving design education by blending traditional observational techniques with analytical and experiential methods. Incorporating percentage-based feature analysis, clearer instructions, hands-on activities, and site visits can make learning more engaging and insightful.

Future research could explore how digital tools and visual analytics further enhance Product Line-Up Analysis, particularly in identifying user preferences and market trends. Expanding this study across different design disciplines could also reveal broader applications and improve curriculum design. Enriching the learning environment with structured and experiential methods can better prepare students for real-world product development challenges.

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DELPHI ANALYSIS IN FORMULATING A FRAMEWORK FOR POLICY AND PLANNING DEVELOPMENT OF OIL POLLUTION ON COASTAL WATER IN THE WEST COAST OF SABAH

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ABSTRACT

Effective management of marine oil pollution is essential for meeting the Sustainable Development Goals in Sabah's West Coast regions. This study employed the Delphi method, systematically gathering expert opinions through multiple rounds of questioning. Participants included government officials, industry experts, academics, and other stakeholders. Over three rounds of structured questionnaires, 76.47% of respondents identified land-based operations as the main source of pollution (standard deviation: 0.44), and the same percentage agreed that marine biology is the most affected receptor (standard deviation: 0.59). The panel reached a 94.12% consensus on the importance of policies to prevent oil pollution (standard deviation: 0.24). These results provide valuable guidance for Sabah, supporting improvements to the current framework and aiding the development of effective strategies for preventing and remedying oil pollution.

Keywords: Delphi, oil spillage, consensus, Likert scale, sustainability, environment

1.0 INTRODUCTION

Over the past several decades, oil and gas development has expanded significantly throughout Malaysia, particularly in the state of Sabah, making the industry increasingly vital to national economic growth (Lim & Goh, 2019). This rapid expansion, however, has introduced numerous ecological challenges, notably the management of oil pollution, as the region's sensitive ecosystems and coastal communities experience adverse environmental impacts. In response, the Malaysian government has enacted several legislative measures, including mandates for Environmental Impact Assessments (EIAs) under Section 34 of the Environmental Quality Act 1974 (EQA 1974). The Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 2015 further strengthens this legislative framework. Despite these regulatory efforts, oil spills and hydrocarbon pollution continue to pose a threat to Sabah's maritime environment and coastal populations. A significant incident occurred in 2004, when a crude oil leak from a subsea pipeline transporting oil from offshore fields to an onshore terminal resulted in a spill into the South China Sea, approximately 2 kilometres off the southwest coast of Labuan Island. The response escalated from Tier 1 to Tier 2, coordinated by the Labuan Beach Clean-up Committee, which included representatives from government agencies, the oil and gas sector, and non-governmental organisations. This event highlights the necessity of robust emergency response strategies, comprehensive oil spill contingency plans, and effective collaboration among stakeholders in addressing oil pollution. To address the complex issue of oil pollution management in Sabah's coastal waters, this paper presents findings on the primary causes of oil pollution, including offshore oil and gas production and exploration, pipeline and shipping spills, and land-based sources such as urban runoff and industrial effluents. The study utilised a panel of experts, including officers, administrators, managers, engineers, planners, academic scholars, and fishery professionals with a minimum of five years of experience. The panel also included environmental researchers, marine biologists, oil spill response engineers, representatives from environmental protection agencies, local community leaders, and industry stakeholders from shipping and oil companies, as illustrated in Figure 1. Synthesising the perspectives of these panellists enables identification of the key causes

and effects of oil and grease pollution. The report further outlines a framework designed to develop a balanced strategy for managing oil and grease pollution, which safeguards the environment, promotes public health, supports economic activity, and incorporates the perspectives of all major stakeholders. Implementation of these measures is expected to reduce pollution and ecological degradation associated with oil and gas production, while promoting sustainable management practices across other industries and sectors (Esiri et al., 2024).

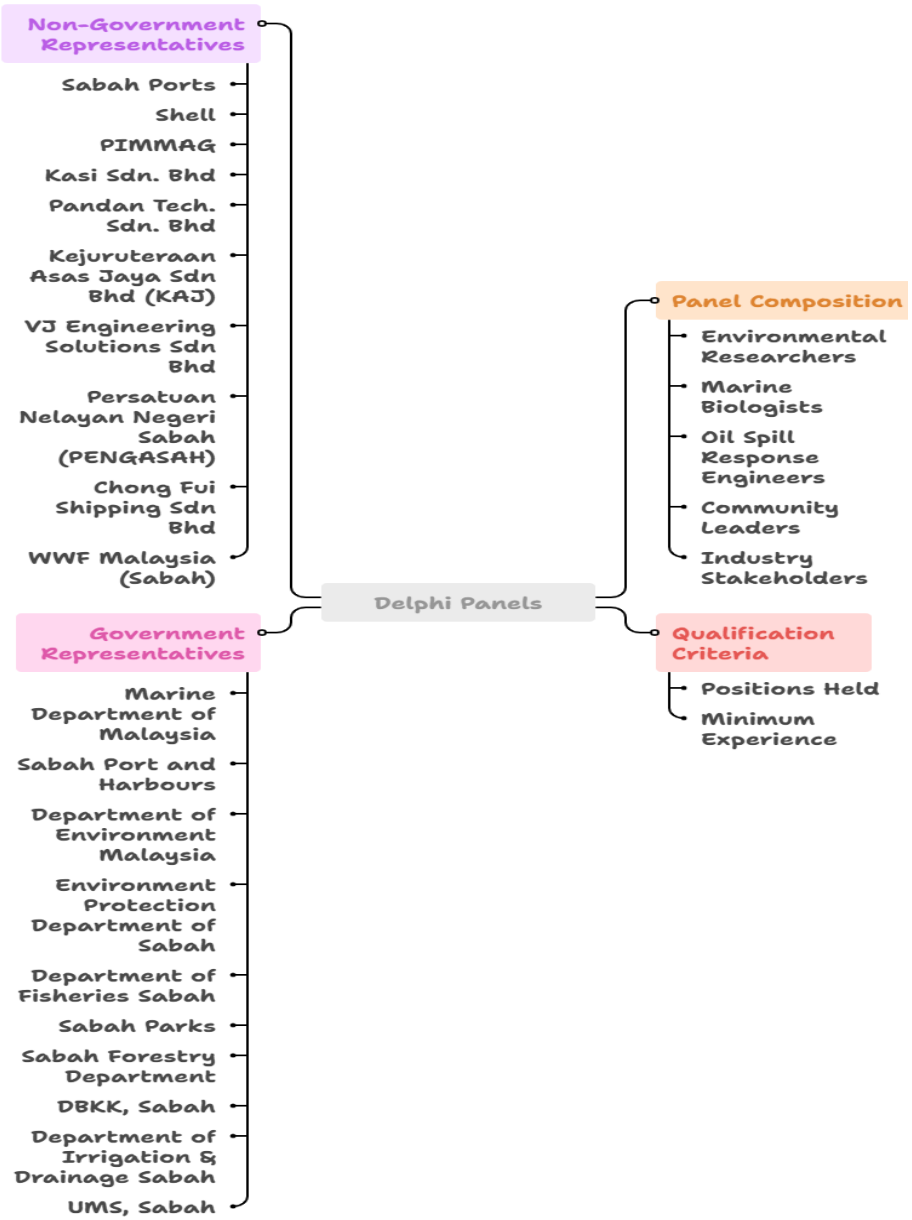

Fig. 1: Delphi panels backgrounds

2.0 LITERATURE REVIEW

Pollution in Malaysian waters is primarily caused by petroleum and gas exploration, high population density, intensive industrialisation, and evolving land use patterns along coastlines (Camara et al., 2019). Oil pollution poses a significant environmental concern, having a substantial impact on the marine ecosystem. The coastlines along the Straits of Malacca and the west coast of Sabah are particularly vulnerable, as oil spills and hydrocarbon contamination pose a significant threat to marine life and compromise water quality in these regions. Multiple studies have highlighted concerns regarding oil and grease pollution in Malaysian waters (Fadzil et al., 2017). Documented incidents of oil spillage, especially from offshore activities, have occurred around the West Coast of Sabah (Francis et al., 2024b). In several critically affected areas, there is clear evidence of disruption to marine

ecosystems and processes (Campagne et al., 2023). These disruptions include mass extinctions of marine species, loss of fishing grounds, and contamination of coastal waters used for aquaculture (Yuewen & Adzigbli, 2018), as well as a reduction in the region's value for recreational and other ecosystem services. Coastal communities, which depend on the coastal environment for food, livelihoods, and recreation, are among the most severely impacted (Andrews et al., 2021).

MIMA (2018) identified oil pollution as a significant threat to both the maritime community and the environment. According to the marine environmental profile, the majority of oil pollution incidents result from operational discharges associated with routine tank operations. These incidents typically occur during deballasting, oil tank and cargo cleaning, and the operation of fishing boats and small vessels (Chua et al., 1997, 2000). The resulting residues are washed away with seawater and ultimately discharged into the sea. Zakaria et al. (2001) emphasised the importance of source identification in enabling effective control of marine-based oil pollution sources. Pourvakhshouri et al. (2003) highlighted the critical role of knowledge-based systems in efficiently determining optimal response strategies. Their approach involves assessing sensitivity factors that impact coastal environments, such as oil movement, environmental conditions, and the effectiveness of monitoring and clean-up operations. Integrating coastal development operations with marine environmental protection requires a multidisciplinary strategy that incorporates frameworks for sustainable development, environmental preservation, and effective management (Tiquio et al., 2016). The demand for petroleum-related products has increased due to rapid industrialisation. Since 1976, the Department of Environment (DOE) in Malaysia has implemented a marine water quality monitoring program to safeguard aquatic ecosystems and public health by ensuring marine water is suitable for ecological functions and human use. Malaysia's National Marine Litter Policy and Action Plan (2021–2030) currently prioritises land-based sources, waste management, clean-up activities, and multi-stakeholder coordination.

3.0 METHODOLOGY

Francis et al. (2024) identified significantly elevated oil and grease concentrations at specific sites along the West Coast of Sabah, suggesting the presence of a pollution source that requires further investigation and remediation. The Delphi technique is commonly utilised to address complex environmental challenges. This method involves defining the research problem, selecting expert panellists, maintaining participant anonymity, providing structured feedback, conducting multiple iterative rounds, establishing and analysing consensus criteria, applying closing standards, and verifying the stability of the results. The quality of Delphi studies was assessed using nine established criteria (Nasa et al., 2021). Panellists were invited via email to participate in a three-round evaluation, which included demographic questions. In rounds one and three, participants rated the importance of each indicator using a 5-point scale (Jamieson, 2004); round three also incorporated risk matrix analysis. Participants could also submit free-text comments. Two reminder emails were sent during each round. Outcomes were discussed until response patterns stabilised. When disagreements or insufficient information arose, additional efforts were undertaken to achieve consensus. Once an agreement was reached, a report was prepared. If conflicts persisted, more targeted questions were introduced to clarify responses. This iterative process continued until consensus was achieved for the final report, thereby reducing bias (Beiderbeck et al., 2021).

3.1 Delphi procedure

Panels were invited via email to participate in a three-round evaluation process, which commenced with the collection of demographic data. Participants subsequently rated the importance of each indicator using a 5-point scale (1 = very low relevance, 5 = extremely high importance) (Jamieson, 2004). Following the initial round, participants were consulted regarding the outcomes in subsequent rounds to promote response stability. In cases of disagreement or insufficient information, additional efforts were undertaken to achieve a reliable consensus. Upon reaching an agreement, a report was prepared based on the documented responses. If conflicts remained, more specific questions were incorporated into the questionnaire to clarify responses. This iterative procedure continued until consensus was achieved for the final report.

3.1.1 Design of the survey

The questionnaire addresses several key issues, such as the current state of oil pollution, existing management strategies, potential environmental impacts, socioeconomic effects, legal and regulatory frameworks, technological innovations, and stakeholder engagement initiatives. These topics were selected to ensure alignment with the study’s objectives and parameters, as shown in Figure 2.

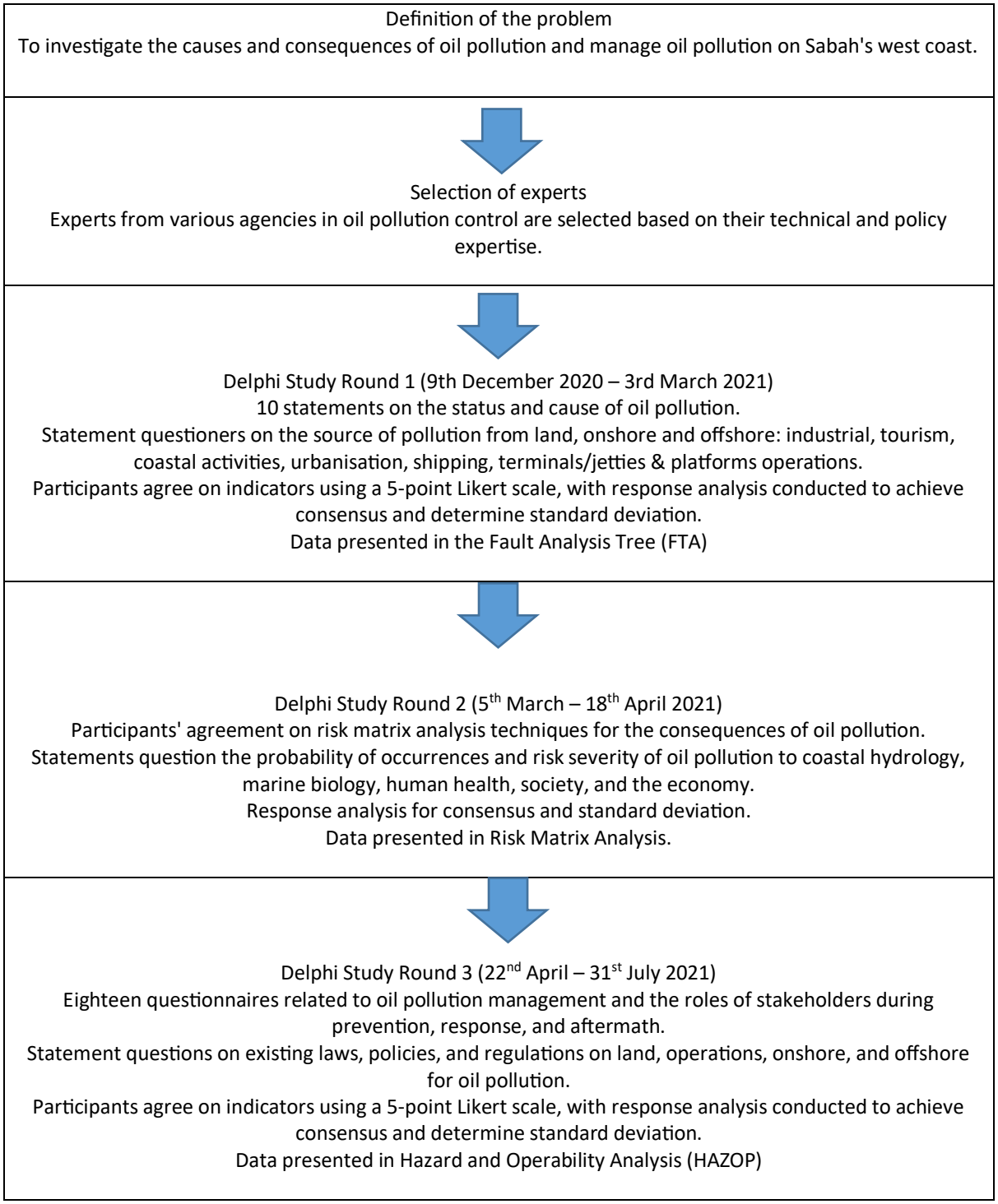

Fig. 2: Overview of Delphi study rounds

3.1.2 Analysis of Rating

This study incorporates three distinct types of analysis: Likert scale analysis, consensus analysis, and risk matrix analysis. By integrating these assessments, we develop a robust, data-driven framework that addresses significant issues, fosters expert consensus, and effectively manages the risks associated with oil and grease pollution. The Likert scale was utilised in rounds 1 and 3, while the risk matrix was employed in round 2. The Likert scale is a psychometric response measure commonly used in surveys to assess respondents' perceptions of a particular topic or issue. It presents ordinal data on a 5-point scale, assigning a numerical value to each item (Wadgave & Khairnar, 2016). Additionally,

the Australian Standard AS/NZS 4360 (2004) supports this approach, stating that the risk matrix is a risk analysis technique used to determine the likelihood and consequences of risks and establish a risk rank (Pickering & Cowley, 2010). Identifying risks is crucial, as it also assesses their severity and enables organisations to manage their impacts (Aven, 2016). A 51% consensus was applied based on both the mean and mode (McKenna, 1989). When evaluating consensus information using standard deviation, a value less than 1.5 was considered acceptable (Christie & Barela, 2005). This flexibility facilitated the achievement of the research's goals and objectives, since there is no established standard procedure for reporting Delphi findings (Schmidt, 1997). Three sets of combined criteria measurements are utilised to evaluate consensus. The analysis includes a median score of ≥ 4, which is crucial (Horner et al., 2009), an interquartile range (IQR) of 1 or less, and a standard deviation of less than 1.0 on a 5-point Likert scale (Geist, 2010). The risk matrix analysis technique evaluates the level of risk associated with significant actions by examining the likelihood of a consequence occurring, along with the risk management framework and risk and safety management (Yang & Mannan, 2010). This approach simplifies the processes of analysis, recording, and reporting. The risk rank is calculated by summing the likelihood and consequence ranks, based on a matrix that uses probabilities and consequences as its axes. The risk matrix highlights the risks with the highest priority, providing a clear visual representation of varying levels of risk. This matrix provides a graphical representation of the relationship between consequences and their likelihood of occurrence.

3.2 Delphi methodology

There were three rounds of the questionnaire. The first round's eight questions covered the assessment's release, which aimed to identify the primary sources of oil pollution from land-based, offshore, and onshore activities. During this round, a 5-point ordinal data statistic was provided, with a scale ranging from "strongly disagree" to "agree strongly". Each level on the scale had a numerical value assigned to it. The data and the Fault Tree Analysis (FTA) method were used to identify the most significant environmental risks associated with human activities. Using a graphic representation of events and their relationships, FTA helps identify faults by ensuring that an event's cause and relationship to other occurrences are appropriate and reasonable (Dunjó et al., 2010).

The second round examined the impact of oil pollution on human health, society, the economy, coastal hydrology, and marine life. In the study areas, twelve questions covered the likelihood of occurrence and level of risk. Questions 1–5 pertained to the probability of occurrence, while questions 6–10 addressed the risk severity using the risk matrix analysis statement format. Based on the possibility of a consequence, a standard method for assessing the degree of risk associated with priority actions combines the probability of occurrence and the severity of risk. The risk management framework extensively utilises risk analysis, recording, and reporting (Ale et al., 2015).

The third round aimed to prevent oil and grease pollution, as well as manage the situation during and after pollution events. It included eighteen questions about managing onshore operations, offshore oil drilling and associated activities, and managing on-land activities. It was, therefore, necessary to review the current regulations for preventing pollution during and after oil spills. This round's Delphi analysis was conducted in accordance with the Hazard and Operability Analysis (HAZOP) methodology. Risks were identified, and steps were taken to lessen or eliminate the potential sources of risk using HAZOP analysis (Kotek & Tabas, 2012)

4.0 RESULTS

Table 1 presents the results of the Delphi study ratings across three rounds. In each round, all consensus values exceed 50%, and the standard deviation is less than 1. The first round identified land-based operations as the primary source of pollution in the coastal waters along the west coast of Sabah. In the second round, it was determined that marine ecology is the most affected receptor, and that the most effective and efficient way to manage oil pollution is through prevention on land. It is crucial to revise all prevention strategies prior to any accidents or incidents occurring.

Table 1: Rating Results of Delphi Study in Three Rounds

Delphi round	Indicator	Consensus (%)	Median	Mode	Std. Deviation
1	On land (source of pollution)	76.47	1	1	0.44
2	Marine Ecology (Consequences)	76.47	2	1	0.59
3	Prevention on Land (Management)	94.12	2	2	0.24

5.0 DISCUSSIONS

A study by Delphi in round one (Table 1) indicates that the coastal waters on the west coast of Sabah have experienced substantial development, primarily driven by urbanisation, tourism, industrialisation, and coastal expansion, with a notable increase in oil and gas activities. Additionally, mining, reclamation, construction, erosion, untreated sewage, land runoff, agriculture, and aquaculture are significant contributors to land pollution associated with industrial activities (Polidoro et al., 2017). Industrial activities, manufacturing, and urbanisation in the coastal areas of West Coast Sabah are the primary contributors to oil and grease pollution—a key environmental concern in the region. Direct or indirect discharges from these sectors, such as those from the Sipitang Oil and Gas Industrial Park (SOGIP), Sabah Ammonia Urea (SAMUR), Sabah Forest Industries (SFI), and the Sabah Oil and Gas Terminal (SOGT), frequently enter rivers and the ocean. According to Hoegh-Guldberg et al. (2007), industrial activity accounts for up to 80% of ocean pollution. The Sabah Structure Plan 2020 further indicates that urban infrastructure and associated services, including water supply, solid waste management, sewerage, drainage, and transportation, are significant sources of pollution resulting from urbanisation.

Based on the study's findings on round two, as shown in Table 1, oil spills have the most severe effects on marine ecosystems. An oil spill occurs when liquid petroleum hydrocarbons are released into the marine environment, resulting in widespread pollution. Both natural and human activities can cause oil spills. Notable incidents include the Deepwater Horizon, Exxon Valdez, Arabian Gulf, and Mumbai oil spills, which are among the most significant in recorded history. Oil spills severely threaten marine ecosystems, harming diverse species and disrupting critical habitats such as coral reefs, mangroves, and seagrass beds (Kapila et al., 2021; Dudgeon et al., 2006; Sharma et al., 2024; Samiullah, 1985). These effects include health impairments, decreased survival and reproduction, and altered behaviour and physiology in marine organisms, depending on concentration (Holdway, 2002; Yuewen & Adzigbli, 2018b; Weis, 2015). Oil pollution degrades food sources and habitats, causes severe mortality, and leads to long-term biodiversity loss, with impacts persisting for years or decades (Shigenaka, 2017; Kingston, 2002; Deng & Adzigbli, 2018).

The third round of Delphi analysis revealed a consensus among panellists that current land regulations are insufficient to address oil contamination risks in both prevention and recovery phases. Legalising preventive measures could help avert such incidents. Guiding an incident is regarded as an effective way to support affected parties. Additionally, Hazard and Operability Analysis (HAZOP) is instrumental in identifying hazards and recommending actions to minimise or eliminate potential risks (Pasman & Rogers, 2020). Table 1 summarises the current legislation and practices for oil pollution management in Sabah, as identified through the Delphi study. The panellists reached the highest level of agreement that these measures require improvement. Policy changes are proposed to address the environmental consequences of oil pollution, particularly in light of the increasing number of human activities along Sabah's West Coast. Figure 4 indicates that oil spills, vessel operations, leaks during ship repair, and vessel sinking were the most common causes of accidents from 2011 to 2019. Data from the Sabah

Department of Environment (DOE) confirm that these incidents significantly contribute to marine pollution in Sabah waters.

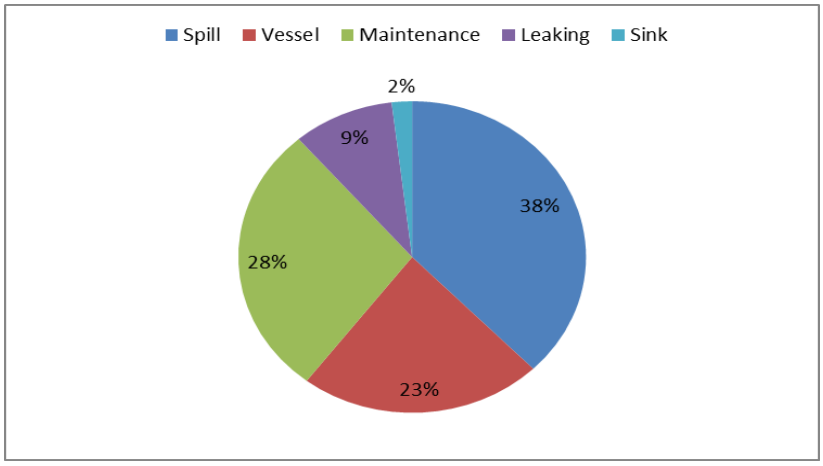

Fig. 4: The Cause of Marine Incidents in Sabah Waters
Source: Department of Environment Report 2011-2019

The proximity of sensitive receptors to pollution sources determines the effects of oil spills and the necessary response actions. Safeguards for oil pollution prevention in Sabah currently include laws, policies, and regulations. The Delphi study established guidelines for preventing and responding to oil pollution incidents. The expert panel's recommendations were assessed to identify the authorities responsible for mitigating risks and protecting sensitive receptors. To develop an effective framework for oil pollution control on Sabah's west coast, it is necessary to employ Delphi analysis to engage stakeholders from multiple sectors, conduct stakeholder mapping and analysis, establish coordination mechanisms, enforce existing laws, prioritise research and development, and implement public awareness and education campaigns (Shi et al., 2019; Maidin, 2005).

6.0 CONCLUSION

Enhancing local policy and coastal management leads to more effective responses to pollution events. The results reinforce the Sabah state government's initiatives to position the region as a biodiversity hotspot and underscore the need for stronger safeguards against pollution from shipping and industry. Healthier marine ecosystems, in turn, bolster Sabah's eco-tourism and blue economy, both of which are vital to its tourism-driven economy. Strengthening state-level contingency plans—such as improved emergency response coordination and oil spill monitoring—enhances disaster preparedness and response capabilities. By providing scientific support for stricter marine pollution regulations and enforcement, this study advocates for the improvement of policy and regulatory frameworks, ensuring compliance with global environmental standards.

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ADDRESSING VULNERABILITY AND ENHANCING RESILIENCE IN COASTAL AREAS: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Coastal areas are regions that are susceptible to hazards due to the impact of climate change. In adapting to the vulnerability condition, it is necessary to understand the adaptive strategy which can enhance resilience in coastal areas. This study examines the integration of vulnerability and resilience in coastal areas to inform adaptive strategies in disaster management. Through a systematic literature review, the study highlights four key gaps: the integration of local knowledge and longitudinal studies, the impact of socio-economic factors, an interdisciplinary approach and technology innovation, and community-based approaches.

Keywords: Vulnerability, resilience, adaptation, disaster management, coastal area.

1.0 INTRODUCTION

Coastal areas are regions that act as a buffer between land and sea, providing people with essential life needs and interacting with their ecological systems (Arda et al., 2025). Coastal areas also host various activities, including economic, industrial, and tourist activities, to support regional development. Due to these activities, coastal areas are also threatened by increasing human activities and associated environmental pressure, such as climate change (O'Higgins et al., 2019). Climate change poses serious threats to coastal areas worldwide, with rising sea levels, increasing temperatures, and more frequent storms, which directly affect natural ecosystems and human settlements (Niu et al., 2023) and could make these areas more vulnerable.

Vulnerability could be described as the susceptibility of physical and social systems to hazards and their inability to cope with the adverse effects (Adger, 2006). This concept integrates multiple dimensions, including sensitivity, exposure, and adaptive capacity. In the context of coastal areas, vulnerability can also be understood as the combined sensitivity of physical, socio-environmental and socio-economic aspects. It reflects how these factors interact to determine resilience of coastal communities against hazards such as flooding, storms and erosion (Bevacqua et al., 2018; Roukounis et al., 2022). Factors such as population density, urbanisation, and socio-economic status have a significant influence on vulnerability. For instance, densely populated urban areas may experience greater risks during disasters due to congestion and limited escape routes.

Climate change increases vulnerability, rendering coastal areas less capable of withstanding hazards and leading to the loss of ecosystems and services that mitigate risks (Bevacqua et al., 2018). However, most coastal vulnerability assessments are limited to physical and geological parameters (Nigam et al., 2024). Current vulnerability indices often employ a static approach, failing to account for the dynamic nature of coastal environments and the evolving risks associated with climate change. Research is needed to develop indices that

can adapt over time and reflect changing conditions, such as population growth, land use changes, and climate impacts (Pantusa et al., 2022). Addressing coastal vulnerability to climate change requires disaster risk management that integrates ecological restoration, sustainable planning and community participation. Understanding vulnerability is fundamental for disaster management, as it identifies which populations, infrastructures and ecosystems are most at risk. Disaster management frameworks then build upon this knowledge to design preventive, mitigative and adaptive strategies that directly target the sources of vulnerability.

Disaster management (DM) can be broadly defined as the set of measures and programs that span from preventing disasters to addressing their impacts (Tay et al., 2022). DM efforts aim to strengthen the capacity and resilience of communities by assessing vulnerabilities, avoiding adverse effects, and providing reliable hazard forecasts. DM efforts also seek to mitigate risks and enhance resilience across communities, both in the public and private sectors (UNDRR, 2025). Effective DM must be comprehensive and inclusive, ensuring that no sector is overlooked. The integration of ecological, physical and social systems is essential to guarantee that climate adaptation in one sector does not undermine another. The interconnectedness of social (human community) and ecological (nature) components within the coastal environment emphasises the importance of local knowledge, cultural practices, and community participation in developing the solutions that resonate with residents' lived experiences. To reduce disaster risk, it is essential to address vulnerabilities directly, thereby achieving the goals of disaster risk reduction and supporting better planning for social, economic, and ecological aspects (Ahmad Basri et al., 2022). Policies for disaster risk management must consider the specific vulnerabilities of different populations. This includes addressing the needs of marginalised groups and ensuring that disaster preparedness plans are inclusive and equitable (Asih et al., 2023).

Current adaptation strategies predominantly focus on complex engineering solutions, such as seawalls and levees, which may not be sustainable in the long term and can exacerbate ecological degradation (Dedekorkut-Howes et al., 2020). It has been found that while adaptation strategies are abundant in policy and governance literature, very few works examine implementation, financial costs, or the management of uncertainty in exposure and hazard projections (Cabana et al., 2023). Moreover, temporal dynamics and potential maladaptive outcomes are overlooked, as a framework developed for metropolitan resilience in Taipei reveals that infrastructure investment does not necessarily lead to long-term reductions in vulnerability or resilience shortfalls (Hung et al., 2024). Adaptation efforts, however, should be comprehensive and should not exclude any sector. The integration of ecological, physical, and community aspects is essential to ensure that climate adaptation in one sector does not undermine efforts in another. The interconnectedness of social (human community) and ecological (nature) components within the coastal environment emphasises the importance of local knowledge, cultural practices, and community participation in developing the solutions that resonate with residents' lived experiences. Other gaps include inconsistent or vague definitions of resilience, underrepresentation of ecological and livelihood dimensions in vulnerability indices, and a lack of studies from regions with high vulnerability but low research output, such as small island states or parts of the Global South (Laidlaw & Percival, 2024; Sealey, 2024).

This review is guided by an integrated framework that connects vulnerability, disaster management and resilience as interrelated dimensions of coastal adaptation. Vulnerability serves as the diagnostic lens, identifying the degree of exposure, sensitivity and adaptive capacity of coastal socio-ecological systems (Adger, 2006; Bevacqua et al., 2018). It highlights where risks are most acute and which communities, infrastructures or ecosystems are most susceptible to climate hazards. On the other hand, DM represents the operational response to these vulnerabilities. It encompasses prevention, preparedness, mitigation, response and recovery efforts aimed at reducing risks and safeguarding communities (Tay et al., 2022; UNDRR, 2025). By directly addressing identified vulnerabilities, DM provides the mechanism through which adaptation strategies are designed and implemented.

Furthermore, resilience constitutes the desired outcome of this process. It reflects the capacity of coastal systems not only to absorb and recover from disturbances but also to adapt and transform in the face of long-term climate pressure (Cabana et al., 2023; Roukounis & Tsihrintzis, 2022). While vulnerability points to system weakness and DM provides interventions, resilience captures the extent to which those interventions translate into sustained adaptive capacity. Positioning these concepts together enables the systematic review to move beyond fragmented definitions and examine how the literature connects these dimensions. It also offers a structured lens for identifying gaps in current approaches, such as the tendency of vulnerability assessments to

remain static (Nigam et al., 2024), the limited integration of ecological and livelihood dimensions into DM strategies (Pantusa et al., 2022) and the insufficient attention to long-term transformative resilience (Dedekorkut-Howes et al., 2020).

This paper systematically reviews the existing literature on coastal vulnerabilities and adaptive strategies to identify key knowledge gaps and highlight directions for future research. The aim is to provide a comprehensive understanding of how vulnerabilities are addressed globally and to generate insights that can inform more inclusive and sustainable approaches for strengthening disaster management frameworks and resilience planning in coastal areas.

2.0 METHODOLOGY

Analytical Overview and Search Strategy

A systematic literature review (SLR) is employed in this research to understand the adaptive strategies of DM, addressing vulnerabilities and enhancing resilience in coastal areas. The literature review process is conducted through the Scopus and Dimensions databases, with a focus on articles published between 2015 and 2025. The limitation of literature reviews to the last 10 years will ensure inclusion of the most recent and relevant evidence, reflecting current knowledge, technologies and practices in dynamic vulnerability and DM fields (Furuya-Kanamori et al., 2023; Helbach et al., 2022). The string used in search terms included "vulnerability" AND "disaster management" AND "resilience" AND "coastal zone".

Data were synthesised using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to increase transparency and rigour in the reporting process (Hossain et al.,2024; Makbul et al., 2024). The articles were chosen using the following inclusion and exclusion criteria: 1) articles published at least 10 years ago or in 2015; 2) articles written in English; 3) articles in the form of journals or proceedings; 4) articles that conduct analyses and demonstrate methodological quality; 5) articles that primarily discuss adaptation strategies based on vulnerability conditions; and 6) studies that analyse DM strategies to enhance resilience. This research does not include the articles that do not meet those criteria.

Data Extraction and Analysis

Thematic coding and narrative synthesis were used to extract and analyse the data. The thematic coding process was used to extract data, which was then coded to identify recurring themes and grouped into broader categories. These categories were organised into a structured narrative that compared findings across cases and linked them to theoretical frameworks of vulnerability, disaster management, and resilience. The data extraction and analysis process is illustrated in the PRISMA diagram in Figure 1. This diagram outlines the stages involved, beginning with the identification process, which involves identifying relevant studies, followed by the screening process, which assesses the article's eligibility based on established criteria. Although citation frequency was included in the results to illustrate the bibliometric significance of each study, the analysis primarily relied on qualitative synthesis rather than quantitative bibliometric mapping or meta-analysis.

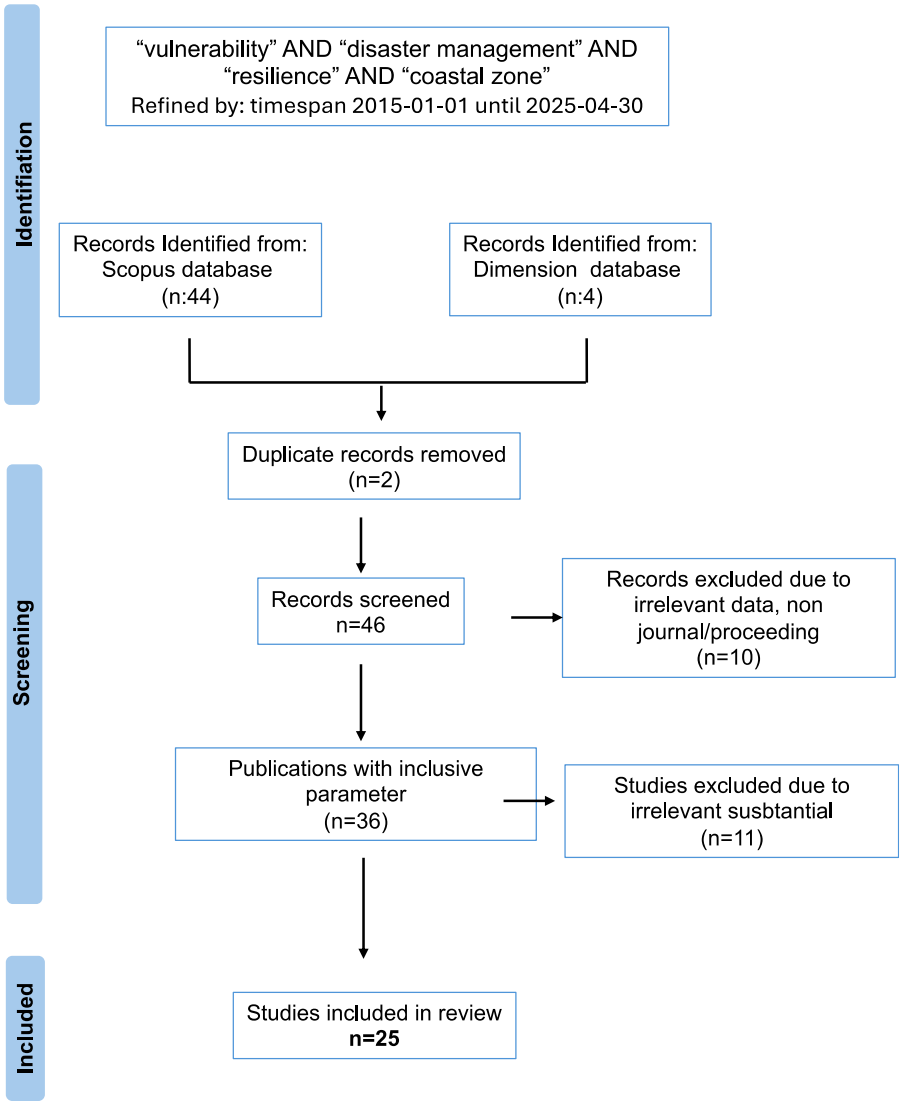

Fig. 1 PRISMA Diagram

Figure 1 illustrates the PRISMA diagram outlining the process of the systematic literature review conducted in this study. During the review, 48 articles were reviewed from databases such as Scopus and Dimensions. In the screening process, duplicate articles were removed, and 46 records remained. Additionally, 10 articles were excluded due to irrelevant data and those that were not in the form of a journal or proceedings, resulting in a total of 36 articles with inclusive parameters. After refining the eligibility of the articles using inclusion and exclusion criteria, this review included 21 articles for review. The summary of articles being reviewed is shown in Table 1.

3.0 RESULT

Table 1 provides an overview of the research articles focusing on vulnerability, DM and the resilience of coastal settlements around the world. These studies, published over several years, appeared in journals indexed by both Scopus and the Dimensions database. These articles explore topics such as the impacts of coastal floods, social and economic vulnerability, disaster strategies, and community resilience, highlighting their academic significance. Regional differences emerge in emphasis, for example, studies in Asia (Añasco, et al., 2021; Park, et al., 2024) tend to highlight community preparedness and the role of local adaptive capacity, while research in Europe (Chu, et al., 2021; De Risi, et al., 2022) focuses on technical tools such as stress testing and simulation models. In contrast, studies from Africa (Bello et al., 2024; Odunsi et al., 2024) point to household-level variation in resilience and the role of geospatial technology, while research from the Americas (Martinez et al., 2018; Qin

et al., 2017) emphasises socio-economic systems and governance structures. These comparisons illustrate how geographic context shapes both vulnerability framing and resilience strategies.

Table 1: Summary of Articles' Results

Author	Citation	Result
Park et al., 2024	0	The impacts of coastal floods triggered by SLR and other hazard factors can be reduced by aligning practical regulatory measures with adaptive strategies and enhancing the disaster resilience of coastal communities
Al-Maruf et al., 2023	8	The importance of human capital in disaster resilience strategies, highlighting that investments in education and skills development can lead to more effective responses to environmental threats
Añasco et al., 2021	21	The study revealed that Guimaras Island has disaster risk preparedness and effective community initiatives, in which the adaptive capacity of the local community was a key factor
Uddin et al. 2020	109	The findings demonstrate that community resilience attributes function interactively rather than independently, and require a clear understanding of network functioning that drives institutional structures, relations, and outcomes
Qin et al., 2017	59	The findings emphasised several critical elements necessary for enhancing community resilience, including a developed economic system, an excellent education program, infrastructure investment, and good policies
Bello et al., 2024	1	The findings revealed that the Delta coastal State has extensive medium to high-risk flood zones and emphasised the critical role of geospatial technology in enhancing DM and community resilience
Risi et al., 2022	5	The use of simulation-based procedures will allow for stress testing of communities to assess their resilience against multiple cascading hazards, ensuring that they have adequate resources to cope with extreme events
Chu et al., 2021	5	The social resilience to flooding hazard in Vancouver at the Census Tracts and Dissemination Areas census scales can have contradictory results depending on the census scale adopted
Martinez et al., 2018	40	The qualitative approach is used to understand the knowledge, values and behaviours of institutional and non-institutional stakeholders in formulating appropriate risk reduction
Mojtahedi & Oo, 2016	23	The understanding of socio-economic and built environment vulnerabilities is essential for effective DM and resource allocation
(N. Lam, et al., 2016)	235	The research revealed that the resilience inference measurement (RIM) model can be applied to derive resilience indices at different spatial and temporal scales
Barquet et al. 2018	7	The integrated approach in assessing disaster risk can be effective for triggering local dialogue, disseminating information, and achieving greater ownership and local acceptance of DRR
Lee et al., 2022	9	The environmental degradation has increased the vulnerability of coastal areas and highlights that integrated Nature-based Solutions could be implemented as disaster resilience strategies in Jamaica
Cai et al., 2016	22	Communities with higher resilience were generally located in the northern part of the study area, while lower-resilience communities were found along the coastline and in lower elevation areas

Author	Citation	Result
Bukvic, 2015	19	The RPACC framework encourages the inclusion of local perspectives and preferences, which can significantly impact the decision-making process regarding relocation
Giang et al., 2024	1	The study locations are generally well-prepared for climate change, and by focusing on social capital development and land-use planning, the coastal communities can further strengthen their resilience
Odunsi et al., 2024	5	The household resilience to flood disasters varies depending on the specific dimensions within each component in different flood zones
Dakey et al., 2023	6	The research identified vulnerabilities in human systems and the impact of governance strategies on critical SES components
Imani et al., 2022	9	The framework integrates the concepts of capability and resilience into four main sectors: resource, reason, roadmap, and response.
Tasnuva et al., 2024	2	The study underscores the importance of evolving from traditional approaches to advanced data-driven tools to understand disaster risks
Saravanan, 2016	2	The various disaster pre- and post-activities and their effect during a disaster, with the various mitigation steps

Table 1 presents a summary of the results derived from the various articles included in this systematic literature review, providing a detailed overview of the key findings. The table also presents the citation frequency of each article, which indicates the publication's significance based on its high number of citations (Ibrahim et al., 2024). It is essential to recognise that citation frequency should be viewed as a measure of academic influence, rather than direct relevance to practice. For example, N. Lam et al. (2016) is widely recognised for its methodological innovation in measuring resilience, with 235 citations. More recent contributions, such as those by Bello et al. (2024) and Giang et al. (2024), provide critical, region-specific insights into contemporary challenges, but have received fewer citations. Both types of contribution are significant but serve different roles in advancing the field.

4.0 DISCUSSION

As the integrated zone between land and sea, the coastal area is the zone with the most frequent human activities and the most vital area for the sustainable development of the global economy (Zhang et al., 2023). This zone is prone to disaster risk due to the impact of climate change, which has an adverse effect not only on the environment but also on the physical and economic aspects. Furthermore, disaster risk can be expressed as the loss of life, destruction and damage from a disaster in each period (Ahmad Basri et al., 2022). An adaptation strategy is needed to overcome the risk and minimise the damage. Many coastal cities tend to implement adaptation measures reactively, primarily in response to high-impact events such as floods and storms, rather than proactively planning for future risks. This reactive approach limits the effectiveness of DM strategies and fails to address long-term vulnerabilities (Wannewitz et al., 2024).

In the context of coastal areas, adaptation to climate change is a critical strategy to address the unique challenge of increased storm intensity and other environmental hazards. Climate adaptation refers to the process of adjusting to the actual or expected effects of climate change. This includes actions taken to prevent or minimise damage from climate impacts, as well as exploiting potential beneficial opportunities that may arise. In essence, adaptation aims to reduce vulnerability and enhance resilience in human and natural systems facing climate change challenges.

These findings demonstrate how the concepts of vulnerability, DM and resilience are interconnected yet unevenly addressed in current scholarship. Vulnerability is often assessed through physical and socio-economic indicators, but translation into proactive DM strategies remains limited. Moreover, while many studies highlight adaptive or absorptive resilience, fewer explore transformative resilience, which requires systemic change. This indicates a theoretical imbalance that needs to be addressed to operationalise resilience frameworks fully.

Several gaps were found from a systematic literature review regarding addressing vulnerabilities and enhancing resilience to conduct adaptive strategies and DM. The gaps are divided into four sections, which elaborate on the keywords used as a string in systematic literature reviews. The gaps will help us to understand the current literature and the future research that can be adopted.

Integration of Local Knowledge and Longitudinal Studies

Adaptation to enhance resilience can't be done without involving local communities
since the adaptive capability is defined as the capacity to adjust the system to minimise the adverse impact of climate change (Zen et al., 2019). This adaptive capability should involve the community as the subject that is critically influenced by climate change. While some studies reference local knowledge or community involvement, there is a lack of systematic integration of local knowledge into resilience planning. On the other hand, assessing the resilience of coastal communities, which involves understanding their connectedness, risk levels, disaster planning procedures, and available resources, is a crucial step that communities should undertake (Añasco et al., 2021; Park et al., 2024). The integrated approach in assessing resilience and disaster risk can be effective for triggering local dialogue, disseminating information, and achieving greater ownership and local acceptance of disaster risk (Barquet et al., 2018; Bukvic, 2015; Imani et al., 2022; Tasnuva et al., 2024). It can influence community recovery and adaptation strategies.

The time series studies or longitudinal studies are still rare in the articles found. Most studies employ a short-term or cross-sectional approach. Longitudinal studies can be used to understand the evolution of climate impacts and community adaptation over time. Communities can use the simulation-based procedure to assess their resilience against multiple cascading hazards, ensuring that they have adequate resources to cope with extreme events (De Risi et al., 2022).

Impact of Socio-economic Factors

Socio-economic status directly affects access to adaptive resources, the ability to relocate, and even participation in planning processes. Although studies often mention vulnerabilities, many do not deeply explore how socio-economic disparities (e.g., income, education, access to services) influence resilience capacity. There is limited discussion of marginalised groups (e.g., informal settlers, women, youth) in policy frameworks and planning processes. Assessing vulnerabilities to enhance resilience in disaster risk management requires considering socio-economic characteristics as indicators (Chu et al., 2021). Some scholars reveal that when both socio-economic and built environment factors are considered together in determining resilience, the results show a higher percentage of greater resilience rather than neglecting those aspects (Cai et al., 2018; Mojtahedi et al., 2016).

The need for a comprehensive resilience approach that goes beyond mere physical infrastructure (structural resilience). Human capital is a critical resource that not only enables households to respond to floods and storm surges but also facilitates the effective use of other resources available to them. By focusing on enhancing human capital, policymakers can create targeted interventions that strengthen the adaptive capacity of vulnerable communities in coastal areas (Al-Maruf et al., 2023). The findings emphasised several critical elements necessary for enhancing community resilience, including a developed economic system, an excellent education program, infrastructure investment, and good policies. While the overall level of resilience improved, the study found that regional differences in CRI also increased. This indicates that some areas may be advancing more rapidly in resilience than others, highlighting the need for targeted interventions. Resilience is not uniformly distributed across the coastal areas, and there are pockets of both high and low resilience (De Risi et al., 2022; Imani et al., 2022; Odunsi et al., 2024; Qin et al., 2017; Tasnuva et al., 2024).

Interdisciplinary Approach and Technology Innovation

Climate resilience is inherently multi-dimensional; tackling it from a single discipline limits the scope of solutions. Technology can significantly enhance data collection, monitoring, forecasting, and participatory planning (e.g.,

real-time flood warnings, crowd-sourced vulnerability mapping). The use of technological innovation (e.g., GIS, remote sensing, AI for predictive modelling) is underrepresented or underutilised in planning and monitoring efforts. Several studies remain confined to single-discipline perspectives (e.g., urban planning, environmental science), with limited collaboration across disciplines like social science, economics, or information technology. The lack of a universally accepted definition of risk emphasises that risk analyses must consider uncertainties and provide probabilistic descriptions of potential adverse events affecting a specific region. The use of simulation-based procedures, such as geospatial technology, will enable stress testing of communities to assess their resilience against multiple cascading hazards, ensuring they have adequate resources to cope with extreme events (Bello et al., 2024; De Risi et al., 2022). Integrating qualitative and quantitative data from various disciplines can enhance the understanding of how societies cope with risks and manage disasters (Mojtahedi et al., 2016). This collaboration can lead to unexpected insights and a more comprehensive understanding of disaster risk management (Martinez et al., 2018).

Constructing a community resilience index that addresses vulnerabilities can be conducted through several approaches, one of which is using city-level social and economic data (Qin et al., 2017). The other approach is the Resilience Inference Measurement (RIM) model, which can be used to assess community resilience to coastal hazards (Cai et al., 2016; N. Lam et al., 2016). The integrated approach in evaluating disaster risk can be effective for triggering local dialogue, disseminating information, and achieving greater ownership and local acceptance of disaster risk reduction. An interdisciplinary and technology-supported approach is crucial for integrating local knowledge systematically, monitoring changes over time, and designing inclusive strategies that account for socio-economic realities.

Community-based Approaches

Communities are the first responders to climate events. Their involvement ensures that adaptation measures are relevant and sustainable. Without robust participation, planned interventions may face resistance or become ineffective. While community participation is referenced, very few studies offer clear frameworks or evidence on how community-based adaptation is operationalised, funded, or sustained. There is also a lack of evaluation on the effectiveness of these approaches in achieving long-term resilience.

In terms of risk and vulnerability, the community had some awareness of hazards, but not all local people had access to hazard maps. Households actively engaged in disaster planning and response procedures, with community members participating in drills and planning activities (Añasco et al., 2021; Lee et al., 2022; Martinez et al., 2018). Community members became more organised and better connected, which enhanced their ability to respond to disaster (Uddin et al., 2020). By focusing on the identified areas for improvement, such as social capital development and land-use planning, the coastal communities can further strengthen their resilience against climate change impacts (Giang et al., 2024). The importance of involving local stakeholders in the assessment process revealed that local actors and institutions often operate without a shared strategy for DRR, leading to fragmented decision-making (Barquet et al., 2018). The interviews indicated a desire among community members to participate in DRR activities, such as volunteering for dune vegetation planting, which suggests potential for greater community involvement. The findings emphasised the importance of education and building trust between local authorities and residents. Many community members expressed a lack of knowledge about emergency procedures, indicating a gap that needs to be addressed to enhance resilience (Martinez et al., 2018).

Across regions, different emphases in resilience strategies were observed. In Asia, community-based initiatives and social capital development are central (Añasco et al., 2021; Park et al., 2024), while European studies focus more on technical stress-testing and modelling (Chu et al., 2021; De Risi et al., 2022). In Africa, resilience research highlights household-level disparities and the application of geospatial technology (Bello et al., 2024; Odunsi et al., 2024). Meanwhile, as mentioned before, the Americas emphasise governance structure and socio-economic systems (Martinez et al., 2018; Qin et al., 2017). This variation reflects how contextual vulnerabilities shape strategies, underscoring the importance of adaptive governance that bridges global frameworks with local realities.

Understanding people's resilience to flood disasters highlights that different households exhibit varying levels of vulnerability, which can lead to different material and human losses during such events (Odunsi et al., 2024).

The importance of community involvement in DM activities, including training and awareness programs, will engage local populations in disaster preparedness, can enhance resilience and ensure that communities are better prepared for future disasters (Saravanan, 2016).

For policymakers and practitioners, three priorities emerged: (1) systematically integrating local knowledge into DM and resilience planning; (2) ensuring equitable inclusion of marginalised and vulnerable groups; and (3) fostering interdisciplinary collaboration supported by technological innovations. Collectively, these priorities point toward more inclusive, adaptive and context-sensitive approaches that can strengthen resilience and reduce risks in coastal settlements.

5.0 CONCLUSION

Coastal zones serve as critical interfaces between terrestrial and marine systems, hosting vibrant human activity and underpinning global economic sustainability. However, these areas face escalating risks from climate change-induced hazards such as sea-level rise, coastal flooding, and intensified storms. Although numerous adaptation measures have been implemented, they often remain reactive, fragmented, and insufficiently integrated into long-term planning frameworks. This undermines the capacity of coastal communities to withstand and recover from future climate impacts. A systematic review of the literature reveals four key gaps that limit the effectiveness of disaster risk management and climate adaptation in coastal regions: (1) Integration of Local Knowledge and Longitudinal Studies, (2) Impact of Socio-economic Factors, (3) Interdisciplinary Approach and Technology Innovation, and (4) Community-Based Approaches. These gaps are deeply interconnected and highlight systemic challenges in current resilience strategies.

Beyond mapping gaps, this study contributes to advancing both theory and practice. Theoretically, it reframes vulnerability, DM and resilience not as linear stages but as an iterative cycle in which lessons from resilience feed back into future vulnerability assessment. Empirically, it shows that despite the prominence of highly cited works, many continue to reinforce static framings while more integrative approaches remain underutilised. Practically, the findings underscore the need for context-specific and actionable pathways, particularly in the Southeast Asian context, where hybrid approaches that combine community-led initiatives with formal governance frameworks can yield transformative resilience outcomes.

Future research and policy must move beyond reactive measures to proactively design and implement inclusive, forward-looking adaptation pathways. By bridging these four key gaps in a coordinated manner, stakeholders can enhance the adaptive capacity and resilience of coastal communities in the face of accelerating climate challenges.

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THE RELATIONSHIP BETWEEN RESIDENTIAL LAND COVER CHANGE AND URBAN POLICY IN MALANG CITY: CASE STUDIES AND RECOMMENDATIONS

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ABSTRACT

This study aims to analyse the relationship between changes in residential land cover and urban policy dynamics in Malang City. With rapid population growth and increasing urbanisation, demand for residential land has surged. The methods used in this study are spatial analysis of satellite imagery and a qualitative approach to evaluate policies implemented by local governments. The results of the study show that changes in residential land cover in Malang City are closely related to existing spatial planning policies that are often not aligned with the community's need for decent housing. In addition, recommendations are offered to improve integration between land-use planning and settlement policies, creating a more sustainable urban environment that is responsive to social dynamics. This research is expected to contribute to the development of more effective urban policies in the future.

Keywords: Land Cover, Malang City, Urban Policy, Settlement, Spatial Planning

1.0 INTRODUCTION

The development of settlements in Malang City has become a major concern in urban planning, particularly amid rapid urbanisation and population growth (Wagistina & Antariksa, 2019). Malang City, one of the main urban centres in East Java, faces significant challenges in managing land cover changes amid high housing demand (Rachmansyah & Halim, 2019). These changes are often out of control and have the potential to disrupt the balance of the environment and urban spatial planning. In this context, it is important to understand how urban policies shape changes in residential land cover and, conversely, how these changes affect policy decision-making (Yasin et al., 2020).

Previous studies have shown that spatial planning policies in many developing cities are often less adaptive to changing societal needs (Hurliman et al., 2021). In Malang City, this phenomenon is reflected in the emergence of informal settlement areas and the mismatch between the regional spatial plan (RTRW) and the reality on the ground (Adrianto, 2022). Related studies also indicate that the lack of integration between spatial planning and settlement policies can exacerbate socio-economic problems, such as inequality of access to decent housing (Kajiita & Kang'ethe, 2024). Therefore, this study seeks to fill this gap by exploring in greater depth the relationship between urban policy and residential land cover change.

This study hypothesises that there is a significant relationship between residential land cover change and urban policy in Malang City. To test this hypothesis, the study used a spatial analysis approach based on satellite imagery to map changes in land cover over time (Latue, 2023). In addition, qualitative methods, through in-depth interviews with stakeholders and document studies, are used to understand the development of urban policies in Malang City. This approach allows research to identify spatial patterns of land change while evaluating the effectiveness of policies in responding to community needs.

The results of this study are expected to contribute to a better understanding of the interaction between urban policy and settlement development dynamics. The findings can also provide strategic recommendations for local governments in formulating more responsive and sustainable spatial planning policies. By understanding the patterns of land cover change and their impact on society, the government can design spatial planning strategies that are not only oriented towards physical development but also take into account social and environmental aspects (Thahir, 2023; Siregar et al., 2025).

The article begins with a review of the literature on settlement development and urban policy, providing a theoretical context for this research. The next section describes the research methodology, including the spatial and qualitative data collection techniques used. The findings will be presented in detail in the results and discussion section, where an in-depth analysis will be conducted to answer the research questions. This article concludes with a summary of the main findings and policy recommendations to support more effective spatial management in Malang City.

With this interdisciplinary approach, this research not only makes an academic contribution but also offers practical implications for future urban planning. The city of Malang can serve as an example of how integrating spatial analysis and policy evaluation can yield innovative solutions to urban challenges. This research is expected to serve as a reference for policymakers and academics in creating an urban environment that is more inclusive, sustainable, and adaptable to society's socio-economic dynamics.

2.0 LITERATURE REVIEW

2.1 Changes in Residential Land Cover

Land cover change, especially in urban areas, is often associated with urbanisation and population growth (Zhai et al., 2021). A study in Kedungkandang, Malang, shows that infrastructure plays an important role in land cover change. Technology-based prediction models, such as Artificial Neural Networks (ANNs), achieve high accuracy in mapping these changes (Hariyanto et al., 2024). Another study in Malang also revealed that the conversion of agricultural land to settlements has increased significantly over the past two decades, driven by the need for housing due to rapid population growth (Darmawan et. al, 2024). This trend aligns with the global trend, in which urbanisation leads to the expansion of built-up areas and the decline of green land, increasing surface temperatures and contributing to environmental degradation (Arshad et al., 2022).

2.2 Urban Policy and Its Influence

Urban policies have an important role in regulating land cover change. In Chengdu, China, spatial planning policies integrated with economic reforms and housing markets have successfully guided the city's growth in a more targeted manner (Lu et. al, 2022). Conversely, the lack of coordination between spatial planning policies and community needs can exacerbate socio-economic problems, such as inequality in access to decent housing (Abascal et al., 2022). A study in Chennai, India, highlighted the importance of policies that support green development to mitigate the negative impacts of land-use change on water resources (Razi et al., 2024). This research shows that spatial data-driven policies can help governments design more effective mitigation strategies.

2.3 Sustainable Development Theories

Sustainable development theory is a framework that integrates economic, social, and environmental aspects in a balanced manner to achieve development that not only meets the needs of today but also ensures the fulfilment of future generations' needs (Hariram et al., 2023). In the context of urban planning, this theory emphasises the need for effective and inclusive resource management that ensures social welfare while preserving the environment (Gupta & Vegelin, 2016). This approach demands cross-sector coordination and community participation as key success factors. The application of sustainable development principles is an important foundation in formulating spatial planning policies and settlement management that are adaptive to social and environmental changes (Schetke et. al., 2012). This theory is highly relevant to the study of land cover dynamics in urban areas within a sustainable development framework.

2.4 Urban Spatial Planning Theories

Spatial planning theory concerns regulating the use of space through policies and regulations that direct regional development in a structured and systematic manner (Acheampong, 2018). This theory links spatial policy to land-use change, focusing on regulating land functions to meet ecological, social, and economic needs (Gomes et al., 2024). This approach positions physical planning as the primary instrument for achieving integrated development and management of regional resources (Harahap et al., 2023). Urban spatial planning is the foundation for the arrangement of settlements, green areas, and infrastructure to create a harmonious, efficient, and sustainable urban environment (Wang et. al., 2023). The integration of this theory is important in understanding how urban policies affect patterns of land cover change in developing cities.

2.5 Complex Adaptive Systems (CAS) Theories

Complex Adaptive Systems Theory views cities as dynamic, complex systems in which various elements and actors interact and adapt to changing internal and external conditions (Shi et al., 2021). In the context of changing land cover, the CAS approach helps explain how factors such as policies, community behaviour, economics, and the environment interact and shape changing patterns of settlement and land use (Daba & You, 2022). This theory emphasises the importance of flexibility, adaptability, and the ability of systems to learn from change to achieve long-term balance and sustainability (Alzoraiki et al., 2024). The CAS approach provides a holistic perspective for designing planning interventions that can accommodate the uncertainty and complexity of urban dynamics.

2.6 Concept of "*Verbrechting Village*" and "*Indlansche Gementee*"

Verbrechting Village is a village concept introduced by the Dutch colonial government to prevent the spread of disease outbreaks from slums. This system aims to control and separate people based on social status (Tucunan et. al., 2018). Meanwhile, *Indlansche Gementee* is a Dutch colonial local government system for ordinary citizens, in contrast to *Stads Gementee* for the *priyayi* (Javanese aristocratic) and elites. This system reflects the colonial government's efforts to regulate and segregate communities based on social status (Kusumastuti, 2017).

2.7 Methodological Approach in the Study of Land Change

Studies analysing land cover changes commonly rely on satellite imagery and spatial analytical tools to capture temporal dynamics effectively (Abebe et al., 2022; Furusawa et al., 2023; Rambe et al., 2024). Models such as the Patch-Generating Land Use Simulation (PLUS) have been utilised to forecast land cover changes under varying socio-economic scenarios (Tian et al., 2022). Supervised classification techniques have proven effective for accurate land-use monitoring, as demonstrated in regions such as Balochistan and Sindh (Raza et al., 2024). These approaches provide essential evidence for informed urban planning and land management decisions.

2.8 Theoretical Framework for Urban Land Change Analysis

Urban land change analysis requires integrating socio-economic, environmental, and policy dimensions under dynamic frameworks. Sustainable development theory, urban spatial planning, and CAS collectively underpin a comprehensive framework that explains land cover change not simply as a physical transformation but as the outcome of complex interactions among human behaviours, policy governance, and ecosystem responses. This integrated theoretical perspective guides the interpretation of spatial data and policy assessment, enabling a nuanced understanding of how urban policies shape land use patterns while responding to environmental and social sustainability imperatives. Employing this framework strengthens the connection between empirical findings and policy recommendations in urban land management.

3.0 METHODOLOGY

This study employs a mixed-methods approach, integrating quantitative spatial analysis with qualitative policy analysis, to explore the relationship between residential land cover change and urban policy in Malang City (Sarfo et al., 2022). The research is structured into three main stages: (1) mapping land cover change using satellite imagery processed with machine learning algorithms, (2) analysing policies through document reviews and stakeholder interviews, and (3) integrating spatial and qualitative data to identify patterns of linkage (Figure 1).

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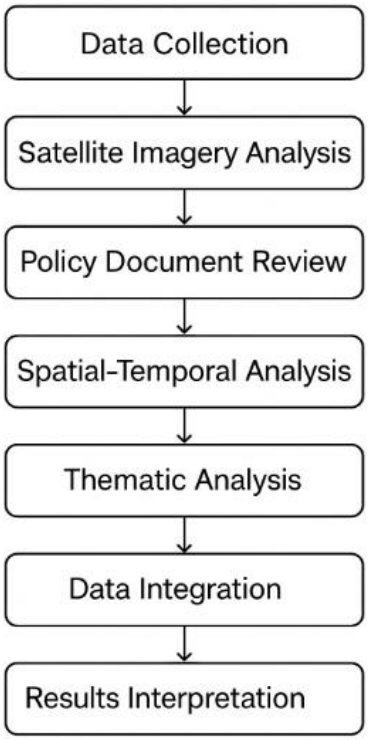

Fig. 1: Research Method Flowchart
(Source: Researchers' Analysis, 2025)

Spatial Data Collection

The spatial data collection utilises an integrated approach via the Google Earth Engine (GEE) cloud computing platform to access multitemporal satellite imagery from the USGS Earth Explorer and the Copernicus Open Access Hub (Amani et al., 2020). The dataset includes Landsat 5-7 imagery at 50-meter resolution (1979–2000) and Landsat 8-9 imagery at 30-meter resolution (2000–2025). Land cover classification is performed using the Random Forest (RF) algorithm within GEE, categorising land into three primary classes: built-up areas (settlements and infrastructure), green areas (vegetation and agricultural land), and water bodies (rivers, lakes, reservoirs) (Pande et. al., 2024). This method has been validated in multiple studies as efficient and accurate for land cover classification, benefiting from GEE's capability for processing large satellite datasets with high spatial and temporal resolution

Policy Study Analysis

The policy analysis focuses on reviewing settlement policies in Indonesia with a specific emphasis on Malang City, periodised into the Independence Era, New Order, and Reform periods. A thematic analysis method is employed to systematically identify key policy themes related to slum improvement, housing accessibility, and environmental sustainability (Batra, 2021). Policy data are gathered from official government documents, prior research, and scientific publications, including central government policies, regional regulations (Perda), and the Regional Medium-Term Development Plan (RPJMD). To enhance the validity of the findings, in-depth interviews were also conducted with key stakeholders involved in urban planning and policy implementation. These interviews provided contextual insights and helped triangulate the documentary analysis.

Thematic Analysis

The thematic analysis was conducted through several interrelated steps. First, key themes were identified, and settlement policies were categorised by period and central issue. Subsequently, the data were coded and organised using qualitative analysis techniques to ensure consistency and depth of interpretation. Finally, a chronological policy periodisation was prepared to highlight the shifts in strategic approaches to settlement development over time.

Contextualisation

The periodisation of settlement policy development in Indonesia can be divided into three major phases. The Independence Era (1945–1966) was characterised by efforts to establish the initial legal and policy foundations related to settlements. During the New Order period (1966–1998), the focus shifted to large-scale infrastructure expansion and mass housing programs, with significant impacts on urban communities. In the Reform Era (1998–present), settlement policies underwent a paradigm shift toward greater inclusivity, emphasising sustainability and community participation in planning and development. The integration of spatial and policy data adopts a qualitative descriptive approach to correlate land cover changes detected via multitemporal satellite imagery (Landsat and Sentinel) with policy evolution (Liu & Cai, 2012). Thematic key policy points are linked to observed spatial patterns of land change.

Data Validation and Interpretation

Data triangulation is conducted through in-depth interviews with relevant stakeholders, including city planners and local communities, to validate findings (Ogunkan & Akinpelu, 2025). This integrated methodological approach provides a comprehensive understanding of the interplay between urban policy and land cover dynamics, thereby supporting the formulation of evidence-based, sustainable settlement policy recommendations.

4.0 RESULTS

Results of Land Cover Changes in Malang City

The results of the land cover analysis in Malang City for 1989, 1994, and 1999 show significant changes in land classification, including settlements, vegetation, and water bodies (Figure 2). In 1989, it was visually evident that the largest area was vegetation, followed by residential areas, while water bodies had the smallest area. In 1994, residential areas began to spread, especially in the northern and southern areas, and expanded to the east and west sides of Malang City. The decrease in vegetated land that year can be attributed to the expansion of residential areas and the increase in areas classified as water bodies.

Furthermore, based on 1999 land cover data, residential development occurred more in the northern part of Malang City. Compared to the previous two periods, residential areas are expanding, while vegetated areas are decreasing. This change indicates the ongoing urbanisation trend in Malang City, which has the potential to affect the balance of the ecosystem and environmental quality. Therefore, it is important to consider sustainable land management strategies to maintain green open space and reduce the negative impacts of settlement expansion.

The results of the land cover analysis in Malang City (Figure 3) show that in 2014, residential areas dominated the city, with vegetation conditions declining. In that year, although there was still vegetated land on some of the north and south sides, the development of settlements was becoming clearly visible. Then, in 2019, settlement expansion extended into previously vegetated areas on the north and south sides, reducing the area of vegetated land through conversion to settlements.

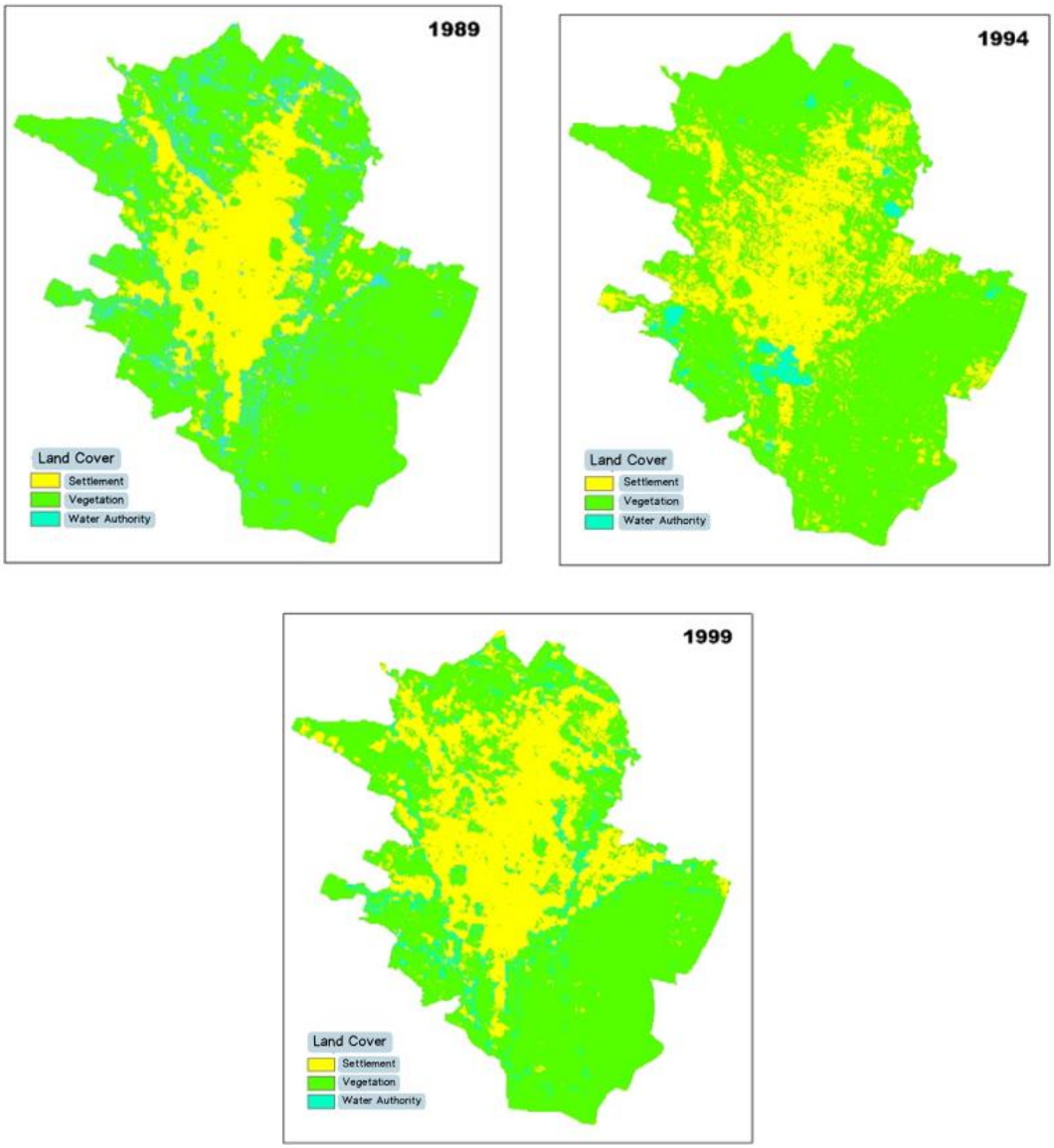

Fig. 2: Land Cover of Malang City, Indonesia for the Period of 1989, 1994 and 1999
(Source: Researchers' Analysis and Interpretation of USGS Landsat Imagery, 2025)

In 2024, land cover shows that residential areas are expanding across various areas of Malang City, while vegetated areas are concentrated in the southern part of the city. These changes reflect the ongoing urbanisation trend and show a significant impact on local ecosystems. A decrease in vegetation area can affect environmental quality and the balance of ecosystems. Hence, the government needs to formulate policies that manage settlement growth sustainably and protect the remaining green open space.

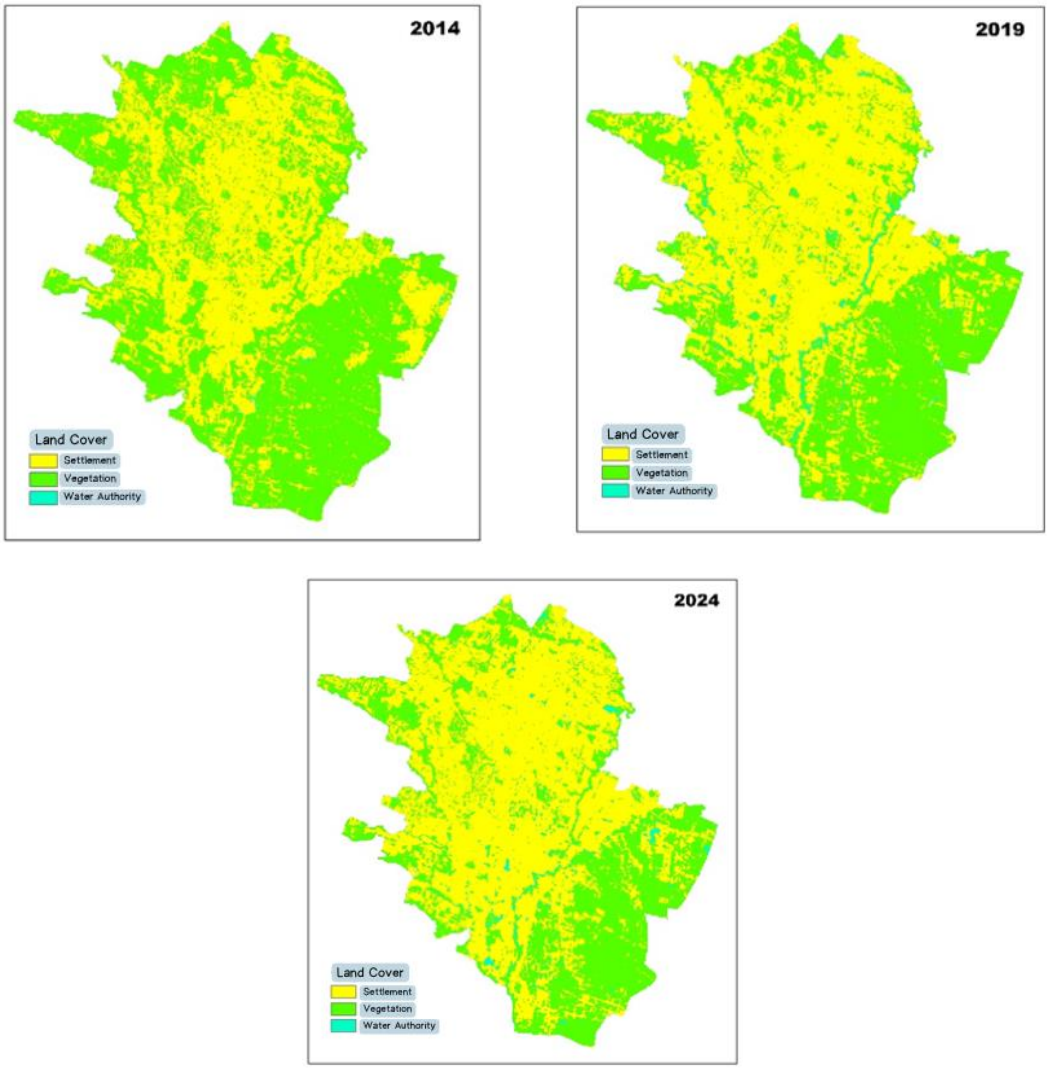

Fig.3: Land Cover of Malang City, Indonesia for the Period of 2014, 2019 and 2024
(Source: Researchers' Analysis and Interpretation of USGS Landsat Imagery, 2025)

Policies Assessment

Several key policies were analysed to understand their influence on changes in residential land cover in Malang City, including the Regional Spatial Plan (RTRW), the KOTAKU and PNPM programs, and the Regional Regulations on settlement planning and green open space management. The Malang City Regional Spatial Plan (RTRW) has served as a strategic planning document governing land use and spatial management within the city for over 20 years. It functions as the principal guideline for urban development, aiming to maintain a balance between residential growth, economic zones, and the preservation of green open spaces in support of sustainable development. The KOTAKU (City Without Slums) and PNPM (National Program for Community Empowerment) programs represent national initiatives focused on improving settlement quality, particularly in slum areas. KOTAKU emphasises revitalising residential environments through community and stakeholder participation, while PNPM promotes grassroots empowerment in planning and managing neighbourhood infrastructure and facilities. Complementing these, the Regional Regulation (Perda) on settlement planning and green open space provides more detailed provisions for land-use control, spatial organisation, and environmental preservation. This regulation reinforces legal protection for urban green areas, supports ecological and social functions, and establishes sustainability standards in the residential sector.

Development of Settlement Policy in Malang City

The development of settlement policy in Malang City is discussed in four (4) periods: before Independence, the independence era, the New Order era, and the Reform era.

Before Independence, settlement policies in Indonesia, including in Malang City, originated during the Dutch colonial period. At that time, the Verbrechting Village concept was introduced to prevent the spread of infectious diseases from slum areas. Society was classified into social strata, with the Indlansche Gementee system applied to ordinary citizens and the Stads Gementee reserved for the *priyayi*, or Javanese aristocratic and bureaucratic elites. This policy reflected the colonial government's effort to control and segregate communities based on social status while addressing public health issues arising from poor living conditions.

During the Independence Era, following Indonesia's Independence, the government launched the Kampung Improvement Program (KIP) in the 1960s. This initiative aimed to enhance the physical and infrastructural quality of residential areas, particularly in underdeveloped urban neighbourhoods. Despite limited financial and technical resources, the program marked an important shift toward improving community welfare, especially in slum areas requiring immediate intervention.

In the New Order Era, settlement development was guided by the Repelita (Five-Year Development Plan), which adopted the Tribina and Tridaya approaches. The Tribina concept emphasised physical, economic, and social development, while Tridaya focused on strengthening environmental, economic, and social capacities. In 1989, the government introduced the Group-Based Housing Development Program (P2BK), promoting community participation and self-reliance in managing settlements. This approach encouraged local communities to play an active role in developing and maintaining their living environments.

During the Reform Era, continuous evaluations were conducted to enhance the effectiveness and relevance of urban settlement policies. For instance, the Kampung Improvement Program evolved into KIP-K in Surabaya, serving as a more comprehensive model later adopted nationwide. The government subsequently launched the National Program for Community Empowerment (PNPM), which integrated various initiatives to improve urban settlements. Under President Joko Widodo's administration, particularly during his first term, the KOTAKU (City Without Slums) program was introduced as part of the 2015–2019 National Medium-Term Development Plan (RPJMN). This program focused on reducing and revitalising urban slums through community-based, sustainable development strategies.

Table 1: Development policies that affect land change

Period	Key Policies	Impact on Land Change
Pre-Independence	Verbrechting Village, Indlansche Gementee	Social segregation and controlled settlement
Independence Era	Kampung Improvement Program (KIP)	Focus on physical infrastructure
New Order	Tribina-Tridaya, P2BK Program	Mass housing development
Reform Era	PNPM, KOTAKU Program	Participatory and sustainable approach

Source: Researchers' Analysis, 2025

In line with the KOTAKU program at the national level, the Malang City Government also designed and initiated the Thematic Village Program to improve the living standards of people in various marginalised areas. Through this approach, a better, more sustainable environment can be created for the people of Malang City.

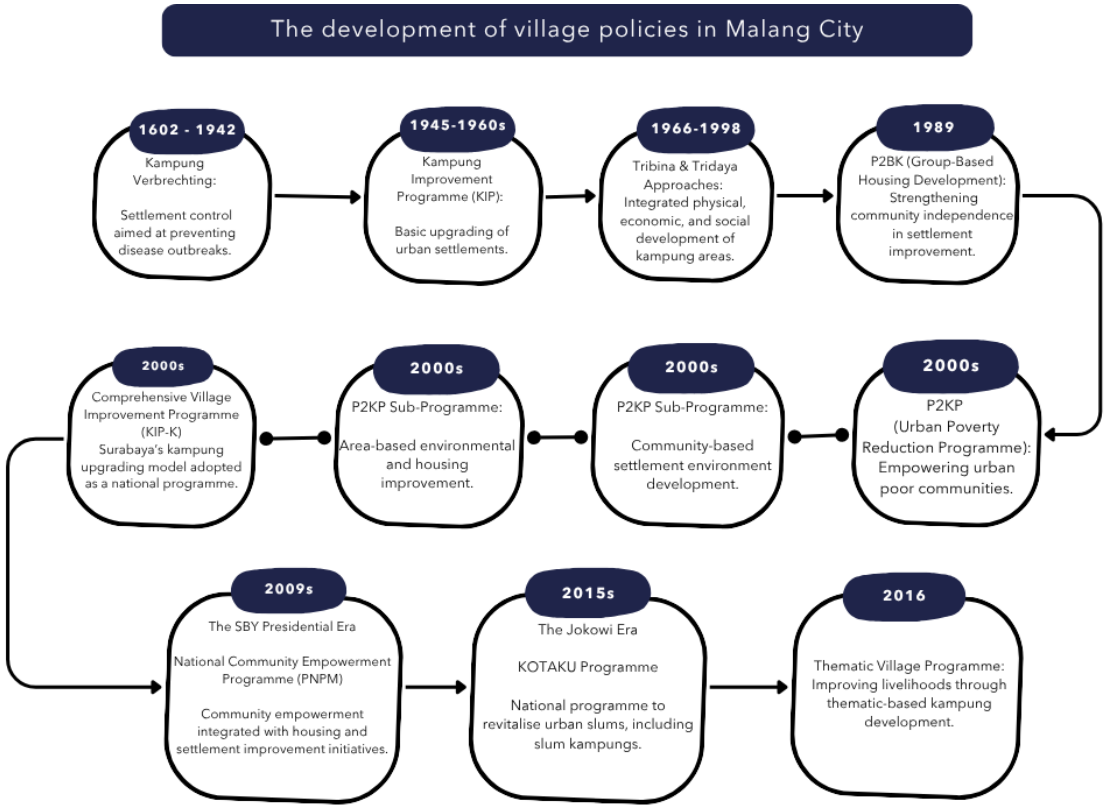

Fig.4: Timeline of Settlement Policy Development in Malang City, Indonesia
(Source: Researcher's Analysis of Various Policy Literature, 2025)

5.0 DISCUSSIONS

The results of this study strengthen the hypothesis that residential land cover changes in Malang City are closely related to urban policy dynamics over the past few decades. Spatial analysis reveals significant settlement expansion from the late 1980s to 2019, particularly in the city's northern and southern parts. This growth aligns with sustainable development theory, which holds that urban expansion driven by socio-economic needs should be balanced with environmental conservation. However, in Malang, it has led to a substantial reduction in vegetation and green open spaces (Isdianto et al., 2025). Such loss affects ecological balance and challenges the environmental dimension of sustainability frameworks.

During the New Order era, urban policies emphasised physical infrastructure and economic development, following a top-down spatial planning approach (Tjondronegoro, 1978). This approach neglected broader socio-economic impacts and environmental integration, a detail explicated in urban spatial planning theory, which warns against overly rigid land-use regulations detached from community needs. Consequently, social inequalities and spatial planning problems emerged due to this disjointed governance. This statement highlights the risks of non-adaptive planning, which fails to address the complex, multidimensional nature of urban systems.

During the Reform era, a paradigm shift toward participatory, sustainable policy approaches emerged, reflecting adaptive spatial planning concepts that emphasise flexibility and inclusivity (Haqi, 2023). Nevertheless, challenges such as weak cross-sector coordination and limited local government capacity slowed effective implementation. The gap between formal plans and on-ground realities persists, indicating the difficulty in achieving truly adaptive and community-responsive urban governance. This gap exacerbates informal settlement growth and misaligned land-use change.

A significant issue identified is the lack of synchronisation between the Regional Spatial Plan (RTRW) and the community's actual needs, which drives unplanned expansions outside designated zones. This problem, coupled with weak law enforcement, accelerates the conversion of green areas to residential land. From an Urban Heat

Island perspective, such loss of vegetation increases urban heat accumulation, contributing to higher localised temperatures and degraded living comfort—a pattern observed globally, where reduced green cover intensifies urban climatic stresses (Singh et al., 2020).

The growth of informal settlements due to planning inconsistencies raises serious socio-economic challenges, including unequal access to public services and increased disaster vulnerability. Sustainable urban development theory suggests that such issues require integrative policy frameworks that link physical, social, and environmental aspects cohesively (Ajirotutu et al., 2024). Addressing these challenges demands participatory planning and policies that explicitly incorporate equity and resilience principles.

In-depth interviews conducted during this study further validate the long-standing dynamics of land-use change in Malang City's marginal areas. A representative from the Spatial Planning Division of the Malang City Planning Office confirmed that "the development of settlements in marginal areas is part of a long-standing dynamic. The agency is only responsible for ensuring no new construction occurs in these areas, while enforcement lies with the mayor's office and the municipal police. For instance, riverbank zones also involve other authorities such as the Provincial Government, Perum Jasa Tirta, and the Brantas River Basin Authority." This policy highlights the fragmented institutional responsibilities that complicate enforcement and coordination in managing marginal lands.

Community perspectives also reveal deep-rooted historical settlement patterns. A resident representative from a riverbank tourism village stated, “We have lived here for a long time, since our parents and grandparents. So we are simply continuing to live here." This statement underscores the intergenerational nature of informal settlement in marginal areas, where tenure is shaped more by legacy than legality.

Additionally, a local spatial planning academic emphasised that "the development of settlements in marginal areas of Malang City is a consequence of high urbanisation rates and the city's role as a national activity centre in East Java, alongside Surabaya." This statement reinforces the structural pressures driving land conversion and the need for more adaptive, inclusive, and anticipatory planning responses.

Remote sensing technologies and spatial data analytics used in this study are vital for accurately capturing land cover dynamics and enabling informed, evidence-based decision-making. Combining spatial data with thorough policy evaluation helps identify priority intervention zones, supporting the development of effective land management strategies. This integration is crucial for building adaptive governance systems in line with contemporary spatial planning research.

Post-Reform policy reforms have increased opportunities for community participation and focus on sustainability, echoing multi-stakeholder governance frameworks. Collaboration among government, society, and the private sector enhances planning responsiveness and counters centralist inefficiencies. This participatory governance model is fundamental to effectively managing the growing complexities of urban life and environmental constraints.

This study underscores the essential integration of spatial planning, settlement policy, and environmental protection. Unregulated residential land cover change threatens both urban livability and long-term sustainability. In response, urban policies must evolve towards adaptive, data-driven, and ecologically sensitive approaches that embody sustainable development and adaptive spatial planning principles. Strengthening the partnership between spatial and socio-economic policies is urgently needed to resolve informal settlement issues and access inequalities. An inclusive, data-supported governance approach can boost policy effectiveness and equity, promoting just and sustainable urban development. Furthermore, robust supervision, regulatory enforcement, institutional capacity development, and community empowerment remain key to realising democratic and adaptive urban spatial planning.

Overall, this research offers a comprehensive understanding of the complex interplay between land cover change and urban policy in Malang City. The findings provide a theoretically grounded and practical basis to formulate more effective policy strategies, applicable not only locally but also in similar urbanising contexts. Future research should deepen explorations of adaptive governance mechanisms and further leverage spatial technologies to advance sustainable urban futures.

6.0 CONCLUSION

This study reveals that spatial planning policies significantly influence residential land cover changes in Malang City; however, these policies have historically emphasised physical development without adequate integration of social and environmental dimensions. Such an approach has contributed to declining environmental quality and uneven community welfare. Nevertheless, advances in spatial technologies and post-Reformation policy reforms have created opportunities for more participatory, inclusive, and sustainable settlement planning. The rapid expansion of residential areas between 1989 and 2024 underscores the urgent need for adaptive urban planning strategies that balance physical growth with socio-environmental resilience.

Specific policy recommendations are proposed to promote more sustainable settlement development in Malang City. First, implementing smart growth principles through compact development and mixed-use zoning is essential to prevent uncontrolled urban sprawl. Establishing green belt policies, supported by strict enforcement mechanisms, is also necessary to preserve the remaining vegetated areas, particularly in the southern part of the city. Furthermore, community-based settlement planning should be strengthened by integrating local participation into decision-making processes to ensure social inclusivity and local relevance. In addition, urban heat island mitigation strategies should be developed through the enforcement of mandatory green space requirements for new residential projects. Finally, inter-agency coordination among spatial planning, environmental, and housing authorities must be enhanced to achieve coherent, well-integrated urban policies.

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INTEGRATING HEALTH DISASTER RISK MANAGEMENT INTO URBAN RESILIENCE IN MALAYSIA: BARRIERS, PRACTICES AND CONSTRUCT VALIDATION

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ABSTRACT

The COVID-19 pandemic highlighted critical vulnerabilities in Malaysia's urban health systems and disaster risk management, particularly in responding to complex health emergencies in densely populated areas. This study examines barriers and current practices of Health Emergency and Disaster Risk Management (Health-EDRM) within the context of urban resilience. A quantitative survey was conducted among 179 practitioners across multiple agencies. Descriptive analysis identified key barriers, including overwhelmed healthcare capacity (M = 3.29, SD = 0.957), low public compliance (M = 3.20, SD = 0.925), and insufficient resource allocation (M = 3.13, SD = 0.985). Confirmatory factor analysis (CFA) was used to assess the reliability and validity of the key constructs. The validated constructs, such as governance, risk assessment, preparedness, capacity building, and recovery demonstrated strong internal consistency and sampling adequacy. These findings highlight systemic gaps in current practices and provide empirical evidence that existing Health-EDRM approaches remain insufficient to address the complexity of urban disasters. By validating these constructs, this study lays the groundwork for an integrated framework to guide policymakers and practitioners in strengthening governance, multisectoral collaboration, and preparedness for future health emergencies.

Keywords: Disaster Risk Management, Urban resilience, WHO- HEDRM, Construct validation

1.0 INTRODUCTION

The COVID-19 pandemic has highlighted vulnerabilities in global health systems and urban governance, particularly in the management of health emergencies. Urban areas, characterised by high population densities and socioeconomic structures, faced unique challenges in addressing the virus's rapid spread. The Health Emergency and Disaster Risk Management (Health-EDRM) framework emphasises the need for coordinated efforts across sectors and community engagement to enhance urban resilience. This framework aligns with international initiatives, such as the Sendai Framework and the 2030 Agenda, underscoring the importance of integrating risk-reduction strategies into urban planning. However, current and future urban disaster risk management must address not only COVID-19 but also other large-scale health emergencies and compounded risks. In the urban risk literature, the interconnected "three C's" — climate change, COVID-19 (and other health crises), and conflict which are widely acknowledged as exacerbating urban vulnerabilities. Climate change

intensifies extreme weather and health hazards, COVID poses ongoing pandemic threats, and conflict further complicates urban resilience. Therefore, a holistic, integrated approach is imperative for effective preparedness and response to these overlapping challenges (International Federation of Red Cross and Red Crescent Societies [IFRC], 2021; Sharifi, 2020).

In addition, policymakers must adopt a holistic approach to disaster management that involves diverse stakeholders and promotes resilient infrastructure. The interconnected challenges of climate change, COVID-19, and conflict exacerbate urban vulnerabilities, underscoring the need for effective preparedness and response strategies. Malaysia's Health Emergency and Disaster Risk Management (HEDRM) system during the COVID-19 pandemic exemplifies both strengths and challenges in addressing complex health crises. Therefore, this paper aims to explore Malaysia's experience with the COVID-19 pandemic through a holistic framework. It identifies key barriers, current practices, and integrative factors within Health Disaster Risk Management that contribute to urban resilience. Additionally, it presents the process of construct validation, providing a robust foundation for developing an integrated Health-EDRM and Urban Resilience framework for future application.

2.0 LITERATURE REVIEW

This literature review explores the barriers to effective health emergency management, the components of the Health-EDRM framework, and the need for an integrative approach that enhances urban resilience.

2.1 Barriers to Effective Health Emergency Management

The COVID-19 pandemic has revealed significant barriers to effective health emergency management, including insufficient resources, overwhelming healthcare capacity, inadequate policies, low public compliance, and poor inter-agency coordination, which were issues observed globally, not just in Malaysia (Kruk et al., 2020). Historically, pandemics such as the 1918 influenza, SARS, and cholera outbreaks have significantly impacted urban health systems and governance, affecting demographics and infrastructure resilience (Sharifi, 2020; Gallardo-Albarrán, 2025; UN-Habitat, 2024). In Malaysia, past cholera epidemics have influenced urban growth and socioeconomic recovery. Lessons from previous outbreaks have led to improvements in early warning systems and inter-agency collaboration, with countries such as South Korea and Singapore enhancing their response capabilities (Khatri et al., 2023; WHO, 2020; UNDRR, 2024). The rise of overlapping threats necessitates the integration of health risks into disaster management. While the Sendai Framework faces challenges such as vague guidelines and weak enforcement, Health EDRM can enhance resilience by integrating epidemiological data with risk assessments and community preparedness, making it essential for effective risk governance (UNDRR, 2024).

2.2 Health Emergency Disaster Risk Management (Health-EDRM)

The Health Emergency Disaster Risk Management (Health-EDRM) framework is a comprehensive approach developed by the World Health Organization (WHO) to guide countries and partners in reducing the risks and impacts of all types of emergencies and disasters, including epidemics and pandemics such as COVID-19, through a structured, multisectoral, and risk-based strategy (WHO, 2021). WHO identified ten core (10) components for effective Health-EDRM: i. Policy, regulation, and legislation; ii. Planning and coordination; iii. Human resources; iv. Financial resources; v. Information and knowledge management; vi. Risk communication; vii. Health infrastructure and logistics; VIII. Health and related services; ix. Community capacities; x. Monitoring and evaluation (WHO, 2021).

2.3 The Public Health Emergency

Health EDRM is a continuum of measures that emphasises managing the risks of potential emergencies or disasters, rather than solely responding to the event or crisis, and building the resilience of communities and countries (WHO, 2019).

The WHO Health Emergency and Disaster Risk Management (Health-EDRM) Framework **(Fig. 1)** prioritises people's Health during emergencies and disasters, providing both academic and practical solutions, while also addressing management aspects (Chan & Lam, 2020; Chan & Shaw, 2020; World Health Organisation, 2019). It also includes strengthening collaboration between health authorities and stakeholders to strengthen the country's capacity for disaster risk management (WHO, 2019).

Fig.1: Public Health Emergency Preparedness Cycle
(Source: Belfroid et al., 2020).

2.4 Malaysia Disaster Governance and Pandemic Response

Malaysia's National Disaster Management Agency (NADMA) issued Directive No. 1 in 2024, establishing a multi-stakeholder framework for disaster risk management. This framework emphasises early coordination among government agencies, district councils, NGOs, and local communities (NADMA, 2024). As the primary agency, NADMA collaborates with federal, state, and district committees to provide disaster-specific early warnings and risk assessments (Sharifi-Sedeh et al., 2024; Abdullah, 2022). During the COVID-19 pandemic, this directive facilitated a coordinated national response led by the Ministry of Socioeconomic Affairs addressing transmission, treatment, and socioeconomic support. This framework highlights the importance of stakeholder cooperation in enhancing Malaysia's disaster resilience.

2.5 Disaster Risk Management Cycle

The UN Office for Disaster Risk Reduction (UNDRR) defines a disaster as "a serious disruption of the functioning of a community or society involving widespread human, material, economic, or environmental losses and impacts, which exceeds the affected community's ability to cope using its resources." The conventional risk and disaster management framework is shown in **Fig. 2.**

Fig 2: Disaster Risk Management Cycle
(Source: United Nations Office for Outer Space Affairs. (n.d.). Risks and disasters. UN-SPIDER. Retrieved October 14, 2025, from https://www.un-spider.org/risks-and-disasters)

2.6 Health Resilience in Disaster Risk Management Cycle

The COVID-19 pandemic has profoundly influenced urban planning, underscoring the critical need to integrate public health considerations within the disaster life cycle framework, which comprises prevention/mitigation, preparedness, response, and recovery phases. Below is the analysis of this relationship and its implications:

Table 1: Analysis of the Relationship of Disaster Risk Management Cycle Framework and Implications

Disaster life cycle framework	Analysis of Relationship and Implications	Sources
Prevention/Mitigation	Overcrowding and poor ventilation in urban planning can facilitate the transmission of illnesses. Green areas and active transit are essential for health-centric design. To lower pandemic risk, healthcare and sanitation networks must be resilient.	Afrin et al. (2021).
Preparedness	COVID-19 exposed weaknesses in urban healthcare access and public communication. To improve readiness, urban design should incorporate simulation models, capacity-building initiatives, and decentralised governance. Crisis response requires adaptable urban settings that accommodate health measures.	Okoli et al. 2024; Capolongo et al. 2020
Response	The "15-minute city" concept promotes local access to essential services, boosting economies and reducing travel. Temporary urban interventions improved mobility during lockdowns. Inclusive design and targeted investments in underserved areas are essential for equitable urban development.	Stoltenberg 2024; Jennings et al. 2021; Pineda & Corburn 2020
Recovery	Integrating health and disaster risk reduction into urban policy through cross-sector collaboration and community engagement fosters resilience, sustainability, and social equity.	UNDRR 2023

The COVID-19 pandemic has underscored the need for health-centric urbanism, prompting city leaders to prioritise public health in their design. Effective urban planning must integrate infrastructure, social factors, and stakeholder engagement to build resilient communities and ensure preparedness for future health crises through a comprehensive, health-centred approach.

2.6 Urban Resilience

Urban resilience has emerged as a critical priority for cities facing escalating natural and health-related disasters driven by climate change and rapid urbanisation (Wu et al., 2024). Resilience is broadly conceptualised along four key dimensions: planning, absorption, adaptation, and recovery, each integral to sustaining urban functionality and protecting public health during crises (Terblanche, 2022).

Planning as a dimension involves proactive governance, strong legal frameworks, and integrated risk reduction strategies that incorporate health disaster risk management (DRM). Effective planning requires multisectoral coordination, policy coherence, and risk-informed urban development, ensuring that cities are prepared for health emergencies and other hazards (Terblanche, 2022). Planning supports anticipating vulnerabilities and allocating resources to safeguard critical health infrastructure and populations. The WHO Health Emergency and Disaster Risk Management (Health-EDRM) framework emphasises the importance of integrating health risk considerations into urban resilience planning to reduce inequalities and enhance overall community well-being (WHO, 2022).

Absorption refers to the capacity of urban systems to withstand and buffer the immediate impacts of disasters without incurring significant functional loss. This includes robust health systems, the availability of emergency services, and effective risk communication that prevents health services from collapsing under strain (Terblanche, 2022). Urban areas with resilient health systems absorb shocks more effectively, ensuring continuity of care and minimising mortality and morbidity during disasters.

Adaptation emphasises the ability of urban systems and communities to learn from past events and progressively adjust protocols, infrastructure, and policies. This agility supports flexible responses to evolving risks, such as pandemics and climate-induced health hazards, by incorporating scientific knowledge and

technological innovation (Wu et al., 2024). Adaptation also includes community engagement in health risk management, fostering local capacities, and behavioural changes that reduce vulnerabilities over time.

Recovery involves restoring and improving health and urban systems after a disaster, with a crucial focus on "building back better" to enhance future resilience (Terblanche, 2022). Health service rehabilitation, psychosocial support, and inclusive social policies are key elements that contribute not only to returning to normalcy but also to addressing systemic inequities exposed by disasters.

In sum, an integrative approach linking Health-EDRM and urban resilience highlights the interconnectedness of disaster risk factors and health outcomes. Inclusive governance and cross-sector collaboration are vital for comprehensive planning, enhancing adaptive capacity, and developing effective recovery strategies to safeguard cities from health emergencies and promote sustainable urban futures.

3.0 METHODOLOGY

3.1 Research Design and Data Collection

This study employs a quantitative research approach to explore the intersection of health resilience and urban planning in the context of health disaster risk management (HDRM). Initial data collection involved a comprehensive literature review of scholarly articles, official reports, and case studies on HDRM, urban resilience, and policy frameworks. This provided a contextual foundation for the research. A structured questionnaire was then administered to a purposive sample of practitioners, including urban planners, public health officials, and representatives from the armed forces, to gather insights into Health EDRM practices in Malaysian urban settings (Creswell, 2014). Data collection began with online surveys during the pandemic and continued face-to-face from October 2022 to January 2025.

3.2 Questionnaire Design

The questionnaire was developed by extracting variables from city resilience frameworks, including the Making Cities Resilient 2030, WHO's Health-EDRM, and UNDRR. Content analysis identified key constructs relevant to HEDRM in urban planning, with items tailored to the Malaysian context. Structured into four sections, the questionnaire uses a 5-point Likert scale: Section A: Respondent Profile, Section B: Respondent's Experience, Section C: Key Factors for Integrating Health and Urban Resilience, Section D: Urban Resilience for Cities
Item variables are detailed in the respective tables below.

Table 2: Barriers or challenges during COVID-19

No of item	Barriers or challenges	Sources
1	Resource allocation was insufficient	Kruk et al. (2020)
2	Public compliance was low.	Adebisi et al. (2021)
3	Healthcare capacity was overwhelming	Khan et al. (2022)
4	Policies and regulations were inadequate	Marmot et al. (2020)
5	Lack of coordination among agencies	Gooding et al. (2022)
6	Communication with the public was poor	Tambo et al. (2021)

Table 3: Health Disaster Risk Management Practices in Malaysia

No of item	Statement	Adapted and self-constructed from Sources
1	Health disaster risk management is adequately integrated into urban planning policies in Malaysia.	WHO (2019), Khan et al. (2022)
2	Local authorities actively involve health practitioners in disaster risk assessments	UNDRR (2023),(Kruk et al. (2020)
3	Community engagement is prioritised in urban resilience planning related to health disasters.	UNDRR (2023), Tambo et al. (2021)
4	There are sufficient training programs for local authorities on health disaster preparedness.	WHO (2021), Marmot et al. (2020)
5	Communication among stakeholders regarding health disaster risk management is effective.	WHO (2021), Gooding et al. (2022)
6	Funding for health disaster risk management initiatives is adequate in urban areas.	WHO (2019), Adebisi et al. (2021)
7	Policies promoting collaboration between health agencies and urban planners are in place.	UNDRR (2023), Pineda & Corburn (2020)
8	Monitoring and evaluation of health disaster preparedness plans are regularly conducted.	WHO (2021), Sharifi & Khavarian-Garmsir, 2020
9	Public awareness regarding health disaster risks is sufficient in urban communities	UNDRR (2023), Johnson & Lee, 2020
10	The current health disaster risk management framework effectively supports urban resilience efforts.	WHO (2021), UNDRR, 2023, Meriläinen et al. (2020).

Table 4: Key Integrative Factors Health Disaster Risk Management into Urban Resilience

Construct Code	Key Components Variables	No of items	Adapted and self-constructed from various sources
GPI	Governance And Policy Integration	7	WHO (2021), WHO (2023), UNDR(2023), Abbas, R. (2025), Pineo, H. (2020), Soalihin, S., Asmawi, A., Riyanto, D., Ariyani, I., Nur, H., & Sudiyasa, I. K. (2025)
RAM	Risk Assessment and Management	11	WHO (2021), WHO (2023), UNDRR (2023), Ingelbeen et al., (2025), Jeleff et al., 2022, Anand, 2024, Jeleff et al., 2022), Alharbi et al., 2025,
PRC	Preparedness And Response Coordination	10	WHO (2021), WHO (2023). UNDRR (2023), Abbas, R. (2025), Sydnes, M. (2025).
CB	Capacity Building	5	WHO (2021), WHO (2023), UNDRR (2023), Abbas, R. (2025), Soalihin, S., Asmawi, A., Riyanto, D., Ariyani, I., Nur, H., & Sudiyasa, I. K. (2025)
FP	Financial Preparedness	5	WHO (2021), WHO (2023), UNDRR (2023), Griffith-Jones, S., & Tanner, T. (2016), Iqbal, A., et al. (2024), Khan, A., et al. (2022)
IF	Infrastructure	5	WHO (2021), WHO (2023), UNDRR (2023), Ferguson, A. (2024), Lamberti-Castronuovo, A., Monaro, M., & Lami, F. (2022),
PDM	Post-Disaster Management	5	WHO (2021), WHO (2023), UNDRR (2023), Noboa-Ramos, C., et al. (2023), Wang, W., et al. (2023)

Construct Code	Key Components Variables	No of items	Adapted and self-constructed from various sources
ME	Monitoring And Evaluation	5	WHO (2021), WHO (2023), UNDRR (2023), Global Preparedness Monitoring Board (GPMB). (2021), Khan, Y., O'Sullivan, T., Brown, A., Tracey, S., Gibson, J., Généreux, M., et al. (2018)
PL	Planning	4	WHO (2021), WHO (2023), UNDRR (2023), Chen, X., et al. (2020), Guan, X., & Gao, H. (2022), Shang, B., & Huang, X. (2020)
AB	Absorption	4	WHO (2021), WHO (2023), UNDRR (2023), Hao, Y., Tie, Y., Zhang, L., Zhang, F., & Sun, C. (2024), Kapucu, N. (2011), Liu, Y., Wang, J., & Chen, K. (2023), Rong, L., Zhang, T., & Wang, H. (2024)
RE	Recovery	4	WHO (2021), WHO (2023), UNDRR (2023), Abbas, R. (2025), Kapucu, N. (2011), Sydnes, M. (2025)
AD	Adaptation	4	WHO (2021), WHO (2023), UNDRR (2023), Luchi, K., & Mutter, J. (2020), Setiadi, A., Rudwiarti, L. A., Langer, I. J., & Wardhani, M. K. (2021), UNDP, 2020

3.3 Respondent sample size

A purposive sampling technique was employed to select participants based on their specific roles, expertise, and involvement in disaster governance and urban planning, ensuring representation of key stakeholder groups relevant to the study objectives (Stratton et al., 2019). Selection justification based on practitioner representative roles and responsibilities that cover Malaysia's three-tier disaster governance, as follows:

- Search and Rescue: For pandemics, lead agencies, including the Ministry of Health, the Crisis Preparedness Response Centre (CPRC)
- Health and Medical: Ministry of Health (MOH)
- Support agencies assisting operational responses include District Officials, Municipal/Town Councils, and the Royal Malaysian Police.
- Technical agencies provide scientific and technical expertise. (Eg: NADMA, National Security Council (NSC), Urban Planners from Town and Country Planning Department (JPBD), Plan Malaysia)
- Assistance and recovery agencies handling welfare, counselling, logistics, and rebuilding (Eg, such as a Welfare officer from the Welfare Department)
- Volunteer organisations and individuals are participating in relief and recovery. (Eg, the Private sector, NGO and academic institutions)
- Security control (Eg, Royal Malaysian Police Officers)

The sample size for this study was set for 179 respondents, following guidelines for statistical adequacy in multi-group research (Bujang, Omar, & Foo, 2024; Julious, 2005). Proportional allocation reflected the significance of stakeholder groups, with urban planners comprising approximately 28% and minority groups ranging from 1% to 8%. This stratified purposive sampling ensures a reliable foundation for construct validation while capturing diverse perspectives.

3.4 Data Analysis

Content analysis of relevant literature, World Health Organisation (WHO) reports, and urban policy documents were conducted to align current urban planning practices with the WHO Health Emergency and Disaster Risk Management (Health-EDRM) framework. To quantify perceptions of barriers and the adoption of Health-EDRM practices, descriptive statistical analysis (means and frequencies) was conducted on survey responses. This approach is intended to inform the refinement of survey instruments and theoretical frameworks, rather than to test hypotheses or produce generalisable conclusions (Field, 2018).

SmartPLS-SEM was used to assess the measurement model, focusing on construct reliability and validity by evaluating indicator loadings, internal consistency, convergent validity, and discriminant validity (Hair et al., 2021). Structural model testing was not performed, as the primary goal was to confirm the soundness of indicators and latent variables. PLS-SEM is well-suited for this analysis, as it accommodates small to medium sample sizes, such as the 179 respondents in this study, and handles both reflective and formative constructs under non-normal data conditions. Bootstrapping techniques were employed to test the statistical significance of indicator loadings. **Fig. 3** presents a simplified framework for integrating Health Disaster Risk Management into Urban Resilience in Malaysia.

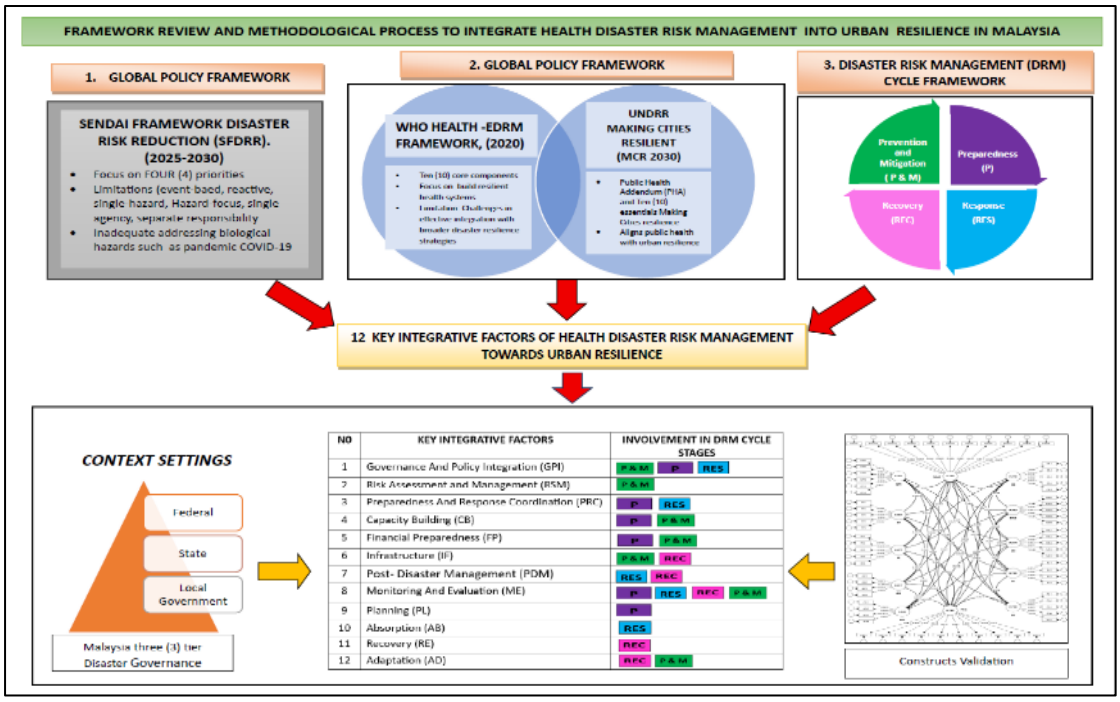

Fig 3: Simplified Diagram of Framework Review and Methodological Process to integrate Health Disaster Risk Management into Urban Resilience in Malaysia
(Source: Author's work)

4.0 RESULTS AND ANALYSIS

This section presents findings from a survey on health disaster risk management practices during the COVID-19 pandemic in Malaysia. It includes respondents' demographic profiles, key barriers encountered, and current management practices. 179 respondents responded.

4.1 Practitioner Demographics

Table 5, which lists 179 health disaster risk management professionals in Malaysia, reveals a predominantly experienced workforce, with 63.1% having over 10 years of experience, emphasising expertise in urban resilience. Urban Planners constitute the largest specific group (27.9%), highlighting the critical role of urban planning. Most hold a Bachelor's degree (33.5%), while the "Others" category (35.2%) suggests reliance on practical, non-traditional qualifications. Regional distribution is concentrated in Sabah (44.1%) and the Eastern Region (25.1%), indicating a regional focus in disaster management. The data highlights the vital role of experienced professionals and urban planners in fostering resilient urban environments, emphasising the need for ongoing professional development to address regional disparities in urban resilience challenges. This profile underscores the importance of multi-agency collaboration and diverse expertise in enhancing urban health resilience (UNDRR, 2023).

Table 5: Demographic Profile

Factors	Group	Frequency	Percent
A1. What is your role or position?	Health Practitioner	11	6.1
	Crisis Preparedness Response Centre (CPRC) Representative	1	0.6
	National Disaster Management Agency (NADMA) Representative	14	7.8
	Urban Planner/Planner from PLANMalaysia	50	27.9
	Local Government Official (City Councils, Municipal Councils & District)	13	7.3
	Royal Malaysian Police (RMP) Officer	9	5.0
	Social Welfare Officer	1	0.6
	Academia/ Institute Researcher	1	0.6
	Others (please specify);	79	44.1
A3. How many years of experience do you have in your current field?	1- 3 years	25	14.0
	4-6 years	12	6.7
	7-10 years	29	16.2
	More than 10 years	113	63.1
A4. What is your highest level of education?	High School Diploma	32	17.9
	Bachelor's Degree	60	33.5
	Master's Degree	23	12.8
	PhD (Doctor of Philosophy)	1	0.6
	Others (Please specify)	63	35.2
A5. In which state or region do you work?	Central Region (e.g., Selangor, Kuala Lumpur, Putrajaya)	30	16.8
	Eastern Region (e.g., Pahang, Terengganu, Kelantan)	45	25.1
	Northern Region (e.g., Perak, Kedah, Penang)	5	2.8
	Southern Region (e.g., Johor, Malacca, Negeri Sembilan)	19	10.6
	Sabah	79	44.1
	Sarawak	1	0.6
	Total	179	100.0

4.2 Barriers to Effective Health Disaster Risk Management

The COVID-19 pandemic presented unprecedented challenges to global health systems, exposing vulnerabilities and barriers that hindered effective response and management. Understanding these barriers is crucial for informing future public health strategies and improving preparedness for similar crises.

Table 6: Significant barriers or challenges during the COVID-19 disease outbreak

Barriers or challenges	Mean	SD	Level
Resource allocation was insufficient	3.13	0.985	Moderate
Public compliance was low.	3.20	0.925	Moderate
Healthcare capacity was overwhelming	3.29	0.957	Moderate
Policies and regulations were inadequate	2.97	0.927	Moderate
Lack of coordination among agencies	2.85	1.012	Moderate
Communication with the public was poor	2.93	1.014	Moderate

Table 6 reveals that barriers during the COVID-19 outbreak were rated as moderate, with the highest being overwhelmed healthcare capacity (M = 3.29, SD = 0.957), reflecting the global strain on healthcare (Kruk et al., 2020). Key challenges included low public compliance (M = 3.20, SD = 0.925) and insufficient resource allocation (M = 3.13, SD = 0.985), highlighting the need for improved public health communication. Inadequate policies (M = 2.97, SD = 0.927) and poor public communication (M = 2.93, SD = 1.014) underscore the importance of transparent messaging (Tambo et al., 2021). Coordination challenges among agencies (M = 2.85, SD = 1.012) point to institutional fragmentation, suggesting that these manageable challenges can be addressed through targeted improvements.

4.3 Current Health Disaster Risk Management Practices

Current practices in health disaster risk management are crucial for enhancing urban resilience. Table 7 highlights the findings from Malaysia, showing a mix of moderate to high agreement on integrating health strategies into urban planning and community engagement, while also identifying areas that require improvement.

Table 7: Current practices of health disaster risk management in Malaysia

Statements	Mean	Std. Deviation	Level
Health disaster risk management is adequately integrated into urban planning policies in Malaysia	3.64	0.898	Moderate
Local authorities actively involve health practitioners in disaster risk assessments	3.85	0.862	High
Community engagement is prioritised in urban resilience planning related to health disasters	3.84	0.886	High
There are sufficient training programs for local authorities on health disaster preparedness	3.51	0.979	Moderate
Communication among stakeholders regarding health disaster risk management is effective	3.72	0.861	High
Funding for health disaster risk management initiatives is adequate in urban areas	3.46	0.931	Moderate
Policies promoting collaboration between health agencies and urban planners are in place	3.60	0.914	Moderate
Monitoring and evaluation of health disaster preparedness plans are regularly conducted.	3.56	0.943	Moderate
Public awareness regarding health disaster risks is sufficient in urban communities	3.35	0.974	Moderate
The current health disaster risk management framework effectively supports urban resilience efforts	3.62	0.855	Moderate

Table 7 shows mixed moderate-to-high agreement on integrating health disaster risk management into Malaysia's urban resilience planning. Respondents moderately agree that such management is included in urban policies (M = 3.64, SD = 0.898), with strong confidence in the roles of local authorities in disaster risk assessments (M = 3.85, SD = 0.862) and community engagement (M = 3.84, SD = 0.886). However, training (M = 3.51, SD = 0.979) and funding (M = 3.46, SD = 0.931) received moderate ratings, indicating areas for improvement. Public

awareness of health disaster risks (M = 3.35, SD = 0.974) is insufficient, highlighting gaps in preparedness and response. Overall, while the framework is deemed adequate (M = 3.62, SD = 0.855), it requires strengthening to enhance urban resilience.

4.4 Construct Reliability and Validity for the Health Disaster Risk Management Practices

The following table presents the confirmatory factor analysis (CFA), common method bias (CMB) assessment, and reliability results after exploratory factor analysis (EFA) for Health Disaster Risk Management Practices.

Table 8 CFA, Common Method Bias (CMB), Extraction Method: Principal Component Analysis and Reliability Analysis after EFA for Domain B (N=179)

Construct	ID	Loading >0.6	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	Bartlett's Test of Sphericity		Initial Eigenvalues (CMB)			Cronbach's Alpha	N of Items
				Approx. Chi-Square	P	Total	% of Variance	Cumulative %		
BOC	BOC1	0.766	0.83	432.43	0.00	3.46	57.64	57.64	0.85	6
	BOC2	0.750								
	BOC3	0.656								
	BOC4	0.787								
	BOC5	0.788								
	BOC6	0.799								
St (Health-EDRM Practices)	St1	0.785	0.93	1215.88	0.00	6.28	62.80	62.80	0.93	10
	St2	0.754								
	St3	0.716								
	St4	0.819								
	St5	0.817								
	St6	0.776								
	St7	0.784								
	St8	0.865								
	St9	0.753								
	St10	0.844								

Table 8 presents the factor loadings for Barriers or Challenges (BOC) and Statement (St) on Health EDRM Practices constructs, all of which exceed 0.6, indicating strong item-construct associations. BOC loadings range from 0.656 to 0.799, confirming the reliability of both constructs. Kaiser-Meyer-Olkin (KMO) measures indicate perfect sampling adequacy: 0.83 for (BOC) and 0.93 for (St). Bartlett's Test of Sphericity, which is highly significant ($p < 0.0001$) for both, validating the data's suitability for factor analysis. Principal Component Analysis reveals eigenvalues above 1 for both constructs, with BOC's first factor explaining 57.64% and St's first factor explaining 62.8% of variance, indicating dominant factors and minimal common method bias. Cronbach's alpha shows good reliability for BOC ($\alpha = 0.85$, 6 items) and excellent reliability for St ($\alpha = 0.93$, 10 items). Both constructs demonstrate strong internal consistency and are deemed reliable for subsequent analyses.

4.5 Construct Reliability and Validity for Integrative Factors of Health Urban Resilience

The following table presents the confirmatory factor analysis (CFA), common method bias (CMB) assessment, and Extraction Method: Principal Component for integrating Health Urban Resilience

Table 9 CFA, Common Method Bias (CMB), Extraction Method: Principal Component Analysis and Reliability Analysis after EFA for Domain C (N=179)

				Bartlett's Test of Sphericity		Initial Eigenvalues (CMB)				
Construct	ID	Loading>0.6	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	Approx. Chi-Square	P	Total	% of Variance	Cumulative %	Cronbach's Alpha	N of Items
GPI	GPI1	0.848	0.89	1380.21	0.000	5.56	79.41	79.41	0.96	7
	GPI2	0.916								
	GPI3	0.912								
	GPI4	0.929								
	GPI5	0.883								
	GPI6	0.904								
	GPI7	0.842								
RAM	RAM 1	0.861	0.95	2936.99	0.000	9.18	83.43	83.43	0.98	11
	RAM 2	0.895								
	RAM 3	0.882								
	RAM 4	0.915								
	RAM 5	0.915								
	RAM 6	0.945								
	RAM 7	0.914								
	RAM 8	0.956								
	RAM 9	0.911								
	RAM 10	0.917								
	RAM 11	0.933								
PRC	PRC1	0.904	0.94	2992.00	0.000	8.67	86.70	86.70	0.98	10
	PRC2	0.904								
	PRC3	0.917								
	PRC4	0.949								
	PRC5	0.956								
	PRC6	0.926								
	PRC7	0.908								
	PRC8	0.952								

	PRC9	0.953								
	PRC10	0.939								
CB	CB1	0.938	0.88	1271.63	0.000	4.50	90.02	90.02	0.97	5
	CB2	0.949								
	CB3	0.937								
	CB4	0.962								
	CB5	0.957								
FP	FP1	0.956	0.91	1182.42	0.000	4.46	89.28	89.28	0.97	5
	FP2	0.951								
	FP3	0.927								
	FP4	0.934								
	FP5	0.955								
IR	IR1	0.958	0.89	1273.75	0.000	**4.51**	**90.14**	**90.14**	0.97	5
	IR2	0.934								
	IR3	0.942								
	IR4	0.958								
	IR5	0.955								
RRB	RRB1	0.958	0.91	1262.56	0.000	4.52	90.36	90.36	0.97	5
	RRB2	0.959								
	RRB3	0.922								
	RRB4	0.958								
	RRB5	0.955								
ME	ME1	0.921	0.88	1264.06	0.000	4.49	89.88	89.88	0.97	5
	ME2	0.960								
	ME3	0.963								
	ME4	0.939								
	ME5	0.955								
PL	PL1	0.916	0.83	622.79	0.000	3.35	83.63	83.63	0.93	4
	PL2	0.898								
	PL3	0.909								
	PL4	0.935								
AB	AB1	0.916	0.86	694.68	0.000	3.45	86.18	86.18	0.95	4
	AB2	0.947								
	AB3	0.941								
	AB4	0.908								
RE	RE1	0.908	0.89	873.00	0.000	4.15	82.91	82.91	0.95	5
	RE2	0.915								
	RE3	0.923								
	RE4	0.903								
	RE5	0.904								
AD	AD1	0.944	0.84	799.27	0.000	3.55	88.65	88.65	0.96	4
	AD2	0.932								
	AD3	0.947								
	AD4	0.944								

Table 9 presents **twelve (12)** factor loadings for risk management and urban resilience constructs, all exceeding the 0.6 threshold, indicating strong reliability. Constructs such as Governance and Policy Integration (GPI), Risk Assessment and Management (RAM), and Preparedness and Response Coordination (PRC) show notably high loadings (mostly above 0.9). Kaiser-Meyer-Olkin (KMO) values range from 0.83 to 0.95, confirming sampling adequacy, while Bartlett's Test of Sphericity is significant ($p < 0.0001$). Principal component analysis reveals eigenvalues above 1.0, with RAM explaining the highest variance (9.18). Cronbach's alpha coefficients range from 0.93 to 0.98, confirming excellent internal consistency and robustness of the measurement model.

4.6 Assessment of Convergent Validity in the Pilot CB-SEM Measurement Model Using Standardised Factor Loadings, Composite Reliability, and Average Variance Extracted

The pilot CB-SEM measurement model demonstrated strong convergent validity, with standardised factor loadings ranging from 0.68 to 0.89, all of which were significant ($p < .001$). Composite reliability (CR) values of 0.83-0.90 indicate high internal consistency, while average variance extracted (AVE) values of 0.57-0.65 confirm that the constructs explain the majority of the variance in their indicators. Factor loadings for constructs like Absorption (0.867–0.943), Capacity Building (up to 0.961), and Financial Preparedness (up to 0.951) were particularly high. Cronbach's Alpha values exceeded 0.70 for all constructs, with Preparedness and Response Coordination leading at 0.983. These findings validate the measurement model, confirming that it reliably captures the intended latent constructs in risk management and urban resilience, thus reinforcing the model's overall robustness and applicability for future research and framework development. Hence, **Fig. 4** illustrates how different factors are interrelated and how constructs contribute to the overall model.

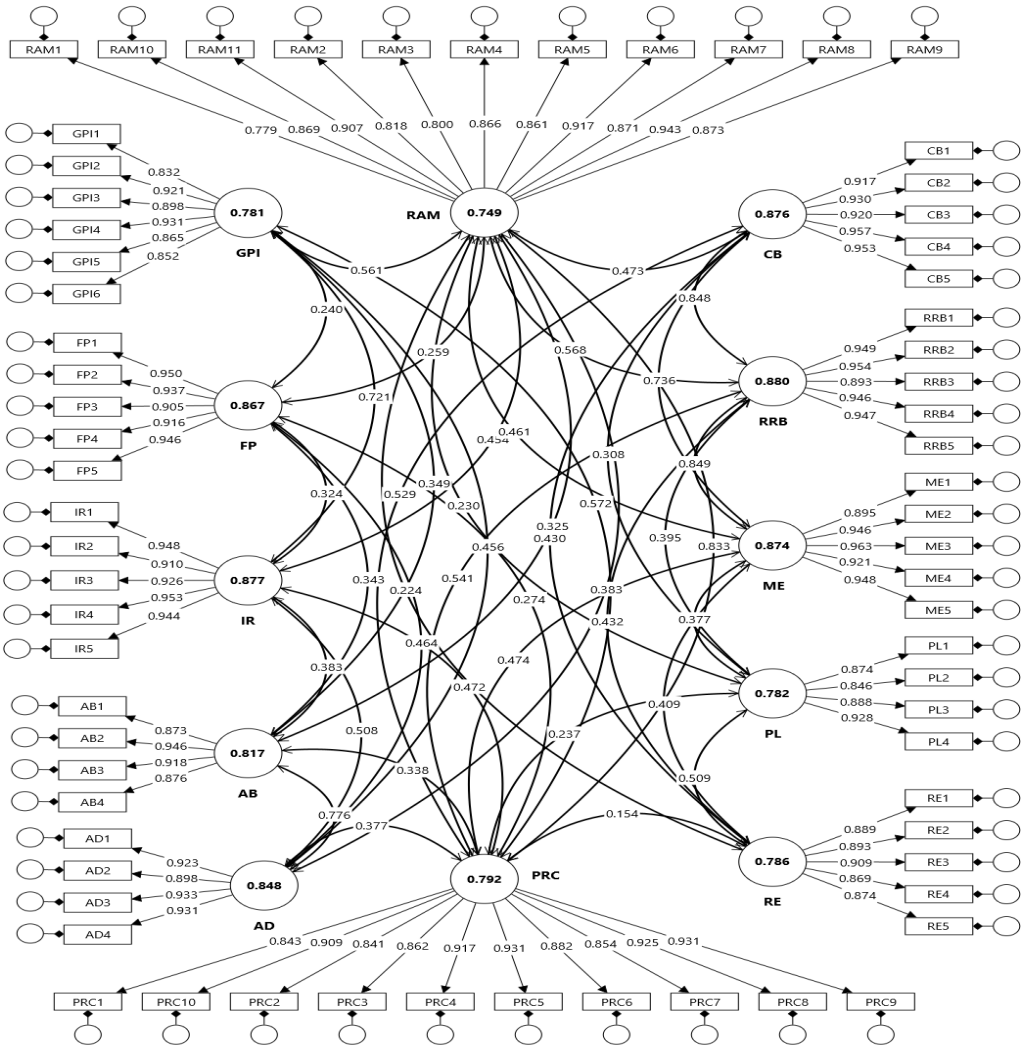

Fig 4: CB-SEM Measurement Model Diagram
(Source: Author's work)

4.7 Model Fit Statistics for the Estimated and Null Models in Risk Management and Urban Resilience

Table 10 Model Fit

	Estimated model	Null model
Chi-square	7073.239	24762.74
Number of model parameters	199	70
Number of observations	179	n/a
Degrees of freedom	2286	2415
P value	0.000	0.000
ChiSqr/df	3.094	10.254
RMSEA	0.108	0.227
RMSEA LOW 90% CI	0.105	0.225
RMSEA HIGH 90% CI	0.111	0.23
GFI	0.517	n/a
AGFI	0.475	n/a
PGFI	0.476	n/a
SRMR	0.161	n/a
NFI	0.714	n/a
TLI	0.774	n/a
CFI	0.786	n/a
AIC	7471.239	n/a
BIC	8105.529	n/a

Table 10 presents the model fit statistics, which indicate that the estimated model fits the data significantly better than the null model, evidenced by a much lower Chi-square (7073.239 vs. 24762.74) and a favourable Chi-square/df ratio of 3.094 (within the acceptable range). Although the RMSEA of 0.108 is slightly above the ideal threshold, it indicates a reasonable fit compared to the null model's 0.227. However, fit indices such as GFI (0.517), AGFI (0.475), NFI (0.714), TLI (0.774), and CFI (0.786) indicate moderate fit, highlighting room for improvement. The high SRMR (0.161) also suggests divergence between observed and predicted correlations. Overall, while the model explains the relationships better than the null model, further refinement is needed to enhance its explanatory power and fit.

5.0 DISCUSSIONS

5.1 Statistical Interpretations and Significance of Barriers

The findings from Table 6 reveal that respondents rated the barriers experienced during the COVID-19 outbreak as moderate, with mean scores ranging from 2.94 to 3.45 on a 5-point Likert scale. The most significant challenges identified include insufficient resource allocation (Mean = 3.13, SD = 0.985), overwhelming healthcare capacity (Mean = 3.29, SD = 0.957), and low public compliance (Mean = 3.20, SD = 0.925). Other challenges, such as inadequate policies and poor inter-agency coordination, also scored in the moderate range.

These results resonate with global observations of healthcare systems under unprecedented strain during the pandemic (Kruk et al., 2020). The moderate rating of public compliance highlights critical issues in risk communication and community engagement, which are essential components of the WHO Health Emergency Disaster Risk Management (HEDRM) framework (WHO, 2021). This suggests that while there is an awareness of the importance of public compliance, practical strategies to enhance community engagement remain lacking. The moderate score for coordination among agencies points to persistent gaps in multisectoral collaboration, a cornerstone of effective health emergency management. These findings suggest a partial resilience in the system, yet they also indicate significant stressors that compromise the effectiveness of health disaster risk management (HDRM). Overwhelmed healthcare capacity underscores the urgent need for surge strategies and scalable infrastructure, as outlined in health system resilience frameworks (Gupta & Nair, 2012). Moreover, the systemic siloing reflected in the moderate coordination scores indicates a failure to integrate disaster governance, a widespread issue during the pandemic (Gooding et al., 2022). Statistically, these findings reveal critical failure points in governance and social mobilisation, serving as leverage points for intervention.

By linking these challenges to the research objectives, which aim to explore Malaysia's experience with HDRM during the pandemic, it becomes evident that addressing these barriers is vital for enhancing urban resilience. The moderate ratings indicate areas that require urgent policy reforms and investment in communication strategies to foster community trust and compliance. Moreover, strengthening inter-agency collaboration is essential for creating a more cohesive and responsive health disaster framework. Furthermore, these findings not only highlight the barriers encountered during the pandemic but also provide new insights into the necessary steps to improve HDRM in Malaysia. By identifying and addressing these challenges, this research contributes to a deeper understanding of how to enhance resilience and preparedness for future health emergencies.

5.2 Policy and Practice Implications

Table 7 illustrates respondents' perceptions of current health disaster risk management (HDRM) practices in the urban planning context of Malaysia. Most items received moderate ratings; however, the involvement of health practitioners in disaster risk assessments was notably high (Mean = 3.85, SD = 0.862). This reflects a positive trend towards multisectoral collaboration, aligning with WHO HEDRM's focus on inclusive governance (WHO, 2021). Community engagement (Mean = 3.84, SD = 0.886) and effective communication among stakeholders (Mean = 3.72, SD = 0.861) were also rated moderately, indicating recognition of their importance but highlighting the need for improvement.

As societies transition beyond the immediate impacts of the pandemic, it is crucial to build on these foundations. The high rating for health practitioners' involvement confirms progress in integrating health expertise into urban planning. However, persistent challenges in community engagement and funding necessitate policy reforms that prioritise inclusive governance and dedicated financial resources for HDRM initiatives (WHO, 2019). Urban planners must embed health risk reduction into statutory plans, supported by capacity-building programs and participatory mechanisms (Sharifi & Khavarian-Garmsir, 2020). In this adaptive phase, which is aligned with the recovery and mitigation phases of the DRM cycle, effective coordination platforms, such as joint task forces or integrated emergency management centres, should be institutionalised to prevent fragmentation (UNDRR, 2023). The deficits in public awareness highlight the urgency for culturally relevant risk communication strategies and ongoing community education to enhance resilience and compliance (Tambo et al., 2021). Investing in digital health infrastructure and community-based monitoring systems will further strengthen preparedness and early response capabilities, ensuring that urban HDRM evolves to meet future challenges effectively.

5.3 Implications for Urban Health Resilience

The moderate levels of barriers and current practices observed in this study suggest that Malaysia's urban health disaster risk management (HDRM) is in a transitional phase, presenting critical opportunities for strategic integration and reforms as follows;

Governance Frameworks and Reforms

A primary implication is the need to strengthen governance frameworks to enhance inter-agency coordination and ensure the development of adaptive, comprehensive policies. The COVID-19 pandemic exposed systemic governance weaknesses in urban planning and policy-making, driving transformative reforms globally (Wilkinson et al., 2020). Decentralisation and local empowerment emerge as crucial; stronger urban local authorities with decision-making capacity can enable more effective health emergency responses. In addition, Malaysia's Disaster Risk Reduction (DRR) Policy 2030 serves as the cornerstone for coordinated, multi-level disaster governance in the country, guided by four core principles and aligned with the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030 (NADMA, 2024). This policy transitions from a recovery-centric approach under the earlier Hyogo Framework to a proactive, risk-informed strategy that prioritises prevention, mitigation, preparedness, response, and recovery. This integration provides a health-centred dimension to disaster risk reduction, strengthening health system preparedness and resilience (WHO, 2022). The blend of SFDRR and Health-EDRM in Malaysia's policy landscape illustrates an effective global-to-local policy translation, ensuring that disaster governance addresses multifaceted risks holistically. Such alignment underpins this research's adoption of international frameworks to critically examine and enhance urban resilience and multi-agency collaboration in the Malaysian context.

Health-Centric Policy Integration

The "Health in All Policies" approach must underpin urban planning to foster health equity and disaster resilience (WHO, 2019). Urban designs emphasising green spaces, walkability, and mixed-use development reduce transmission risks (Sharifi & Khavarian-Garmsir, 2020). Crisis-adaptive infrastructure, including flexible public spaces, pop-up bike lanes, repurposed streets, and a decentralised service hub that can support rapid adaptation during emergencies. Planners should prioritise health in zoning laws, land-use planning, and infrastructure development, ensuring equitable access to healthcare and fostering adaptive urban spaces that can serve as temporary healthcare or recovery zones. This requires sustained investment in health system capacity and infrastructure to enhance preparedness and financial resilience for future health crises (Gupta & Nair, 2012).

Community Engagement and Risk Communication

High ratings for community engagement (median = 3.61) underscore its crucial role in fostering urban health resilience. Engaging communities through participatory planning fosters local leadership and enhances collective capacity to respond effectively to health emergencies (Marmot et al., 2020). Strengthening risk communication strategies is equally vital to improving public compliance and trust, which are critical components emphasised in the WHO Health-EDRM framework (Tambo et al., 2021).

Preparedness and Response Coordination

Effective communication among stakeholders (median = 3.55) is essential for successful coordination of responses. Comprehensive, regularly updated disaster response plans must integrate health emergency preparedness within broader urban governance strategies. Digital communication platforms can facilitate transparent, timely information exchange between governments and citizens, which is indispensable for effective crisis management (Gooding et al., 2022).

Training, Interdisciplinary Collaboration and Innovation.

Regular training and simulation exercises for officials and community leaders enhance readiness for health emergencies. Fostering interdisciplinary partnerships across health, transportation, housing, and environmental sectors can lead to the development of holistic urban resilience strategies. Facilitating the exchange of best practices among cities accelerates collective learning and capacity building (UNDRR, 2023). Investing in innovative city initiatives and leveraging technology, such as data analytics for real-time health monitoring, further modernises urban health management (Sharifi & Khavarian-Garmsir, 2020). These recommendations align with global best practices and WHO guidelines, emphasising a holistic, multisectoral approach to urban health resilience (Wilkinson et al., 2020; WHO, 2021).

5.4 Construct Reliability and Validity

Validation procedures, including factor analysis and reliability testing, help identify suboptimal items and refine the instrument to improve clarity and construct representation (Aithal, 2020). The findings strongly support the construct validity and reliability of the measurement model. All factor loadings exceeded the 0.6 threshold, indicating meaningful relationships between observed indicators and latent constructs (Webster, Watson, & Anderson, 2020). High loadings (mostly above 0.9) for constructs such as Governance, Policy Integration, and Risk Assessment confirm their robustness. Kaiser-Meyer-Olkin (KMO) values ranged from 0.83 to 0.95, and Bartlett's Test of Sphericity was significant ($p < 0.0001$), supporting sampling adequacy. Cronbach's alpha values (0.93-0.98) indicate excellent internal consistency. These psychometric properties validate the measurement model, providing a solid foundation for developing an integrated Health-EDRM and urban resilience framework, essential for effective urban resilience planning. This strengthens both the academic rigour and the practical applicability of Health-EDRM in urban resilience planning, ensuring that future framework development is grounded in robust empirical evidence.

6.0 CONCLUSION

This study emphasises the significance of incorporating health disaster risk management (HDRM) into urban resilience frameworks, especially in Malaysia, amid shifting health crises such as COVID-19. Strategic policy alignment with global frameworks, such as the WHO Health Emergency and Disaster Risk Management (Health-EDRM) and the Sendai Framework for Disaster Risk Reduction (SFDRR), ensures that Malaysia's disaster risk governance is proactive, health-centred, and contextually relevant. This alignment between the international

Framework and national policies allows Malaysian urban characteristics to be addressed in prevention, readiness, response, and recovery efforts.

This study examined the barriers and current practices of Health-EDRM in Malaysia's urban settings and validated key constructs through confirmatory factor analysis. The findings highlight significant barriers, including insufficient resource allocation, overwhelmed healthcare capacity, and coordination challenges, that remain critical obstacles to effective disaster governance. The validated constructs comprising governance, risk assessment, preparedness, capacity building, and recovery demonstrated strong reliability and validity for assessing Health-EDRM integration into urban resilience. These validated constructs provide a foundation for the future development of an integrated Health-EDRM and urban resilience framework. Such a framework would enable policymakers and practitioners to address systemic weaknesses, strengthen governance, and enhance multisectoral collaboration. By grounding urban resilience strategies in robust, validated constructs, Malaysia can better prepare for complex health-related disasters and safeguard urban populations against future emergencies.

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LEGIBILITY OF REGENERATED ALLEYS AS SOCIAL SPACES: THE CASE OF KUALA LUMPUR COMMERCIAL DISTRICT

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ABSTRACT

Alley regeneration has emerged as a crucial strategy for revitalising urban areas that are in decline. This study specifically examines how the legibility of regenerated alleys impacts user engagement and social interaction within the *Bukit Bintang* commercial district of Kuala Lumpur. It combines quantitative analysis with behavioural observations to assess both spatial functionality and user engagement. To achieve this, correlation and multinomial regression analyses were conducted based on on-site questionnaire surveys involving 695 respondents who had visited the regenerated alleys. Systematic physical and behavioural observations were conducted to gain a comprehensive understanding of the existing issues, spatial functionality, and activity patterns within these alleys. The study revealed a moderate correlation between the legibility of an alley and the social interactions of its users. While visual elements positively affect social interaction, they show a lower standardised coefficient. In contrast, a clear structure demonstrates a much stronger relationship, indicated by a higher standardised coefficient. This finding strongly suggests that a clear structural layout has a significant impact on social interaction. By emphasising clear structural layouts alongside visually appealing elements, urban planners can create more engaging public spaces that effectively foster social interaction among users.

Keywords: Regenerated alleys, Legibility, Social interaction, Users' engagement, Commercial district.

1.0 INTRODUCTION

Urban design is essential for conceptualising and planning clusters of structures, streets, and public spaces within city environments to meet the needs of inhabitants (Eni et al., 2020). The evolution of urban areas is driven by a complex interplay of social and economic dynamics, necessitating revitalisation when these areas face significant challenges. Urban redevelopment and regeneration projects extend beyond enhancing private spaces; they substantially shape the built environment, leading to ongoing evolutionary processes over time (Hyseni, Nepravishta, & Asanbejlli, 2021). This paper investigates explicitly regenerated alleys as vital social spaces within commercial districts, aiming to clarify their role in fostering community interactions.

Current regeneration practices aim to enhance the physical, economic, and social dimensions by capitalising on the unique characteristics, history, and identity of a region. Strategies employed in urban regeneration encompass both physical interventions, such as building and infrastructure improvements, and non-physical enhancements, with a focus on community dynamics and vibrancy. These efforts are crucial for restoring the historical identity of sites and fostering community cohesion. In recent years, there has been a notable increase in urban regeneration projects that highlight cultural and social identities through urban art, significantly

attracting tourism and enhancing destination engagement, a phenomenon further accelerated by social media dissemination of vibrant urban narratives (Andron, 2018; Chang, 2023; MacDowall, 2019; MacDowall & de Souza, 2018).

The transformation of vernacular urban alleyways in different Asian urban settings such as *Hutongs* in Beijing, *Golmok* in Korea, *Soi Trok* in Thailand, as well as similar alleyway networks in Singapore, Vietnam, or Taiwan have been a subject of scholarly exploration, shedding light on the changing urban forms and the significant role these alleys play in shaping these cities' cultural and historical fabric (Gibert and Imai, 2020). Despite Kuala Lumpur's prominence as a major Southeast Asian city, initiatives aimed at enhancing its urban alleys remain limited.

A fundamental aspect of urban regeneration focuses on the physical characteristics and visual aesthetics that define a place. As asserted by Lynch (1960), these elements greatly influence a space's legibility, facilitating users' ability to identify, organise, and navigate through it efficiently. Therefore, this study aims to address the question: How does the legibility of regenerated urban alleys in Kuala Lumpur's commercial district impact their effectiveness as social spaces, considering both user experience and social interaction? In the context of Kuala Lumpur's urban alleys, enhancing social interactions necessitates an in-depth examination of the relationship between physical attributes and place legibility. Specifically, the research will concentrate on the *Bukit Bintang* commercial district, evaluating how perceptible clarity and visual elements of legibility in these alleys impact social interaction and user experiences.

2.0 LITERATURE REVIEW

2.1 The Semiotics of Place: Legibility and Meaning in Urban Alleys

The "sense of place" is a fundamental concept in urban studies, encompassing the intricate relationship between individuals and their environments beyond just physical location. It involves complex psychosocial structures that integrate cognition, emotion, and behaviour within specific settings (Relph, 1997). Factors such as landmark visibility, colour dynamics, and design symmetry significantly influence legibility, impacting community interaction and sense of place (Askarizad et al., 2022). Building on this, Lynch's (1960) concept of "legibility" emphasises the ease with which urban environments can be understood and navigated, thereby enhancing social engagement. Contemporary urban theory expands on this concept through "urban semiotics," which views cities as rich tapestries of symbols and signs that convey cultural values and historical narratives (Urban Psycho-Geography, 2025). This perspective examines how elements like street art, monuments, and architecture influence psychological states and social interactions, treating urban forms as non-linguistic signs imbued with meaning (Raj & Patil, 2023; Sima et al., 2016; Chen & Hu, 2024). Consequently, fostering a distinctive sense of place in urban alleys requires not only visual clarity but also a deep appreciation for the cultural and symbolic narratives woven into these spaces.

2.2 Alleys and Urban Regeneration: Art vs. Infrastructure

The debate between art-led and infrastructure-led urban regeneration highlights distinct pathways for regeneration. While infrastructure provides foundational improvements, art-led approaches offer cultural sensitivity and community engagement. However, art-led regeneration often faces criticism for contributing to gentrification and social exclusion (Balliger, 2021; Johnson, 2022). Equitable and sustainable regeneration, regardless of its primary driver, must address socio-economic inequalities and implement policies to protect vulnerable populations. The "The Lost Stream of *Alor*" project in Kuala Lumpur, which used murals (Roche, 2021) to transform neglected alleys, exemplifies an art-led strategy. Murals are considered tools for shaping collective identity (Bruce & Creighton, 2006) and fostering community engagement (Petronienė & Juzelėnienė, 2022), aligning with aesthetic governance, which uses artistic initiatives for urban management and economic aims like touristification (Chang, 2023). While art-led regeneration can enhance social fabric and civic identity (Andriotis, 2022), it also raises concerns about potential displacement and the commodification of local culture.

2.3 Social Interaction in Alleys: Beyond functionality

Building on Lynch's (1960) theory, research has increasingly explored how urban alley legibility, particularly in conjunction with public art, influences social engagement. Elements like kiosks and cafes cultivate social ties (Naghibi, 2024), similar to how shade structures encourage use (Bahriny & Bell, 2021). Al eys can evolve from simple routes into vibrant hubs for cultural exchange. Historical examples**,** such as Japan's *roji* (Imai, 2013; Wardhani & Wang, 2023)**,** demonstrate that these semi-public spaces foster communal activities and neighbourhood identity, challenging their traditional utilitarian view. Social interaction evaluation often considers user presence duration and intensity (Carmona et al., 2010; Gehl, 2011; Moulay, Ujang & Said, 2017). The social environment facilitates emotional bonding and non-verbal communication (Ujang et al., 2018). Despite being historically overlooked, alleys are now recognised for their potential to foster pedestrian activities and relationships (Martin, 2002; Hess, 2008). Therefore, this study aims to correlate the legibility of places with physical elements that influence social interaction in regenerated alleys within commercial districts.

3.0 STUDY AREA

The study was conducted in *Bukit Bintang*, the main commercial area in Kuala Lumpur City Centre, where streets comprise approximately 35% of the area (Wan, 2017). Notably, with 52 alleyways comprising 56.5% of *Bukit Bintang's* public walkways, efficient use is crucial to improving the city's overall quality of life (Wan, 2017). In 2015, Kuala Lumpur City Hall (KLCH) specifically selected the five alleyways (*Alor, Komuniti di Alor, Laman Belakang, Alam Alor,* and *Kehidupan Alor*) as part of the Kuala Lumpur City Regeneration Project. These alleyways were selected due to their proximity to the core urban environment of *Alor* Enclave, *Bukit Bintang*, a vibrant area undergoing significant development. The regeneration initiatives implemented in these locations, which were comprehensively renovated in 2018, sought to enhance not only aesthetic values but also functionality, social interaction, and community cohesion. The study included comprehensive on-site assessments to evaluate the current condition of these renovated alleys, ensuring that each site offers unique characteristics important to the regeneration project. This systematic assessment provided baseline data on the condition of the alleys' infrastructure, landscape, and overall usability.

4.0 METHODOLOGY

This study investigated the relationship between legibility and social interaction in urban alleys within Kuala Lumpur's *Bukit Bintang* commercial district. A mixed-methods approach was employed, combining systematic one-month field observations (with sessions conducted on weekdays and weekends, each lasting one hour) with a visual questionnaire survey. Observations were recorded of the environmental context, infrastructure, alley conditions, features, and user behaviour, including volume, usage, accessibility, and connectivity (Figures 1 & 2). The visual questionnaire assessed legibility attributes, including "Clarity of Structures" and "Visual Elements," and their impact on "Place Engagement" (duration, frequency, and purpose of usage) and "Social Interaction" (place image and types of contact). The survey involved 695 individuals (436 foreigners, 157 Malays, 78 Chinese Malaysians, 24 Indian Malaysians), utilising systematic and time-interval sampling to minimise bias, with respondents answering questions based on alley photographs.

The study will employ descriptive analysis and Multinomial Logistic Regression (MLR) to investigate the relationship between legibility attributes and social interaction/place engagement. ML is suitable for comparing multiple groups of risk processes (Bayaga, 2010), such as different levels of engagement and types of social interaction. It accommodates several explanatory variables, making it ideal for this study. ML can compare multiple groups of risk processes through binary logistic regressions (Bayaga, 2010), providing a nuanced understanding of how specific legibility attributes affect social interaction in regenerated alleys. This approach emphasises the importance of user experience in urban regeneration.

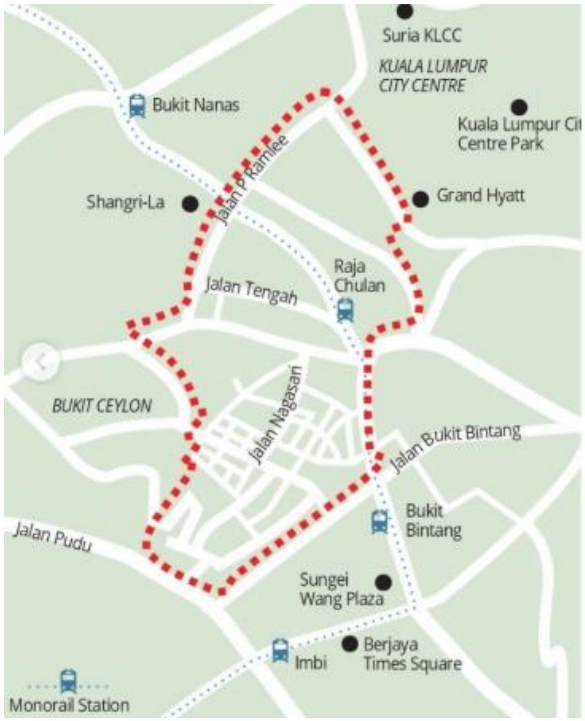

Figure 1: Alleys' location (gmbb.kl, 2020)

Figure 2: Alleys' connectivity (KLCH, 2018)

1. Alor
2. Komuniti di Alor
3. Laman Belakang
4. Alam Alor
5. Kehidupan Alor

5.0 RESULTS

Based on the Likert scale description by Chyung et al. (2017) and James & Lee (2011), the questionnaire survey results can be classified into four groups with an equal range (m = 0.8). The classification shown in Table 1 is derived from Bernard's (2011) framework. Nonetheless, the range established for this classification adheres to the Likert scale (1-5) used in the questionnaire. Furthermore, the number of respondents in *Bukit Bintang* was also taken into consideration during this classification process. Cronbach's Alpha was used to measure the reliability of a set of items or a single unidimensional latent construct. Cronbach's α reliability coefficient was 0.842, indicating a strong correlation.

Table 1: Classification of legible elements for questionnaire survey (Source: Author).

Scale	Weight	Range (mean)	Legibility	Social interaction
Strongly agree	5	4.1 – 5.0	Highly identifiable	Strong SI
Agree	4	3.1 – 4.0	Moderate recognisable	Moderate SI
Disagree	2	2.1 – 3.0	Poorly recognisable	Weak SI
Strongly disagree	1	1.0 – 2.0	Unrecognisable	No SI

This section presents results from descriptive and regression analyses examining the relationships between legibility, place engagement, and social interaction. The discussions of the findings follow them.

5.1 Legibility among Users

Descriptive statistics were employed to analyse and compare the legibility of both clarity and visual elements based on mean scores. As illustrated in Table 2, the feedback from respondents regarding the legibility of the alleys is delineated through the primary variables of Clarity of Structure and Visual elements. Slight differences

were observed between the variable of visual elements (m=3.46) and Clarity of Structure (m=3.61). The findings revealed that the location of the alleys plays a significant role in the clarity of the place. In contrast, the signage and direction within the alleys show a moderate level of clarity. Moreover, the trees and greenery in the alleys were not as prominently featured as murals, colored walls, and facades, which are highly recognisable. Consequently, the Visual elements of the regenerated alleys are less recognisable than the clarity of the place.

Table 2: Legibility of regenerated alleys.

Legibility	Items	M	SD	SE
Clear structure	They are strategically located. (m 3.83) Have a strong physical connection to adjacent streets. (m 3.69) Very clear layout, easy to move. (m 3.62) Very exciting views. (m 3.53) Very clear signage and directions. (m 3.38)	3.61	.50	.19
Visual elements	Colourful place. (m 3.86) Attractive mural art. (m: 3.70) The facades are well decorated. (m 3.60) The place has different lighting designs. (m 3.57) This place has attractive traditional/old buildings. (m 3.33) Attractive wayfinding signage. (m 3.20) There is a lot more greenery /beautiful trees. (m 3.00)	3.46	.47	.18

M: Mean Value, SD: Standard Deviation, SE: Standard Error

The central alleys that traverse the major city blocks of *Bukit Bintang* showcase a myriad of vibrant artworks in the form of painted murals. These murals feature bright colours and depict natural imagery, including rivers, rainforests, and tropical fauna Indigenous to Southeast Asia. Enhancing the artistic landscape, the area also features unconventional neon sculptures shaped like playful cloud silhouettes that hover above the streets and illuminate the night sky after dark. Notably, *Jalan Alor, Berangan, Changkat, Rembia,* and *Tengkat Tong Shin* stand out as some of the most adorned alleys in this district (Figure 3). However, upon conducting field observations, the initial data collection phase revealed several common issues. These include substandard paving and flooring of walkways, insufficient shelter and canopies, inconsistent signage, narrow thoroughfares, a stark contrast between the architectural styles of old and new buildings, limited facilities for individuals with disabilities, and inadequate public services and maintenance (Figure 7). These challenges significantly contribute to the degradation of urban alley legibility.

Fig. 3: *Alor*, playful cloud silhouettes (KLCH, 2018)

5.2 Relationship between Legibility, Social Interaction, and Place Engagement

The following section will examine the relationship between legibility, social interaction, and user engagement in the study context.

5.2.1 Social Interactions within The Regenerated Alleys

Table 3 summarises the level of social interaction in the alleys. The regenerated alleys demonstrate generally positive social interactions, with a combined mean score of 3.58 (SD = 0.501).

- Place Image: The alleys are perceived positively (mean: 3.58), driven by good accessibility (mean: 3.77), attractive mural art (mean: 3.70), and well-decorated facades (mean: 3.60), which collectively create a welcoming environment. However, "Shaded all day" received a lower mean (m: 3.02), indicating a potential comfort issue.
- Type of Contact: Social contact is moderately favourable (mean: 3.43), with notable perceptions as a meeting place for different cultures (mean: 3.87) and a popular spot (mean: 3.52). Sc res for "The best place is what I like to do" (m: 3.10) and "The place makes people friendly" (m: 3.25) were lower, suggesting less strong personal alignment or perceived friendliness.

Overall, the regenerated alleys promote moderate social interaction, primarily due to their strong accessibility and positive aesthetic. While they successfully serve as multicultural gathering points, enhancing shaded areas and implementing strategies to boost a sense of personal connection and friendliness could significantly improve user experience and elevate the alleys' role as dynamic social hubs.

Table 3: Social interaction.

Construct	Variables	Items	Level of Social Interaction
Social interaction	Place image	Good access from many parts of the area. (m 3.77) Good image. (m 3.72) Attractive mural art. (m: 3.70) Strong physical connection to adjacent streets. (m 3.69) Well-decorated facades. (m 3.60) Shaded all day. (m 3.02)	M SD 3.58 0.501 Moderate Social interaction
	Type of contact	The meeting place for people from different cultures. (m 3.87) Popular place. (m 3.52) The place makes people friendly. (m 3.25) The best place is where I like to be. (m 3.10)	M SD 3.43 0.475 Moderate Social interaction

M: Mean Value, SD: Standard deviation

5.2.2 Relationship Between Legibility and Place Engagement

The researcher recommended using the multinomial logistic regression (MLR) to determine the relationship between legibility and place engagement. The multinomial (or polytomous) logistic regression model extends the binomial logistic regression model. Firstly, it is utilised when the dependent variable consists of more than two nominal or unordered categories. Similar to binary logistic regression, multinomial logistic regression employs maximum likelihood estimation to assess the probability of membership in each category (Ashok & Balasubramanian, 2014; Tabanick et al., 2001). Secondly, the strength of the MLR relationship was assessed to determine its significance. Lastly, it evaluated the usefulness of the logistic model and the relationship between the independent and dependent variables.

5.2.3 Relationship Between Independent and Dependent Variables

Two types of tests are used to identify the significant individual independent variables. The likelihood ratio test evaluates the overall relationship between independent and dependent variables (Table 4). At the same time, the Wald test assesses whether or not the independent variable is statistically significant in differentiating between groups in each embedded binary logistic comparison.

Table 4: Likelihood Ratio Tests.

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	Df	Sig.
Intercept	507.220	37.161	3	.000
Legibility	494.931	24.872	3	.000

p<.05, n=693

Likelihood ratio tests confirm that "elements" and "clarity" (legibility) are highly significant independent variables influencing user visit duration in upgraded alleys.
Analysis of parameter estimates (Table 5) reveals how legibility impacts the odds of users spending different durations in these spaces, compared to visits "less than 1 hour":

- 1-4 Hours: Legibility has no statistically significant influence on visits lasting 1-4 hours (B: 0.112, Sig: 0.679).
- 4-8 Hours: Surprisingly, increased legibility is associated with a significant *decrease* in the odds of spending 4-8 hours (B: -1.186, Sig: 0.015). The odds ratio (Exp(B): 0.305) suggests a 69.5% reduction in likelihood for each unit increase in legibility. This might indicate that improved navigation efficiency allows users to complete tasks quickly or that mid-range visitors prioritise other factors.
- More Than 8 Hours: Conversely, higher legibility is strongly associated with a significant *increase* in the likelihood of stays exceeding 8 hours (B: 2.688, Sig: 0.000). The substantial odds ratio (Exp(B): 14.708) indicates well-defined, easily navigable spaces facilitate prolonged engagement and social interaction, potentially by reducing cognitive load.

In summary, legibility has a complex, varied impact on visit duration: it doesn't affect short visits, appears to shorten mid-range visits, but significantly encourages very long stays. These findings suggest that while clear pathways may expedite some activities, they also create environments that foster extended engagement, although other factors likely contribute to these patterns.

Table 5: Multinomial regression analysis between legibility and duration of using alleys.

Time duration of using alleys: a		B	Std. Error	Wald	Df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
1-4 hours	Intercept	1.730	.951	3.312	1	.069			
	Legibility	.112	.271	.171	1	.679	1.119	.658	1.902
4-8 hours	Intercept	2.451	1.604	2.334	1	.127			
	Legibility	-1.186	.487	5.923	1	.015	.305	.118	.794
More than 8 hours	Intercept	-11.840	2.649	19.978	1	.000			
	Legibility	2.688	.670	16.093	1	.000	14.708	3.955	54.701

a: The reference category is: Less than 1 hour

5.2.4 Frequency of Using Regenerated Alleys and Legibility

Table 6 reveals a significant relationship between legibility and the frequency of alley usage, compared to "not frequent" visits.

- At Least Once a Week: Increased legibility substantially boosts the odds of visiting weekly (B: 1.991, Sig: 0.000). The odds ratio (Exp(B): 7.325) indicates a 632.5% increase in likelihood for each unit increase in legibility, highlighting it as a strong predictor of frequent use.
- At Least Once a Month: Legibility also significantly increases the likelihood of monthly visits (B: 1.219, Sig: 0.000). The odds ratio (Exp(B): 3.383) suggests a 238.3% increase in odds per unit increase in legibility, emphasising its role in attracting regular visitors.
- 2-3 Times a Month: A robust positive relationship exists between legibility and visiting 2-3 times per month (B: 2.081, Sig: 0.000). The odds ratio (Exp(B): 8.012) shows a 701.2% increase in odds with each unit increase in legibility.

In conclusion, legibility consistently and significantly enhances the frequency of alley usage. Better legibility not only aids navigation but also acts as a strong incentive for users to incorporate the alleys into their routines. The most pronounced impact is observed in the "at least once a week" category, indicating that frequent users are particularly responsive to legibility. This highlights the crucial importance of effective design and signage in promoting sustained and frequent use of public alleys.

Table 6: Multinomial regression analysis between legibility and alley usage frequency.

Usage frequency: a		B	Std. Error	Wald	Df	Sig.	Exp(B)	95% Confidence Interval for Exp (B)	
								Lower Bound	Upper Bound
At least once a week	Intercept	-7.422	1.658	20.051	1	.000			
	Legibility	1.991	.472	17.809	1	.000	7.325	2.905	18.469
At least once a month	Intercept	-2.634	.899	8.593	1	.003			
	Legibility	1.219	.274	19.830	1	.000	3.383	1.978	5.783
2-3 times a month	Intercept	-5.615	.990	32.137	1	.000			
	Legibility	2.081	.296	49.353	1	.000	8.012	4.483	14.318

a: the reference category is not frequent

5.2.5 Purpose of Using Regenerated Alleys and Legibility

Table 7 indicates that legibility does not statistically significantly influence the *purpose* of using the regenerated alleys ($p > 0.05$), meaning there's no direct relationship between the legibility of a space and whether it's used for visiting or entertainment.

Field observations, however, highlight critical needs for enhancing daily maintenance services. The absence of adequate lighting was a concern, underscoring the importance of proper illumination, visibility, and well-managed services to foster social activities and diverse uses. While user perception of the alleys has improved, further enhancements are needed, particularly in terms of safety, through improved lighting and the installation of surveillance cameras. Engaging activities, such as workshops and galleries, can also play a vital role in regeneration.

Since legibility is not a primary determinant for visiting or entertainment purposes, urban planners should investigate other influential factors such as social dynamics, specific events, accessibility, amenities, and personal preferences. Further research using different methodologies or examining broader variables could help to explore these complex relationships further.

Table 7: Multinomial regression analysis between legibility and the purpose of usage.

Purpose of usage: a		B	Std. Error	Wald	Df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Visiting	Intercept	.488	.888	.303	1	.582			
	Legibility	.200	.252	.628	1	.428	1.221	.745	2.000
Entertainment	Intercept	1.342	.879	2.329	1	.127			
	Legibility	-.054	.250	.046	1	.830	.948	.580	1.548

a. The reference category is others. P> .05

5.26 The Relationship between Legibility and Social Interaction

Linear regression analysis revealed a significant relationship between visual elements, clear structure, and social interaction.

- Visual Elements positively impact social interaction (standardised coefficient: 0.198, $p < 0.001$), indicating that improvements lead to increased social engagement, albeit modestly. The confidence interval is [0.118, 0.241].
- A clear structure demonstrates a significantly stronger positive relationship with social interaction (standardised coefficient: 0.704, $p < 0.001$), making it the most impactful variable. The confidence interval is [0.605, 0.735].

Both variables are highly statistically significant ($p < 0.001$), with confidence intervals that do not include zero, reinforcing their genuine effect. The adjusted R-squared value of 0.771 indicates that 77.1% of the variance in social interaction is explained by these variables, showing a strong model fit.

In conclusion, both visual elements and clear structure significantly contribute to social interaction, with clear structure being particularly potent. These findings underscore the critical role of well-designed, explicit communication materials in fostering social engagement.

Table 8: Linear regression analysis between social interaction and legibility (clear structure, visual elements)

Dependent Variable	Independent variables	Standardised coefficient Beta	t-value	Sig.	95.0% Confidence Interval for B	
Social Interaction	Visual elements	0.198	5.707	.000	.118	.241
	Clear structure	0.704	20.287	.000	.605	.735
	Adjusted R^2: .771			P<0.001		

6.0 DISCUSSIONS

The regeneration of *Bukit Bintang's* alleys has significantly altered the daily experiences and patterns of engagement for its users. In the 2000s, public art creation focused on engaging with local communities, positioning public art not merely as a visual solution, but also as a tool for community engagement and problem-solving (Pan, 2015, p.154). In this context, Malaysian local authority initiatives have included vibrant aesthetic enhancements, such as murals incorporating local flora and fauna inspired by the historical *Alor* stream (Figure 4). While these efforts ostensibly aim to imbue the spaces with cultural and historical significance, research and observation suggest a potential disconnect in users' complete understanding or recognition of these artistic elements and their intended meaning. This raises critical questions about the "politics of visibility" in urban regeneration, where certain narratives and aesthetics are made prominent, potentially serving broader "urban branding" initiatives more than deep community connection. Research indicates that certain narratives and aesthetics are indeed made prominent in urban branding, often serving broader "urban branding" initiatives, sometimes at the expense of deeper community connection (Moussaoui, 2024). This is more aligned with economic interests than with fostering genuine community ties.

Fig.4: Alor Information Plaque (KLCH, 2018)

In this study, the pattern of extended engagement (often exceeding an hour) reveals a compelling paradox: users who spend more extended periods (one to four hours) report a diminished sense of legibility compared to those with shorter visits. This "clutter of details" that, while initially interesting (e.g., the visual quality influenced by colours, art, and facades), can ultimately obscure a clear mental map, suggests that the aesthetic legibility primarily caters to transient, first-impression users—often tourists—rather than fostering sustained comprehension for those who linger. The physical dimensions of alleyways, especially in tropical countries, significantly impact walkability. Their length and varying width within a dense commercial sector play a crucial role in this outcome. The typical height of the buildings in *Bukit Bintang* alleys ranges from 7 to 21 meters (2 to 5 stories), resulting in a height-to-width ratio of 3:1 and 2:1 (Figure 5). However, when it rains, people tend to avoid using alleys because they essentially have no shading features for pedestrians (Wan, 2017) (Figure 8).

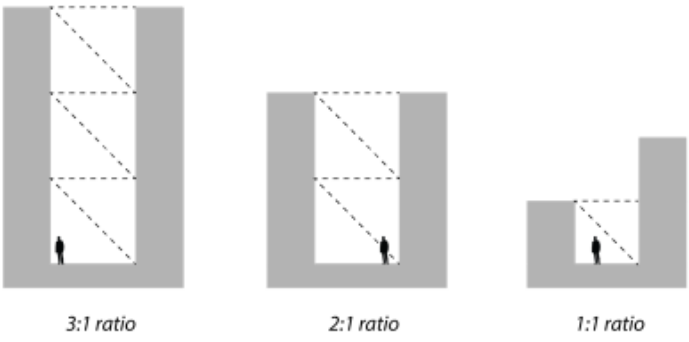

Fig 5: Height-to-Width Ratio (Wan, 2017)

Overwhelming visual density can result from narrow alley sections with numerous commercial signage and diverse storefronts, potentially hindering spatial comprehension and navigational clarity over time. Conversely, wider, unprogrammed sections may lack cohesion. Studies indicate that users primarily engage in leisure activities, such as dining, rather than commercial activities in revitalised alleys, as observed in Alor, Alam Alor, and Laman Belakang alleys (Ng & Sze, 2022) (Figures 7 and 8). This influx of visual information, while initially creating a "wow" factor, can become overwhelming, impacting navigational clarity (Huang et al., 2023). A decline in perception among long-term users may stem from discrepancies between anticipated legibility and actual chaotic signage or confusing spatial arrangements, highlighting a tension between marketability/tourism appeal, on the one hand, and functional legibility for diverse, prolonged resident-oriented use, on the other.

Effective urban design must prioritise user comfort and diverse activities beyond mere aesthetics, especially in tropical climates. Sufficiently broad pathways are crucial to accommodate seating without obstructing movement, and varied lengths encourage exploration while maintaining clear sightlines. While aesthetic upgrades, such as murals, attract initial visitors, particularly tourists (Le & Hoang, 2024), they are insufficient to cater to the varied needs of users and ensure long-term legibility for those who linger. Critiques of "art-led regeneration" suggest it can prioritise superficial visual appeal, potentially neglecting fundamental infrastructure and functional elements crucial for genuine publicness and resident-oriented use. Without addressing these deeper aspects, legibility risks becoming a tool for commodification rather than fostering truly inhabitable spaces for locals.

Legibility is closely tied to fostering social interaction, a crucial aspect for vibrant social environments. Building on Lynch's work, recent research emphasises the role of legibility in promoting spontaneous encounters and enhancing community connections (Jacobs, 1961; Gehl, 2010). The concept of "third places" (Khan, 2021) — informal public gathering spots — is highly relevant, as the physical layout, including alley width and amenities, directly impacts these affordances. Adequately wide alleys can accommodate seating that invites conversation (Figure 8), and carefully considered lengths can create intimacy conducive to social bonding. Well-designed alleys can transform insecure urban passages into welcoming spaces for interaction, such as Kuala Lumpur's Kwai Chai Hong alley, which utilises bright lighting, thematic elements, and murals to create a legible and engaging space that fosters cultural appreciation and interaction (Figure 6).

Fig 6: *Kwai Chai Hong* alley, bright lighting, and murals (Merel Nahuijsen, 2024)

Similarly, the strategic positioning and design of *Alor* Alley (Figure 7), which originated from a feasibility analysis and is rooted in the location's history as a stream (*Alor* in *Bahasa Melayu*), exemplify how regenerated alleys can cultivate connections through shared experiences. However, the lack of clarity in communicating and promoting the historical and cultural significance, such as the *Alor* stream concept, through consistent signage, narrative elements like *manhwa* strips, and wayfinding, can fragment the intended identity and impact visual quality. This 'fragmentation' speaks to a broader issue in urban regeneration, where 'publicness' becomes curated rather than organic. If the historical narrative is unclear, the space risks becoming a generic backdrop for tourist consumption, losing its potential to genuinely foster community pride and identity.

Maintaining consistency in the *Alor* Stream theme is critical for reinforcing *Bukit Bintang's* local identity and significance, encouraging users to develop a stronger connection to the neighbourhood, thereby moving beyond mere aesthetic appreciation towards deeper, resident-oriented engagement. Acknowledging and valuing the historical narratives, such as the origin of the term "*Alor*" (Bavani, 2018), deepens understanding and fosters community pride, intensifying user engagement and contributing to a stronger sense of place (Relph, 1976).

Fig .7: *Alor*, cloudy and green alley (Author, 2025)

Additionally, compared to other alleys, *Laman Belakang* (Figure 8) is the most visited by tourists. Residents and stakeholders express sentiments and emotions about the *Laman Belakang* Alley concept design due to the environment's intense familiarity with the location. The architect Natasha (architect in charge of alley regeneration) stated that the owners who live in the alleys have a strong interest in developing the area, as evidenced by the *Laman Belakang* design concept proposed by one of the owners and the frequent cleaning and maintenance of the plants. The majority of the residents in the other alleys are tenants, who may be interested in the exterior improvements but lack the deeper investment of ownership. Moreover, it was discovered that respondents prefer to spend more time on *Laman Belakang* (Figure 8) than on other alleys; this is due to its strategic location, attracting visitors from *Tengkat Tong Shin* Street, and the provision of facilities (benches) that enhance the experience and encourage lingering, coupled with consistent maintenance. Its dimensions, likely offering a comfortable width for movement and seating without feeling overwhelming, combined with its strategic location within the commercial district, contribute to its success. These variables all contribute to an increase in alley activity. The study found that legibility is substantially connected with achieving people's desires, and higher legibility is dramatically associated with satisfying people's intentions. This implies that when renovated alleys are viewed as more legible, they are more likely to meet the desires of those who use them. Th s success, driven by simplicity of access, clear signage, maintained mural arts, and overall comprehensibility, suggests that genuine resident engagement and practical amenities, rather than just art, contribute to a holistic and truly legible urban space that avoids the pitfalls of mere "artwashing" or arts-led regeneration that conceals issues within the urban community, presenting an attractive veneer of modernity while simultaneously embracing the aesthetics of urban decay as 'authenticity' (Zukin, 2010a, p.30) or grit as glamour (Lloyd, 2010; McIntosh, 2021).

Fig 8: *Laman Belakang*, well-maintained alley (Author, 2025)

In contrast, observational data reveal key challenges that hinder user engagement and social interaction within *Alor's* communal spaces. Specifically, *Komuniti di* Alor (Figure 9), *Kehidupan Alor* (Figure 10), and *Alam Alor* (Figure 11) experienced reduced usage during evening hours due to several factors. These alleys suffer from a lack of integration into the surrounding urban environment, resulting in underutilisation. The ambiguous layout and unclear signage act as barriers, impeding navigation and contributing to user isolation (Nasar & Julian, 1995; Francis et al., 2012). The varying and often inconsistent widths of these alleys, combined with their commercial district context, exacerbate these issues; a narrow, poorly lit section feels unsafe, while a wide, unprogrammed area might become a forgotten thoroughfare or parking space. Moreover, inadequate lighting and insufficient maintenance heighten safety concerns, deterring visitors, especially during evening hours, particularly in *Komuniti di Alor* (Figure 9), where walls show signs of damage and wear, including extensive graffiti and water stains. This evident neglect, particularly the "lack of resident engagement in maintaining regenerated alleys," can be directly linked to a weak sense of belonging. When individuals feel like tourists rather than residents, they are less likely to invest in the upkeep and improvement of public spaces. This highlights a crucial critique of art-led regeneration: if the art and "improvements" are perceived as externally imposed or solely for "urban branding," rather than genuinely rooted in and supported by the community, they fail to foster a sense of collective accountability for the well-being of society (Gürman & Buldan, 2024). Di ly lit conditions compromise legibility, negatively impacting users' perception and sense of security, further reinforcing the idea that purely aesthetic interventions without functional support or community investment can lead to spaces that are visually appealing but ultimately fail as true public realms.

Fig 9: *Komuniti di Alor*, lack of maintenance (Author, 2025)

Fig10: *Kehidupan Alor*, lack of maintenance (Author, 2025)

Alam Alor (Figure 11), the widest and largest alley in the area, holds significant potential due to its strategic location connecting the vibrant *Jalan Bukit Bintang* and *Jalan Alor* in Kuala Lumpur. Its considerable width, while offering potential for diverse activities, ironically contributes to its misuse as parking when not thoughtfully programmed (Figure 11). This situation exemplifies the "instrumentalisation of art" in urban development; a space with high potential for genuine public use is neglected because its "aesthetic" regeneration is incomplete or misguided, failing to create a compelling reason for sustained human activity. The concept of a public space with high potential for genuine public use being neglected due to incomplete "aesthetic" regeneration is a recurring theme in urban studies and regeneration literature. Several academic works explore how regeneration efforts, when overly focused on superficial aesthetic improvements or driven by commercial interests, can fail to foster authentic public engagement and, in some cases, lead to further neglect or displacement of communities.

For instance, research on abandoned buildings in Berlin highlights how a focus on aesthetic changes, often tied to "touristification" and "commodification," can result in neglect of the inherent tangible and intangible qualities of these spaces and the communities that might informally re-appropriate them, challenges and opportunities in the reuse of abandoned buildings (Zecca, 2019). This type of regeneration, driven by "neoliberal immediate revenues," can overlook the existing value and potential for genuine public participation. The paper suggests that "informal re-appropriation" and "minimal interventions" that prioritise public involvement can better preserve a city's unique aesthetics while fostering public use, contrasting with regeneration that prioritises incomplete or misdirected aesthetics over social value (Zecca, 2019).

The idea that "inexpensively providing aesthetic form" can leave spaces "suspended, forgotten or abandoned" further supports this notion, implying that a lack of comprehensive planning beyond mere aesthetics can render regeneration incomplete and ineffective for public utility (Polyak, 2016). Instead, there's an argument for integrating aesthetic function with social value, ensuring that regeneration efforts exploit both aspects for meaningful urban renewal (Landry et al., 1996). To fully leverage its potential and extend the vibrancy of the adjacent streets, Alam Alor requires consistent maintenance and a comprehensive mural program to establish a distinct identity for the space, transforming it into an inviting and engaging public area. Addressing these issues requires prioritising thoughtful design principles that foster inviting environments conducive to social gathering and enhance the overall integration of these spaces into the urban fabric, moving beyond the superficial "prettifying" of urban spaces to cultivate true publicness.

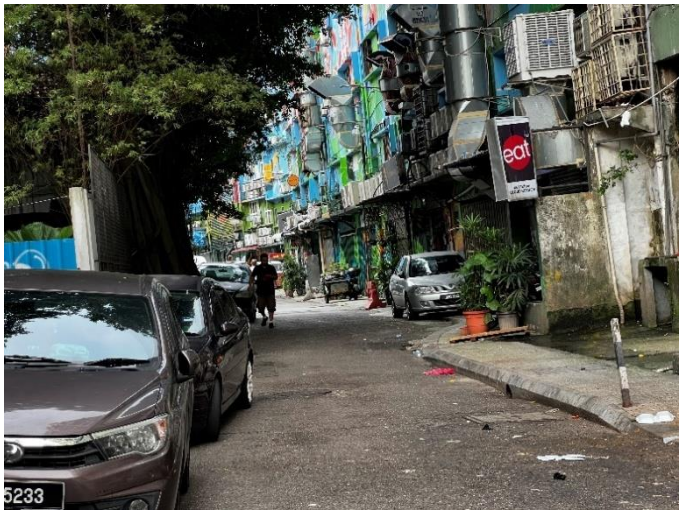

Fig 11: *Alam Alor*, parked cars, and overlooked alley (Author, 2025)

In conclusion, regenerating urban alleys into vibrant, community-oriented social spaces requires a comprehensive, user-centred approach that critically examines the interplay between aesthetics, legibility, and the profound impact of an alley's length, width, and surrounding commercial land use on user experience. Prioritising straightforward navigation, sufficient lighting, regular maintenance, and integrated historical narratives is essential for transforming these underutilised areas. This goes beyond simply using art for "urban branding" or commodification; it demands a focus on authentic community engagement and the creation of truly legible and functional spaces for residents, not just tourists. Successful regeneration also necessitates collaborative efforts among government, community, and private stakeholders to ensure sustainable outcomes that foster social interaction, strengthen community ties, and align with the goals of Sustainable Development (SDG 11), thereby avoiding the pitfalls of "artwashing" and promoting genuine urban resilience.

7.0 CONCLUSION

The regeneration of urban alleys, as exemplified by *Bukit Bintang*, unequivocally demonstrates that spatial legibility is the cornerstone of fostering genuinely vibrant and sustainable communal spaces. While aesthetic enhancements, such as public art and murals, are instrumental in initial attraction and "urban branding," this study reveals a critical paradox: a "clutter of details" can diminish legibility for sustained engagement, effectively prioritising transient tourist appeal over profound resident connection. This highlights a fundamental tension where superficial visual improvements, if not deeply integrated with functional design and authentic community needs, can hinder navigational clarity and social interaction, resulting in visually appealing spaces that are ultimately underutilised and lacking in genuine publicness. Therefore, successful urban alley regeneration must transcend mere "art-led regeneration" or "art washing" and instead embrace a holistic, user-centred paradigm. This necessitates prioritising intuitive spatial design, clear wayfinding, consistent maintenance, and the strategic integration of amenities that facilitate a range of diverse activities. Furthermore, embedding historical narratives and fostering genuine community engagement are vital for cultivating a strong sense of place and ownership. Ultimately, by marrying compelling aesthetics with robust functional design and collaborative stakeholder involvement, cities can transform underutilised urban passages into legible, resilient, and equitable public realms.

However, this study's insights are tempered by its limitations, which stem from its specific geographical and cultural context, as well as methodological constraints, particularly regarding the nuanced relationship between legibility and the diverse purposes for which alleys are used. The reliance on observational data, while providing valuable initial insights, suggests that the findings may not be universally applicable. Future research should therefore focus on comparative analyses across diverse settings, employing varied and more comprehensive methodologies such as spatial tracking and qualitative interviews. This will enable a deeper exploration of how economic impacts affect local businesses, a more nuanced understanding of diverse user experiences, and a comprehensive assessment of accessibility needs. Such expanded research will be crucial for developing a more globally applicable framework for urban alley regeneration, one that truly integrates both aesthetic and functional considerations to create genuinely public, legible, and sustainable urban spaces.

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TWO WATERFRONTS, TWO STORIES: A COMPARATIVE ANALYSIS OF TANJUNG CHALI AND THE MELAKA RIVERFRONT

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ABSTRACT

Urban heritage waterfronts are essential elements for shaping place identity, preserving historical narratives and memories, and supporting local tourism development. This study compares two heritage waterfronts in Malaysia, namely Tanjung Chali in Alor Setar and the Melaka Riverfront in Melaka, to evaluate the role of physical landscapes, conservation policies, and the implications of development for heritage sustainability. Tanjung Chali reflects Kedah's early identity as a traditional trading hub, yet it has received comparatively less attention in conservation efforts. In contrast, the Melaka Riverfront has undergone rapid transformation through conservation and commercialisation projects, making it an iconic world heritage-based tourism destination. The study employs document analysis, historical maps, secondary data, and field observations to identify the similarities, differences, and key challenges faced by both waterfronts. The findings reveal that although both sites share historical value and strategic riverfront locations, differing management approaches have produced divergent development trajectories: the Melaka Riverfront emphasises the commercialisation of heritage, whereas Tanjung Chali remains localised and underdeveloped. This article underscores the need for a balanced management model that reconciles conservation and development, thereby offering policy recommendations to strengthen Tanjung Chali's potential as a sustainable heritage destination without compromising its original identity.

Keywords: Cultural Landscape, Urban Revitalisation, Heritage Tourism, Sustainable Development, Waterfront

1.0 INTRODUCTION

Waterfront or riverfront development has always been central to the sustainability of historic cities, as it not only functions as a hub for trade and connectivity but also shapes the cultural identity of local communities. In Malaysia, many historic towns have grown and flourished along rivers, including Melaka, which is recognised as a UNESCO World Heritage Site, and Alor Setar, which retains its historical heritage within the Tanjung Chali area (Rose & Ghani, 2020). Waterfronts are not merely physical spaces but also cultural landscapes that reflect the interaction between people and their environment (Iqbal et al., 2020). The same scholars emphasise that every waterfront shapes identity, distinctiveness, and symbolism of place, thereby playing a vital role in attracting visitors while preserving the original image and maintaining the sense of attachment, perception, and experience among users. Nevertheless, rapid development and urbanisation pressures often pose challenges to the sustainability of heritage waterfronts. The rapid transformation of the Melaka Riverfront, for instance, has turned it into a major tourist attraction through modernisation and commercialisation initiatives. At the same time, however, concerns have been raised about the erosion of its original heritage values, which risks undermining local identity and authenticity (Amir et al., 2020). In contrast to the urbanised image of the Melaka Riverfront, Tanjung Chali continues to preserve its traditional character as a modest riverside settlement in northern Malaysia. Although it has received less attention in mainstream tourism and mass media, it remains a

meaningful site for visitors. This contrast raises the critical question of how to balance cultural conservation with the demands of economic development in historic waterfronts—reflecting the central dilemma in planning the future of cities with strong cultural identities.

According to Hussain et al. (2022), most previous studies have primarily focused on the development of individual waterfronts and paid less attention to comparative analysis across different contexts. Therefore, this study seeks to fill this gap by comparing Tanjung Chali and the Melaka Riverfront as two distinct narratives of heritage waterfront development in Malaysia. The selection of these two sites is deliberate, as both represent contrasting yet complementary typologies of Malaysian heritage waterfronts. The Melaka Riverfront, recognised as part of a UNESCO World Heritage Site, exemplifies a globally acknowledged model of heritage-led urban tourism and regeneration. In contrast, Tanjung Chali embodies a community-oriented and organically evolved riverfront that maintains its traditional spatial character and socio-cultural functions despite limited exposure to mass tourism. Through this comparison, the study critically examines how different governance frameworks, heritage statuses, and development pressures influence the conservation and transformation of cultural landscapes. Furthermore, employing two case studies is methodologically appropriate within qualitative research (Yin, 2014; Creswell & Creswell, 2017), as it allows for in-depth contextual comparison and the identification of transferable insights applicable to other historic waterfronts in Malaysia and beyond.

Accordingly, the main objective of this study is to compare the physical elements, functions, development policies, and cultural identities of these two waterfronts. Such a comparison is expected to identify the key issues, challenges, and opportunities in managing historic waterfronts, thereby enabling urban development to proceed without sacrificing heritage values. This study also contributes to the academic literature on waterfront cultural landscapes in Malaysia while offering practical insights for urban planners, local authorities, and policymakers. In line with the aspirations of the Sustainable Development Goals (SDG 11: Sustainable Cities and Communities), the findings aim to reinforce the balance between heritage conservation and economic development in historic cities, while demonstrating how differing heritage statuses and development contexts can provide valuable lessons for sustainable waterfront management.

2.0 LITERATURE REVIEW

2.1. Waterfronts as Cultural Landscapes

Waterfronts are not merely physical spaces along rivers or seas; rather, they represent cultural landscapes that symbolise the interaction between humans and nature, while serving as unique witnesses to the evolution of heritage, culture, and civilisation across the world (Shamsuddin, 2011). The same author further emphasises that waterfronts often function as centres of economic, social, and cultural activity that shape the identity of a city. This view is supported by Traboulsi et al. (2023), who note that in historic cities, waterfronts frequently mark the origins of settlement, act as hubs of trade, and provide communal meeting spaces. Thus, understanding waterfronts as cultural landscapes allows for an evaluation that extends beyond physical form to include their symbolic and social values.

2.2. Waterfront Development and Regeneration

Much of the existing scholarship highlights waterfront regeneration as a critical strategy in modern urban development. According to Xie (2023), this concept encompasses efforts to upgrade infrastructure, revitalise public spaces, and transform waterfront areas into attractions for tourism and investment. This perspective is reinforced by Liu et al. (2024), who points to the Melaka Riverfront as a concrete example of how regeneration can generate significant economic benefits through the growth of both domestic and international tourism. Nevertheless, the same scholar cautions that regeneration is often criticised for displacing local communities and reducing cultural landscapes to purely commercial entities. This creates a persistent dilemma between heritage preservation and the pressures of contemporary development.

2.3. Heritage Conservation and Urban Identity

According to C40 Cities (2019), conserving historic waterfronts is vital for maintaining the continuity of urban identity. Previous studies suggest that heritage value is not confined to physical structures but also lies in

collective memory, traditions, and the narratives through which communities engage with place (Ujang & Zakariya, 2015). A clear distinction can be observed between Melaka and Tanjung Chali in this respect. Melaka has undergone extensive transformation marked by strong commercialisation, whereas Tanjung Chali remains more inward-looking, retaining its communal identity without significant external pressures of commercialisation. This comparison raises an important debate on how cities can sustain a sense of place without being overshadowed by economic imperatives, which often risk producing contrived heritage that undermines the cultural authenticity intended to be preserved.

2.4. Research Gap and New Directions

Much of the literature on Malaysian waterfronts has focused on single locations or has limited its scope to assessing the physical impacts of development, without conducting comparative analyses across historic cities. Consequently, there remains a gap in understanding how different approaches to waterfront development and heritage conservation shape urban identity and cultural resilience. Historically, both Tanjung Chali and the Melaka Riverfront evolved as vital nodes of trade and settlement along major river systems in Malaysia. Tanjung Chali, located in Alor Setar, Kedah, once served as a traditional riverside marketplace that connected local communities through fishing and trading activities. Despite urban changes, it still retains its vernacular riverine character and community-based cultural landscape. In contrast, the Melaka Riverfront, which originated as a colonial-era trading hub, has undergone extensive transformation through tourism-oriented regeneration and urban beautification initiatives, reflecting its global prominence as part of a UNESCO World Heritage City. A comparative study of these two sites therefore provides an opportunity to examine two divergent narratives of development—one more conservative and community-based, the other more modern and commercialised. Such an analysis not only addresses an academic gap but also offers practical guidance for stakeholders in designing heritage waterfront policies that balance conservation with sustainable development.

3.0 METHODOLOGY

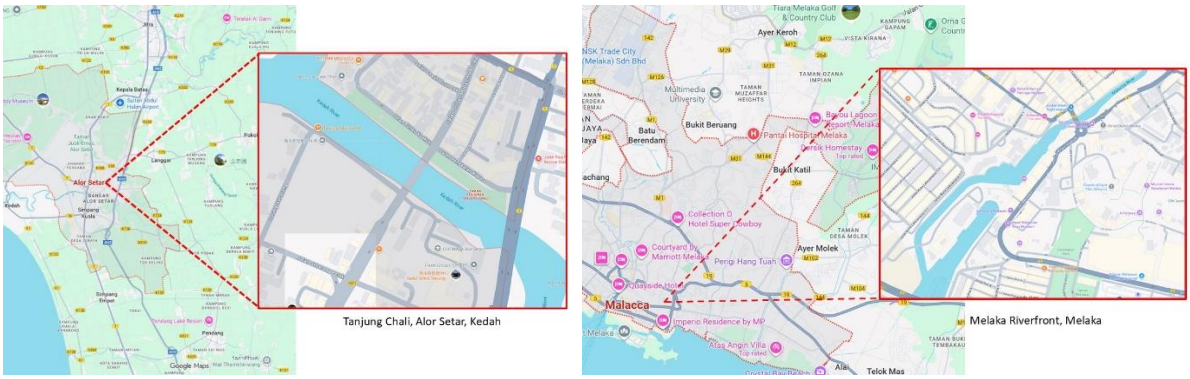

Fig. 1. Location map of the study areas Tanjung Chali, Alor Setar (left), and the Melaka Riverfront (right) illustrating their geographical setting and urban context. (Source: Google Maps)

This study adopts a descriptive qualitative approach, focusing on a comparative analysis between two historic waterfront areas: Tanjung Chali in Alor Setar and the Melaka Riverfront in Melaka as shown in Figure 1 above. According to Ruhizar et al., (2021) and Hussain et al. (2025), this approach was selected as it enables the researcher to identify both similarities and differences in terms of physical elements, development strategies, and the cultural landscape values embedded within the two waterfronts. By emphasising narrative and visual analysis, the study does not involve direct informants but relies instead on secondary sources and limited field observations.

The primary method employed is document analysis, which includes reviewing urban planning reports, heritage conservation documents, academic articles, and other relevant secondary sources (Nursaniah et al., 2021). They also highlight that informal field observations were conducted to assess the physical condition, spatial layout, and visual elements of both waterfronts. This method allows the researcher to gain direct insight into how historical landscape elements are either preserved or transformed within the context of contemporary development.

Furthermore, as Wee Kah Man (2024) and Asriana et al. (2024) emphasise, in order to ensure a more systematic comparison, the analysis was divided into several key themes derived from the literature review, namely: (i) physical elements and urban design; (ii) development and regeneration strategies; (iii) heritage conservation and cultural identity; and (iv) tourism potential and socio-economic impact. These themes served as the analytical framework for evaluating the extent to which both waterfronts balance the demands of modern development with the preservation of historical identity.

To strengthen the findings, a thematic comparative analysis was applied. As Ibrahim et al. (2023) explain, secondary data and field observations were categorised according to the identified themes and then critically compared to identify patterns, similarities, and differences. The outcomes of this analysis are used to formulate both academic and practical implications for planning historic waterfronts in Malaysia, thereby deepening the understanding of the balance between conservation and development.

4.0 RESULTS AND DISCUSSION

This section presents the results and discussion of the study findings, focusing on the comparative evaluation of Tanjung Chali in Alor Setar and the Melaka Riverfront. The discussion is structured around four key themes Cultural Identity and Heritage, Physical Design and Infrastructure, Economy and Tourism, and Environmental Sustainability—which were derived from the literature review and theoretical perspectives on cultural landscape and waterfront development (Shamsuddin, 2011; Haron, 2021; Hussain et al., 2022). These themes reflect the multidimensional relationship between cultural, physical, economic, and ecological dimensions in shaping the sustainability and character of heritage waterfronts.

4.1. Cultural Identity and Heritage

Cultural identity and heritage are fundamental aspects in evaluating waterfront landscapes, as they shape the image, collective memory, and historical continuity of a place. In Tanjung Chali, cultural identity is largely influenced by the Malay and Chinese communities, alongside the river's historical role as a centre for religious activities, small-scale trade, and daily life that has existed since the early 1920s. The presence of iconic landmarks such as Masjid Zahir, Balai Nobat, and Pekan Rabu, as well as Straits Eclectic style-colonial-era buildings dating back to the Kedah Sultanate, gives Tanjung Chali a distinctive position as a symbol of local heritage continuity that remains understated. Nevertheless, efforts to conserve its physical heritage appear relatively marginal when compared with other heritage waterfronts such as Kuching and Melaka, as attention in Tanjung Chali has been more inclined towards oral histories and the collective memory of the local community.

In contrast, the Melaka Riverfront demonstrates a more systematic approach in foregrounding cultural identity and heritage, strongly shaped by place branding and tourism identity. According to Ibrahim et al. (2023), Melaka, along with other recognised heritage cities, has been acknowledged for the preservation of its physical heritage—such as historic buildings and the retention of original architectural styles—while simultaneously integrating historical elements into the city's tourism narrative. Similarly, Wee Kah Man (2023) found that the adaptive reuse of shophouses into restaurants and cafés reinforces the sense of place and supports urban conservation in Melaka, provided that community involvement is carefully implemented to prevent the erosion of its authentic cultural character.

To strengthen this analysis, visual comparison is essential in highlighting the marked differences between the two waterfronts. In Tanjung Chali, heritage elements are more visibly expressed through community living functions that retain traditional aspects, despite the modest yet somewhat weathered condition of old buildings, which silently testify to Alor Setar's urbanisation process. Conversely, along the Melaka River, physical conservation and tourism-oriented commercialisation are accentuated more strongly, supported by substantial public investment from the local authorities—a phenomenon also discussed by Ibrahim et al. (2023) and Hussain et al., (2024). Hence, the following images are utilised to substantiate the narrative of this analysis (Fig.2.).

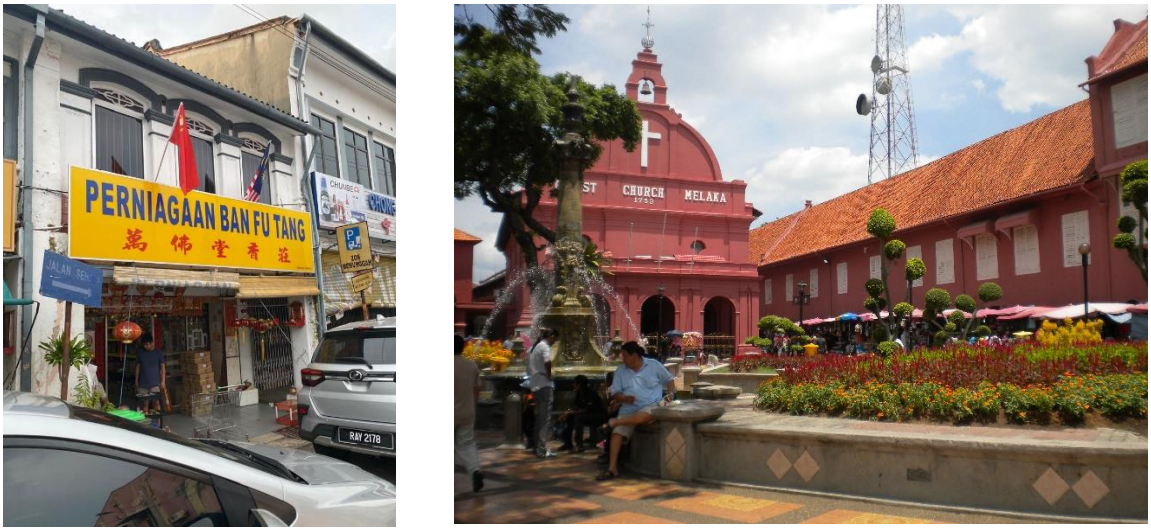

Fig. 2. Old shophouses in Tanjung Chali (left) retain their original architectural character as part of the local community identity, whereas in Melaka (right), historic buildings have been restored and adapted as tourist attractions and as symbols of the city's UNESCO World Heritage status. (Source: Authors)

This comparison illustrates two contrasting approaches: Tanjung Chali remains more community-oriented, with modest heritage that continues to preserve local identity and sustain small-scale trading activities, while Melaka highlights heritage and historical elements as economic assets and as a global image, positioning them as primary attractions. These divergent strategies open up discussion on how cultural values and heritage may be managed—either as symbols of community continuity or as resources for historic city branding—thereby reflecting distinct approaches to the preservation of identity.

Table 1: Summary of the key differences in cultural identity and heritage between Tanjung Chali and the Melaka Riverfront

Comparative Aspect	**Tanjung Chali (Alor Setar)**	**Melaka Riverfront**
Physical Heritage Elements	Zahir Mosque, traditional shophouses in the Malay & Chinese quarters with "Straits Eclectic Style", Pekan Rabu, and Tanjung Chali Tower.	Dutch, Portuguese, and British heritage buildings; well-preserved rows of old shophouses featuring a unique hybrid architecture combining Malay–Portuguese–Dutch–British–Chinese influences, shaping the identity of the UNESCO World Heritage City.
Historical Value	Associated with the history of the Kedah Sultanate and local trading activities.	Linked to the history of international port trade and the colonial era.
Identity Symbol	The river as the lifeline of small-scale trade and a symbol of the state's civilisation.	The river as a symbol of early globalisation and cultural encounters.
Heritage Preservation	Limited, with greater focus on iconic buildings (e.g. Zahir Mosque, Pekan Rabu, Chinese and Malay Quarters).	More comprehensive through UNESCO projects and designated conservation zones.
Contemporary Cultural Role	Still present but has received limited revitalisation within the tourism context.	Positioned as a key asset in cultural tourism and the local economy.

4.2. Physical Design and Infrastructure

From the perspective of physical design and infrastructure, Tanjung Chali and the Melaka Riverfront display striking differences in terms of development planning and strategies for urban space utilisation, as illustrated in Figure 3 below. Tanjung Chali retains its traditional layout, characterised by rows of old shophouses, mosques, and basic community facilities that continue to serve as the heart of local social interaction without undergoing major transformations. While this contributes to authenticity and a sense of heritage, the lack of supporting infrastructure—such as pedestrian-friendly walkways, landscaped recreational spaces, adequate areas for social activities, and systematic night lighting—renders the area less appealing to outside visitors (Rahman, 2022).

In contrast, the Melaka Riverfront has undergone extensive transformation through comprehensive riverbank redevelopment, featuring pedestrian walkways, tourist jetties, decorative lighting, wall murals, and the integration of modern commercial spaces such as cafés and restaurants as key tourist attractions. This approach not only enhances accessibility and safety but also redefines the river as a central tourism icon (Wee, 2023). Nevertheless, rapid development in Melaka has also generated issues of congestion, over-commercialisation, and the challenge of maintaining a balance between modern development and heritage conservation.

In summary, Tanjung Chali highlights the value of traditional authenticity but remains limited in terms of modern infrastructure, whereas the Melaka Riverfront demonstrates success in integrating physical design that appeals to tourists, albeit at the risk of losing its original identity.

Fig. 3. The row of old shophouses infront of Tanjung Chali river(left) reflects a traditional layout that continues to serve as part of the community's social fabric, albeit with limited supporting infrastructure. In contrast, the Melaka Riverfront (right) showcases comprehensive riverbank redevelopment incorporating modern elements such as pedestrian walkways, lighting, and commercial spaces, thereby transforming its function into a major tourist attraction. (Source: Authors)

4.3. Economy & Tourism

In terms of economy and tourism, the two waterfronts demonstrate divergent development trajectories shaped by their respective potential and functional roles. While the two sites differ significantly in their status and scale, Melaka being a UNESCO World Heritage site, and Tanjung Chali, representing a smaller local waterfront, the comparison is made to highlight how differing governance frameworks and development pressures influence economic and tourism outcomes within Malaysia's diverse cultural landscape contexts. In Tanjung Chali, economic activities remain primarily local, centred around small-scale trade such as grocery shops, food stalls, and community services that sustain the daily lives of residents. The impact on tourism is still limited, as the area

has not undergone a large-scale transformation to attract international visitors. Instead, it continues to serve as a cultural and historical space closely tied to the local community. This situation presents challenges in terms of economic sustainability, since the lack of strong tourism appeal means the area's potential is not fully realised (Haron, 2021).

Table 2: Summary of the key differences in physical design and infrastructure between Tanjung Chali and the Melaka Riverfront.

Aspect	**Tanjung Chali**	**Melaka Riverfront**	**Comparative Analysis**
Building Design	Numerous traditional shophouses in the Malay & Chinese quarters with "Straits Eclectic Style".	A mix of modern and colonial buildings, characterised by a unique hybrid architecture combining Malay–Portuguese–Dutch–British–Chinese influences.	Tanjung Chali remains more traditional, whereas Melaka is more commercial and incorporates modern elements.
Tourism Infrastructure	Limited, focusing mainly on markets, mosque, and jetty.	Well-equipped with pedestrian walkways, cafés, galleries, and museums.	Melaka is more systematically planned as a tourist attraction.
Accessibility	Limited vehicle access, serving mostly local users.	Good accessibility with integration into the city's tourism network.	Melaka functions at a more international scale.

In contrast, the Melaka Riverfront has evolved into a world-class tourism icon, with heritage- and recreation-based development that draws millions of visitors each year. A variety of commercial activities—including restaurants, boutique hotels, museums, and the Melaka River Cruise—contribute directly to the growth of the local economy (Ismail et al., 2022). However, comparisons also highlight long-term risks, as a tourism-oriented approach frequently invites issues of over-commercialisation, which may erode the site's authentic heritage values (Lim & Ahmad, 2023).

Tanjung Chali, on the other hand, while less prominent in terms of tourism, preserves the authenticity of its local community, making it an example of a place that continues to balance heritage and modest development. Consequently, the contrast between the two waterfronts underscores the importance of economic development strategies that prioritise not only profit, but also the sustainability of heritage and local identity.

Table 3: Comparison of Economy and Tourism between Tanjung Chali and the Melaka Riverfront.

Aspect	**Tanjung Chali**	**Melaka Riverfront**	**Comparative Analysis**
Main Economic Activities	Traditional markets, fisheries, and local trade.	Tourism, hospitality, and modern retail businesses.	Melaka is more commercial, whereas Tanjung Chali remains locally oriented.
Contribution to the City's Economy	Small-scale, largely community-based.	Large-scale, generating revenue at both state and international levels.	Melaka has a greater impact on the economy.
Types of Tourists	Primarily domestic and local visitors.	Both international and domestic tourists.	Melaka enjoys global recognition, while Tanjung Chali is more regional in scope.

4.4. Environmental Sustainability

The aspect of environmental sustainability also reveals significant differences between Tanjung Chali and the Melaka Riverfront. In Tanjung Chali, the river ecosystem largely retains its natural characteristics, with much of the area remaining relatively untouched by intensive development. This condition allows local aquatic flora and fauna to continue thriving, although challenges persist, such as water pollution and the reduction of green spaces due to urban expansion around Alor Setar (Latif & Hassan, 2021). Conservation efforts here are more basic in nature, typically involving small-scale community initiatives and local participation in maintaining river cleanliness.

In contrast, the Melaka Riverfront demonstrates a more systematic approach through river rehabilitation programmes, including cleaning projects, flood control measures, and the integration of green landscapes along the riverbanks within tourism development. These initiatives not only improve the quality of the urban ecosystem but also create a visually appealing environment for visitors (Chong & Tan, 2022). Nevertheless, the main challenge in Melaka lies in balancing environmental sustainability with rapid development, as pressures from tourism activities and infrastructural expansion pose potential risks to the river's ecology in the long term (Noor et al., 2023).

This comparison highlights that Tanjung Chali holds authentic value through its remaining natural sustainability, whereas the Melaka Riverfront emphasises planned sustainability to support tourism and urban growth. Consequently, both cases illustrate that sustainability approaches must be adaptive—whether by conserving natural heritage or managing modern development in a balanced manner—so that cultural identity and ecological integrity can be safeguarded for future generations.

Table 4: Comparison of Environmental Sustainability Aspects between Tanjung Chali and Melaka Riverfront

Aspect	**Tanjung Chali**	**Melaka Riverfront**	**Comparative Analysis**
River Quality	Still exposed to moderate pollution issues.	Experiencing severe pollution due to intensive development.	Both face challenges, but Melaka is under greater pressure.
Conservation Approach	Community-led initiatives (e.g., gotong-royong, awareness programmes).	State government initiatives and large-scale projects (e.g., river cleaning).	Tanjung Chali is more community-based, while Melaka relies on formal projects.
Integration of Natural Landscape	Retains some natural elements and green spaces.	Much reclaimed for commercial development.	Melaka is more modern but less green, whereas Tanjung Chali remains more organic.

5.0 FINDINGS SUMMARY

The comparative analysis of Tanjung Chali and the Melaka Riverfront demonstrates that cultural landscape preservation is a multidimensional effort requiring the integration of economic, cultural, ecological, and social strategies. From the perspective of economic viability, Melaka Riverfront has achieved greater success due to strong tourism-driven development and diversified income streams, whereas Tanjung Chali remains underutilised with potential for economic revitalisation through heritage-based tourism. In terms of cultural heritage, both sites showcase unique narratives—Melaka with its world heritage recognition and Tanjung Chali with its strong connection to traditional Malay identity—yet differ in their scale of documentation, promotion, and institutional support.

With regard to ecological sustainability, Melaka demonstrates more structured river rehabilitation and urban greening efforts, while Tanjung Chali highlights the need for more systematic environmental planning. Finally,

the integration of tangible and intangible resources reveals that Melaka Riverfront successfully combines built heritage with cultural practices such as festivals and performances, whereas Tanjung Chali is still at an early stage, requiring stronger community involvement and policy support.

Overall, the findings indicate that while Melaka Riverfront stands as a model of integrated cultural landscape management, Tanjung Chali offers opportunities for developing a more place-based and community-driven approach that safeguards identity, enhances resilience, and aligns with sustainable development goals (SDGs).

6.0 CONCLUSION

The comparative study between the cultural landscapes of Tanjung Chali and the Melaka Riverfront underscores that cultural landscapes are not merely physical spaces, but rather serve as vessels of collective memory, identity, and social interaction. From a theoretical standpoint, this research strengthens the framework of cultural landscape studies by emphasising the triadic relationship between people, nature, and heritage, while positioning the landscape as a social text that reflects the interactions between communities and their environments across time. The findings further demonstrate that the preservation of cultural landscapes must extend beyond physical structures, prioritising the integration of symbolic, historical, and local traditional elements.

From a practical perspective, the study provides strategic guidance for planning and conservation. The Melaka Riverfront demonstrates the effectiveness of a development model that integrates heritage with tourism-driven economic growth, whereas Tanjung Chali highlights the potential of community-based development that is inclusive and rooted in local identity. However, both sites face distinct risks: Tanjung Chali risks marginalisation in the absence of sustainable development strategies, while the Melaka Riverfront risks losing its authenticity under excessive commercial pressures.

Based on these findings, several policy directions are recommended to guide future heritage waterfront management in Malaysia. First, urban planning frameworks should integrate cultural identity and local narratives as core components of waterfront development. Second, community-led management committees should be established to ensure local participation and shared responsibility in conservation activities. Third, sustainable tourism strategies should be implemented to balance economic growth with the safeguarding of cultural authenticity. Finally, digital technologies and educational initiatives should be leveraged to enhance public awareness, documentation, and transmission of heritage values across generations.

In relation to the Sustainable Development Goals (SDGs), this study contributes to:

- SDG 11 (Sustainable Cities and Communities): through the preservation of resilient and inclusive urban heritage.
- SDG 4 (Quality Education): by generating academic knowledge that frames cultural landscapes as learning resources.
- SDG 17 (Partnerships for the Goals): through recommendations for collaboration between government, communities, and the private sector in heritage management.

Overall, this study demonstrates that cultural landscapes serve as a bridge between theory and practice. Theoretically, it advances the understanding of the human–nature–heritage nexus; practically, it provides a foundation for policy and conservation strategies. Nevertheless, the continuity of preservation can only be secured through adaptive approaches that balance identity, development, and sustainability.

Thus, cultural landscapes should not be regarded solely as remnants of the past, but as strategic assets for the future. Without inclusive planning, sites such as Tanjung Chali risk further marginalisation, while the Melaka Riverfront risks losing its original spirit. Accordingly, future research should explore socio-economic dimensions and the integration of digital technologies in conservation, ensuring that these cultural legacies remain meaningful and are transmitted to future generations.

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A BIBLIOMETRIC ANALYSIS ON CULTURAL ECOSYSTEM SERVICES ASSESSMENT STUDIES: TRENDS, INSIGHTS AND FUTURE IN A DECADE

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ABSTRACT

Cultural ecosystem services (CES) refer to intangible benefits derived from human interactions with their surrounding environment, such as recreational opportunities, aesthetic value, cultural heritage, and spiritual value. While attention is increasing towards CES, the growing fragmentation of methodologies, varied geographical distribution, and the lack of standardised assessment remain significant challenges for its integration into urban planning strategies. This paper aims to analyse global research trends in CES assessment and valuation between 2015 and 2025 and to formulate the future direction of CES assessment studies to enhance human-environment interaction. This study employed bibliometric analysis using BiblioMagika and VOSviewer to visualise the recent trends and patterns in CES assessment studies, based on a review of 173 journals from the Scopus database. The findings reveal that CES studies have received considerable academic attention over the decade, especially after 2020, and have mostly come from developed countries such as Germany and the United States, and more recently from China. However, regions with rich biodiversity are still underrepresented, such as Southeast Asia countries. Key themes include social media analysis, participatory spatial mapping, urban green space, and urban green infrastructure, which show their credibility in shifting the world's attention towards urban sustainability.

Keywords: Cultural ecosystem services, bibliometric analysis, human-environment interaction, urban planning, sustainable development

1.0 INTRODUCTION

Over the past few decades, the field of environmental psychology has expanded, shifting its focus to the complex interaction between humans and the environment. While initially centred on the influence of external settings on human behaviour, academic interest has expanded to include their impacts on ecological well-being and sustainable environmental planning. This growth led to an increasing emergence in cultural ecosystem services (CES) that can be defined as intangible benefits derived from nature interaction, such as recreational opportunities, spiritual and religious, cultural heritage diversity and sense of place, showing its emphasis in multidisciplinary approaches (Sitas et al., 2015; Hirons et al., 2016).

CES assessment studies provide a vital foundation for advancing the formulated Sustainable Development Goals (SDGs), as they significantly support Goals 3 (Good Health and Well-Being), 11 (Sustainable Cities and Communities), and 15 (Life on Land). Wood et al. (2018) highlighted that effective ecosystem services assessments are needed to tackle environmental challenges while maintaining the flow and trade-offs of the provision of ecosystem services. Despite growing academic interest, the integration of research findings into urban planning is receiving challenges due to the various geographical distributions, the complexities of the

methodology and the lack of standardisation in evaluations (Rózová et al.,2020; Johnson et al., 2019; Gosal et al., 2018; Plieninger et al., 2015). Therefore, a comprehensive review of CES literature is crucial to understand prevailing research trends, identify thematic gaps, and highlight future directions for better planning. Bibliometric analysis serves as a robust tool for systematically identifying these gaps by quantitatively revealing trends, citation patterns, and thematic patterns in CES research over time (Donthu et al., 2021).

This paper aims to conduct a comprehensive review on CES related studies specifically published between 2015 until 2025 and seeks to answer the following research questions: 1) What are the prevailing research trends in CES assessments studies between 2015 and 2025, 2) What are the key thematic of CES assessment studies conducted from 2015 until 2025) and 3) What are the emerging future direction of research in CES that can inform policy development and enhance society well-being?

2.0 LITERATURE REVIEW

2.1 Empirical Studies on Cultural Ecosystem Services

Ecosystem services refer to benefits derived from the interactions between human and natural ecosystems, whether direct or indirect, including provisioning, regulating, supporting, and cultural (MEA, 2000). These services have been central to the development of environmental psychology research, which is expanding knowledge in sustainability science (Chan et al., 2012; Constanza et al., 2017). While provisioning and regulation have received growing attention due to their tangible outcomes, CES capture the intangible benefits such as recreation, cultural heritage, and inspirational and spiritual enrichment. Therefore, by assessing CES values, it offers insights into how people perceive and use value, and how environmental settings influence people's quality of life. Empirical studies on CES have employed various methodological approaches, cultural values and themes to capture the diverse perspectives on the value of CES. For example, Zhang et al. (2021) investigated how the experience of animal-based cultural services is produced through interactions between ecosystem services at cultural heritage sites, thereby enhancing human well-being.

On the other hand, Kokkoris et al. (2020) highlighted the need for localised assessments that capture the diversity of specific ecosystem services to support effective conservation strategies in CES management. Schneider et al. (2024) highlighted the need to prioritise aesthetic and recreational values to improve local tourism, thereby significantly enhancing natural resource management. Additionally, there is growing interest in integrating social preferences into decision-making, underscoring the need for a collaborative approach to CES management strategies (Martin—Lopez et al., Gould et al., 2020). However, despite its global relevance, CES research often focused on developed nations such as Europe, North America, and East Asia, with these regions leading in publication output.

2.2 Previous Studies on Bibliometric Analysis in Cultural Ecosystem Services

Bibliometric analysis offers a systematic tool for examining the intellectual structure, theme evolution, and geographical distribution of research. Through the systematic quantification of publication outputs, citation networks, co-authorship patterns and author keywords, bibliometric analysis illustrates the direction of academic research in the field and identifies its future direction. Global bibliometric analysis of ES began to be driven by the development of the ES framework by MEA (2005) and by efforts to integrate ES research into policy-making strategies. Although early research regarded CES within broader service classification, specialised methodological and conceptual issues of CES have led to the growing literature in the field.

Zhang et al. (2022) conducted a comprehensive review of CES literature from 2005 to 2021, using VOSviewer and CiteSpace, and found that interest in urban green spaces, social media analytics, and participatory mapping is growing in CES research. Liu et al. (2025) investigated the role of CES in human well-being by incorporating bibliometric analysis with content mapping to identify CES values in human health. Similarly, a global review by Chen et al. (2025) assessed CES research in wetland ecosystems by applying systematic review protocols to analyse trends across over 800 studies. These works provide valuable quantitative evidence on integrating cultural values into planning and conservation efforts for environmental settings.

3.0 METHODOLOGY

3.1 Search Strategy

The search strategy for identifying literature on cultural ecosystem service assessment studies is illustrated in Figure 1, a flow diagram that explains the methodological framework of the study and demonstrates the systematic procedures used to retrieve the most relevant literature for article analysis to achieve the objectives formulated in this paper. Scopus was selected as the primary database for this analysis due to its extensive coverage across multidisciplinary fields and its high-quality, reliable data, which make it a robust tool for analysing and visualising research outputs.

To enhance search accuracy and ensure results are relevant, the search field was limited to article titles, thereby capturing only evidence-based studies of cultural ecosystem services. The search was conducted over 10 years, from 2015 to 2025, to reflect the evolution of the relevant literature over that period. Additionally, only the English language was used in the filter search to make it suitable for later data analysis. To ensure academic content only, the search was further refined to include journal articles that advance both theoretical and practical knowledge.

A detailed search string was developed using the keywords "cultural ecosystem service*", "urban green space*" and "assessment*" to capture exact matches. Boolean operators were applied to exclude irrelevant document types and optimise exclusivity. The data extraction was conducted on 5 June 2025, and a total of 495 articles were identified and screened for inclusion, providing a robust foundation for the later bibliometric evaluation. Manual searching was conducted using predefined criteria to ensure the eligibility of the preliminary data analysis. The inclusion criteria were as follows: 1) Should focus on cultural ecosystem services only, 2) CES assessment studies should be conducted in green space settings only, and 3) employ any assessment methods or techniques. As a result, 173 articles were selected and downloaded for a preliminary data analysis using the BiblioMagika worksheet.

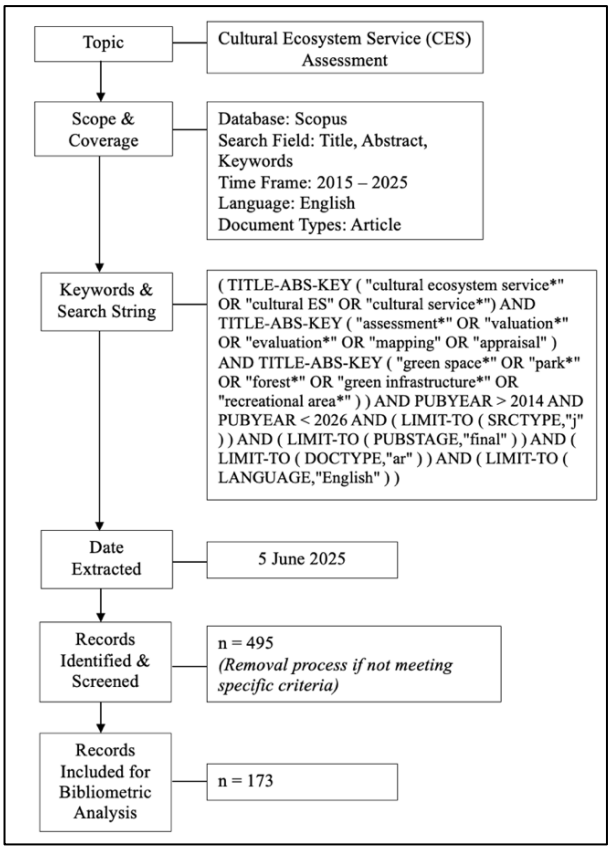

Fig. 1: Flow diagram of the search strategy

3.2 Data Cleaning, Harmonisation and Tools

To ensure the accuracy and reliability of the data, thorough data cleaning and harmonisation were conducted using the advanced functionalities of biblioMagika and OpenRefine. This step is critical to ensuring data validity, and only relevant articles were included in the network analysis using VOSviewer. BiblioMagika was developed by Ahmi (2024) exclusively for data harmonisation, providing greater transparency by systematically cleansing and organising data extracted from the Scopus database. The initial phase began by downloading the Scopus data in CSV format and conducting a thorough review of key columns, including author names, affiliations, author keywords, and country. Advanced clustering techniques were employed to detect inconsistencies, and corrections were made to standardise the output, thereby retaining the integrity of the data after segmentation. Once cleaned, the dataset was reverted to its original format structure for further analysis.

For the next analysis phase, BiblioMagika was utilised to enhance the bibliometric analysis by standardising metadata on authorship, affiliations, and countries. OpenRefine was used to support the effort to refine keyword data by splitting multi-cell data, and a variety of clustering techniques helped expedite the process. Network visualisation was generated using VOSviewer to generate a conceptual network map. This integrated multi-tool approach enabled a comprehensive, structured analysis of research trends, particularly in the field of cultural ecosystem services.

4.0 DATA ANALYSIS AND DISCUSSION

4.1 Document Profile

Table 1 provides an overview of the final documents retrieved from the Scopus database and used in the preliminary data analysis. In the period from 2015 to 2025, a total of 173 publications by 750 contributing authors were identified, focusing exclusively on cultural ecosystem service assessment studies in green space settings. A total of 5,574 citations were received over the period, corresponding to an overall h-index of 46, reflecting the research's publication impact and citation performance within the field.

Table 1: Main information and subject area
(Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

Main Information	Data
Publication Years	2015 - 2025
Total Publications	173
Citable Year	11
Number of Contributing Authors	750
Number of Cited Papers	154
Total Citations	5,574
Citation per Paper	32.22
Citation per Cited Paper	36.19
Citation per Year	557.40
Citation per Author	7.43
Author per Paper	4.34
Citation sum within h-Core	5,303
h-index	46
g-index	69
m-index	4.182

Subject Area	TP	%
Environmental Science	147	84.97%
Agricultural and Biological Sciences	85	49.13%
Social Sciences	71	41.04%
Decision Sciences	16	9.25%
Energy	15	8.67%
Computer Science	10	5.78%
Earth and Planetary Sciences	9	5.20%
Business, Management and Accounting	7	4.05%
Economics, Econometrics and Finance	7	4.05%
Engineering	6	3.47%
Chemical Engineering	2	1.16%
Medicine	2	1.16%
Arts and Humanities	1	0.58%
Biochemistry, Genetics and Molecular Biology	1	0.58%
Health Professions	1	0.58%
Materials Science	1	0.58%
Mathematics	1	0.58%
Multidisciplinary	1	0.58%
Pharmacology, Toxicology and Pharmaceutics	1	0.58%
Physics and Astronomy	1	0.58%

Additionally, by recognising which subject area acknowledges cultural ecosystem service assessment studies, we can determine a current trend within the field, as shown in Table 1—the distribution of publications that show the multidisciplinary interests spanning social, technological, and economic domains. There are three dominant subject areas, with almost 85% of publications falling under Environmental Science, reflecting its strong focus on ecosystems, biodiversity, landscape management, and environmental planning as key elements of CES studies. Other than that, Agricultural and Biological with 49.1% and Social Sciences at 41.04% show significant focus on land-use planning and human-based studies.

4.2 Publication Trends

Table 2 provides information on temporal patterns in cultural ecosystem service assessment studies, reflecting a steady, accelerating growth trajectory in both the number of publications and citations over the decade.

Between 2015 and 2025, academic research increased significantly, with cumulative publications rising from less than 10 in 2015 to over 170 by 2025. The Total Citations (TC) data reveal a substantial rise in 2020, in which 611 citations were recorded as the highest citation count thus far, surpassing the preceding years (2017 – 2019), demonstrating growing scholarly influence and recognition of CES during the time.

Figure 2 illustrates the polynomial trend line (R2 = 0.9948), which shows a clear, strong increase in academic performance for CES studies during this period. Average citations per publication (C/P) indicate that earlier publications received higher average citation rates, suggesting their impact as early foundation studies in CES research.

Table 2: Annual research output and citation metrics
(Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

Year	TP	NCA	NCP	TC	C/P	C/CP	*h*	*g*	*m*
2015	8	45	8	696	87.00	87.00	8	8	0.727
2016	10	44	10	533	53.30	53.30	8	10	0.800
2017	14	59	14	1186	84.71	84.71	14	14	1.556
2018	11	58	11	815	74.09	74.09	11	11	1.375
2019	13	58	13	611	47.00	47.00	12	13	1.714
2020	12	51	12	468	39.00	39.00	9	12	1.500
2021	20	73	19	472	23.60	24.84	12	20	2.400
2022	28	115	28	482	17.21	17.21	13	21	3.250
2023	23	93	21	243	10.57	11.57	11	14	3.667
2024	19	93	15	60	3.16	4.00	5	6	2.500
2025	15	61	3	8	0.53	2.67	2	2	2.000
Total	173	750	154	5574	32.22	36.19	46	69	4.182

Notes: TP = total number of publications; NCA = Number of contributing authors; NCP = number of cited publications; TC = total citations; C/P = average citations per publications; C/CP = average citations per cited publication; h = h-index; g = g-index; m = m-index

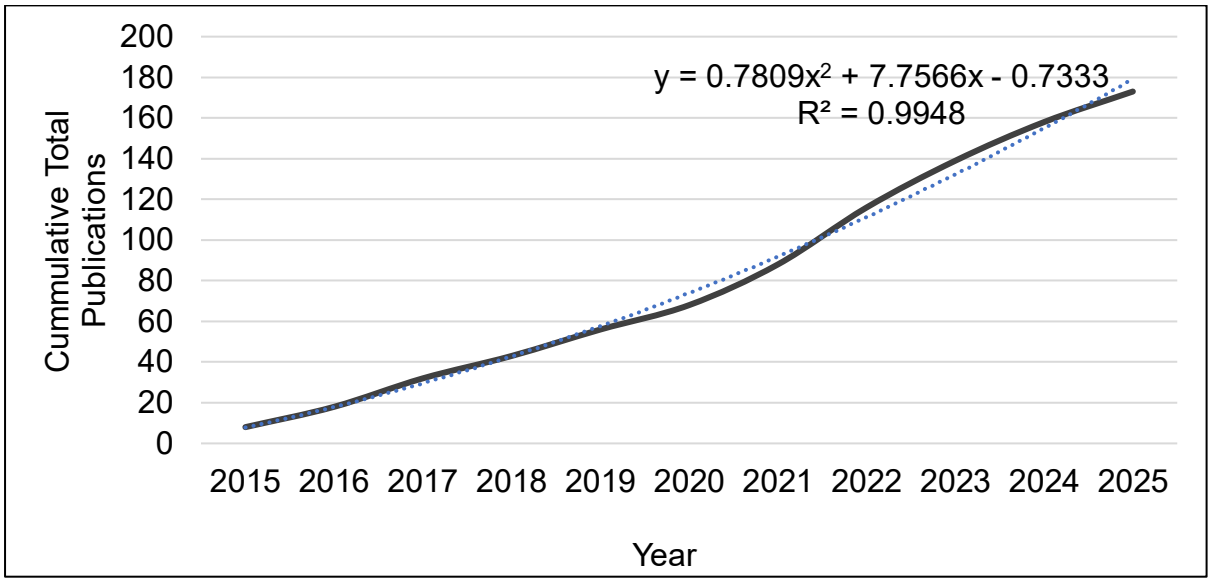

Fig. 2: Cumulative growth of publications
(Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

A significant peak in annual publication volume was observed in 2022, with 28 publications, followed by consistently high numbers in 2023 (23 publications) and 2024 (19 publications). This upward trend shows growing momentum in CES research, potentially driven by efforts to integrate the CES concept into sustainable development planning, sustainability frameworks, and ecosystem management initiatives. Meanwhile, Figure 3 illustrates the citation trend, with the highest total citations recorded in 2017 (1,186), reflecting the influential impact of earlier foundation studies, followed by 2018 (815) and 2019 (611). However, total citation counts are decreasing significantly, with only 60 citations in 2024 and 8 in 2025, suggesting a citation lag.

Fig. 3: Total publications and total citations by year
(Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

Bibliometric indices such as the h-index, g-index, and m-index systematically provide important insights into the quality, impact, and citation dynamics of CES research during this period. The h-index measures productivity and citation impact and shows a progressive increase, reaching a high of 15 in 2021. This method reflects the cumulative influence and consistency of CES publications. The g-index indicates highly cited publications, and the value recorded shows that the top-cited articles collectively received at least 729 citations, which drives most scholarly attention in CES research. The m-index measures the citation rate relative to an academic's age by dividing the h-index by the number of years since the first publication. A moderate yet upward trend in the m-index suggests consistent citation growth over time in CES research.

4.3 Publication by Authors

Table 3 presents a systematic bibliometric analysis of the highest contributors in the field, focusing on cultural ecosystem services research, by calculating the total publication volume and the impact of individual researchers using citation-based metrics.

Table 3: Most productive author
(Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

Full Name	Current Affiliation	Country	TP	NCP	TC	C/P	C/CP	*h*	*g*	*m*
Pereira, Paulo	Mykolas Romeris University	Lithuania	5	5	251	50.20	50.20	5	5	0.556
Semmens, Darius J.	United States Geological I	United States	4	4	254	63.50	63.50	4	4	0.444
Sherrouse, Benson C.	United States Geological I	United States	4	4	254	63.50	63.50	4	4	0.444
Ancona, Zachary H.	United States Geological I	United States	4	4	254	63.50	63.50	4	4	0.444
Inácio, Miguel	Mykolas Romeris University	Lithuania	3	3	109	36.33	36.33	3	3	0.600
Grilli, Gianluca	University of Florence	Italy	3	3	66	22.00	22.00	3	3	0.273
Sacchelli, Sandro	University of Florence	Italy	3	3	69	23.00	23.00	3	3	0.429
Haase, Dagmar	Humboldt-Universität zu Be	Germany	3	2	193	64.33	96.50	2	3	0.222
Kalinauskas, Marius	Mykolas Romeris University	Lithuania	3	3	109	36.33	36.33	3	3	0.600
Gomes, Eduardo	Mykolas Romeris University	Lithuania	3	3	109	36.33	36.33	3	3	0.600
Vuletić, Dijana	Croatian Forest Research	Croatia	2	1	13	6.50	13.00	1	2	0.250
Ciesielski, Mariusz	Forest Research Institute	Poland	2	1	1	0.50	1.00	1	1	0.333
Yu, Tao	Affiliation NA	China	2	2	15	7.50	7.50	2	2	0.667
Tian, Tian	East China Normal Univers	China	2	2	21	10.50	10.50	2	2	0.667
Kičić, Martina	Croatian Forest Research	Croatia	2	1	13	6.50	13.00	1	2	0.250
Deng, Lingzhi	Affiliation NA	China	2	2	21	10.50	10.50	2	2	0.667
Krajter Ostoić, Silvija	Humboldt-Universität zu Be	Germany	2	1	13	6.50	13.00	1	2	0.250
Che, Yue	University of California	United States	2	2	21	10.50	10.50	2	2	0.667
Kovács, Barbara	National Polytechnic Instit	Mexico	2	2	17	8.50	8.50	2	2	0.400
Wang, Peng	Research Institute of Fore	China	2	2	14	7.00	7.00	1	2	0.250
Li, Nan	Economic Research Institu	China	2	2	14	7.00	7.00	1	2	0.250
Correia, Ricardo A.	University of Oxford	United Kingdom	2	2	117	58.50	58.50	2	2	0.250
Barbierato, Elena	University of Florence	Italy	2	2	37	18.50	18.50	2	2	0.333
Baral, Himlal	Center for International Fo	Indonesia	2	2	108	54.00	54.00	2	2	0.250
Dai, Peichao	China University of Mining	China	2	2	71	35.50	35.50	2	2	0.286

Notes: TP = total number of publications; NCA = Number of contributing authors; NCP = number of cited publications; TC = total citations; C/P = average citations per publications; C/CP = average citations per cited publication; h = h-index; g = g-index; m = m-index

Data such as Total Publications (TP), Total Citations (TC), and Citations per Cited Publication (C/CP) were highlighted to assess scholarly influence and its impact within the academic community. Table 4 indicates that Paulo Pereira from Mykolas Romeris University (Lithuania) is the most productive author, having contributed five publications to CES research, with the highest h-index (5) and m-index (0.556) among all contributors. Besides that, a notable group from the United States Geological Survey (Semmens, Sherrouse, and Ancona) followed with four publications each, demonstrating their prominent role in advancing CES methodologies and valuation frameworks.

Table 4 presents the citation influence of each author, thus indicating that a few authors report exceptionally high C/P and C/CP values ranging from 112 to 196 despite a small number of publications. The highest total citation counts are tied among Semmens, Sherrouse, Ancona, and Pereira, each with 254–251 citations, reflecting highly cited and impactful work. Daniel R. Richards, Bige Tuncer, and Rudolf de Groot recorded exceptionally high C/P and C/CP values of 112-196, demonstrating research impact through widespread citation despite fewer publications. The analysis reveals a diverse but geographically concentrated field, with authors from Europe and North America dominating both publication output and citation performance.

Table 4: Most influential authors by total citation
(Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

Full Name	Current Affiliation	Country	TP	NCP	TC	C/P	C/CP	*h*	*g*	*m*
Ancona, Zachary H.	United States Geological I	United States	4	4	254	63.50	63.50	4	4	0.444
Sherrouse, Benson C.	United States Geological I	United States	4	4	254	63.50	63.50	4	4	0.444
Semmens, Darius J.	United States Geological I	United States	4	4	254	63.50	63.50	4	4	0.444
Pereira, Paulo	Mykolas Romeris University	Lithuania	5	5	251	50.20	50.20	5	5	0.556
De Groot, Rudolf	Wageningen University an	Netherlands	2	2	224	112.00	112.00	2	2	0.222
Tappeiner, Ulrike	University of Innsbruck	Italy	2	2	198	99.00	99.00	2	2	0.200
Tunçer, Bige	Singapore University of Te	Singapore	1	1	196	196.00	196.00	1	1	0.125
Richards, Daniel R.	Singapore University of Te	Singapore	1	1	196	196.00	196.00	1	1	0.125
Dou, Yuehan	Wageningen University an	Netherlands	2	2	193	96.50	96.50	2	2	0.222
Zhen, Lin	University of Chinese Acac	China	2	2	193	96.50	96.50	2	2	0.222
Haase, Dagmar	Humboldt-Universität zu Be	Germany	3	2	193	64.33	96.50	2	3	0.222
Yu, Xiubo	University of Chinese Acac	China	2	2	193	96.50	96.50	2	2	0.222
Hiura, Tsutom	Hokkaido University	Japan	1	1	182	182.00	182.00	1	1	0.111
Yoshimura, Nobuhiko	Hokkaido University	Japan	1	1	182	182.00	182.00	1	1	0.111
Bieling, Claudia	University of Hohenheim	Germany	1	1	180	180.00	180.00	1	1	0.111
Rall, Emily	Technische Universität Mü	Germany	1	1	180	180.00	180.00	1	1	0.111
Zytynska, Sharon	Technische Universität Mü	Germany	1	1	180	180.00	180.00	1	1	0.111
Calvet-Mir, Laura	Universitat Autònoma de B	Spain	2	2	172	86.00	86.00	2	2	0.200
Whelan, Christopher J.	University of Illinois	United States	1	1	166	166.00	166.00	1	1	0.091
Westphal, Lynne M.	Northern Research Station	United States	1	1	166	166.00	166.00	1	1	0.091
Belaire, J. Amy	University of Illinois at Chic	United States	1	1	166	166.00	166.00	1	1	0.091
Minor, Emily S.	University of Illinois at Chic	United States	1	1	166	166.00	166.00	1	1	0.091
Baró, Francesc	Universitat Autònoma de B	Spain	2	2	155	77.50	77.50	2	2	0.182
Langemeyer, Johannes	Universitat Autònoma de B	Spain	2	2	155	77.50	77.50	2	2	0.182
Gómez-Baggethun, Erik	Universitat Autònoma de B	Spain	1	1	136	136.00	136.00	1	1	0.091

Notes: TP = total number of publications; NCA = Number of contributing authors; NCP = number of cited publications; TC = total citations; C/P = average citations per publications; C/CP = average citations per cited publication; h = h-index; g = g-index; m = m-index

Figure 4 illustrates an overlay network co-authorship network visualisation generated by VOSviewer, mapping the collaboration of authors in publishing research in the context of CES research. This network visualisation uses a temporal colour scale (from dark blue = older collaborations to yellow = recent collaborations) to show how collaboration patterns have evolved. Based on the network visualisation, it is notable that Paulo Pereira is the most dominant node, aligning with the record as the most productive author, and he is directly linked to multiple co-authors, including Miguel Inacio, Katazyna Bogdsevic, Marius Kalinauskas, and Wenwu Zhao, forming a highly active and growing collaborative network. Figure 4 shows the recent evolution of the co-authorship network in CES research, from Rudolf de Groot, who played a foundational role in earlier years, highlighting the transition in leadership and collaboration over time.

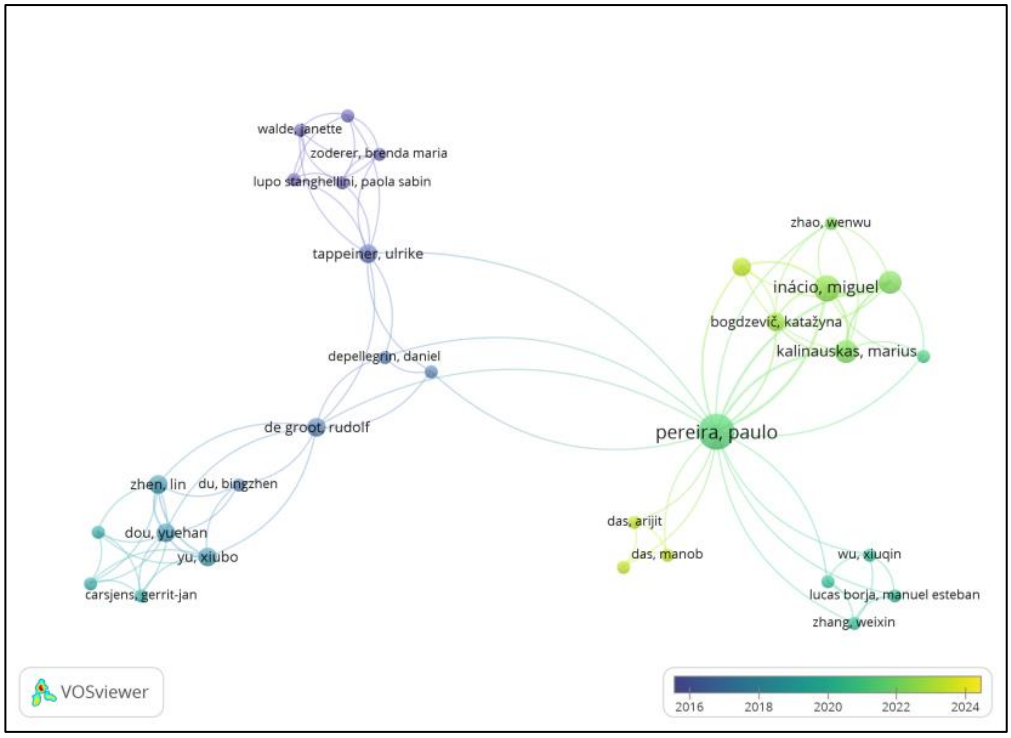

Fig. 4: Overlay visualisation of the co-authorship network based on the number of documents

4.4 Publication by Countries

The data in Figure 5 reveals that China is the top contributor in the field with 43 publications, 861 total citations and the highest h-index of 15, reflecting its recent growing prominence in CES-related publications, followed by Germany with 21 publications and the highest total citation count (TC = 936), showing its strong citation impact in Europe. Spain, the United States and the United Kingdom represent Western countries that show substantial publications with 16, 15 and 12 publications respectively, making strong contributions and consistent citation metrics. However, Southeast Asia remains relatively underrepresented, with India, which recorded five publications, showing low citation performance (C/P = 14.20). Despite being home to rich biodiversity and diverse cultural ecosystems, Bangladesh, Indonesia, and Malaysia each contributed only three publications to the CES field, underscoring significant underrepresentation in global research. Based on this analysis, there is a lack of representation of CES research across much of Africa, the Middle East, and Central Asia, which might reduce opportunities for integrating nature-culture interdependencies.

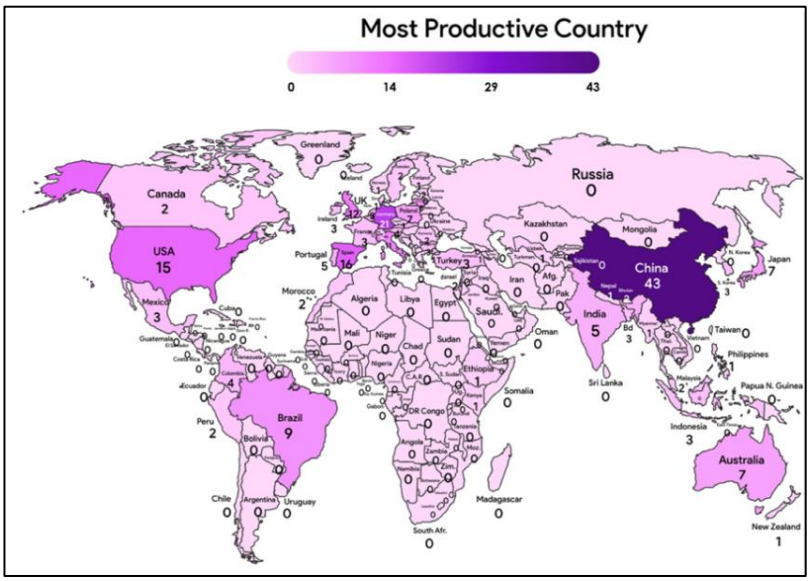

Fig. 5: Distribution of country production in CES assessment studies

4.5 Publication by Source Titles

Figure 6 illustrates the scholarly journals that serve as the most active venues for CES assessment studies and lists the top 20 journals by publication frequency, highlighting their role as platforms for disseminating knowledge about CES research across multidisciplinary studies. The top journal is Ecosystem Services, with 25 publications, underscoring its role as the primary platform for CES research and its alignment with the field's core themes, such as ecosystem services valuation. This method is further followed by Ecological Indicators (16 publications), which highlight sub-topics such as spatial mapping, sustainability indicators and quantitative tools. Other than that, urban-focused areas such as Urban Forestry, Urban Greening, and Urban Ecosystems demonstrate the relevance of CES research to urban resilience, urban green space planning, and urban management. This publication data shows the interdisciplinary nature of CES research, which intersects with a broad range of disciplines and application areas.

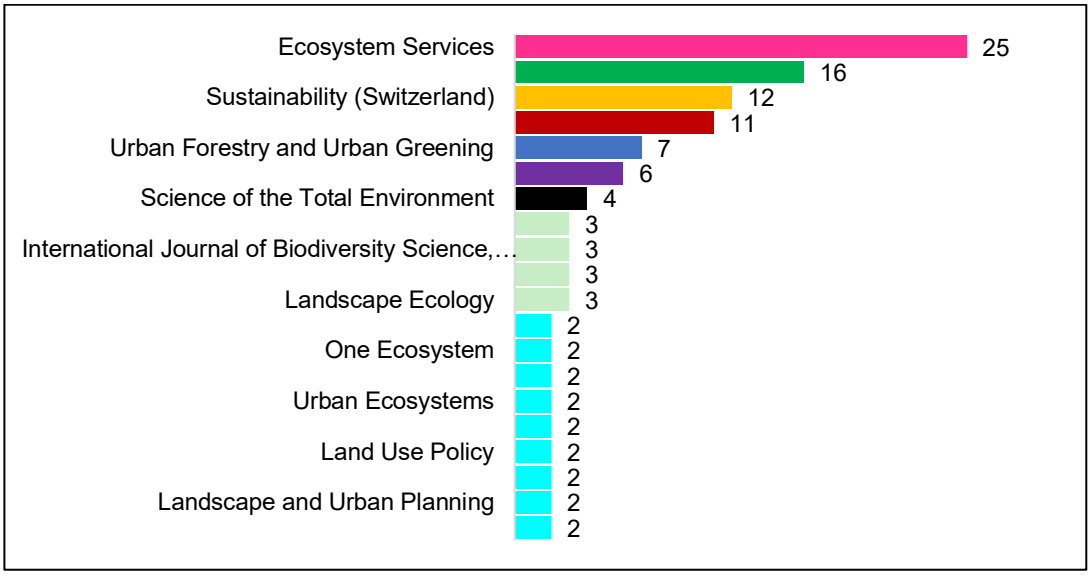

Fig. 6: Top 20 most productive source titles
(Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

4.6 Author Keywords

Figure 7 presents the frequency analysis of author keywords associated with the CES assessment studies as the dominant keywords that represent the core theme of the analysis. Keywords such as "ecosystem services", "social value" and "social media" are among the related keywords indicating the growing integration of public participation methods into studies of urban cultural ecosystem services.

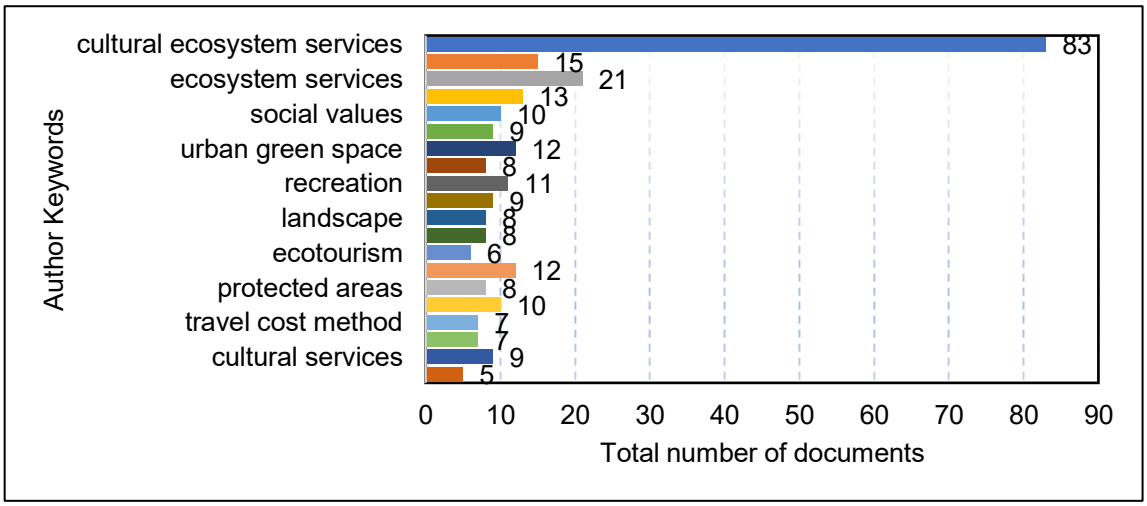

Fig. 7: Frequency of author keywords by total link strength
(Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

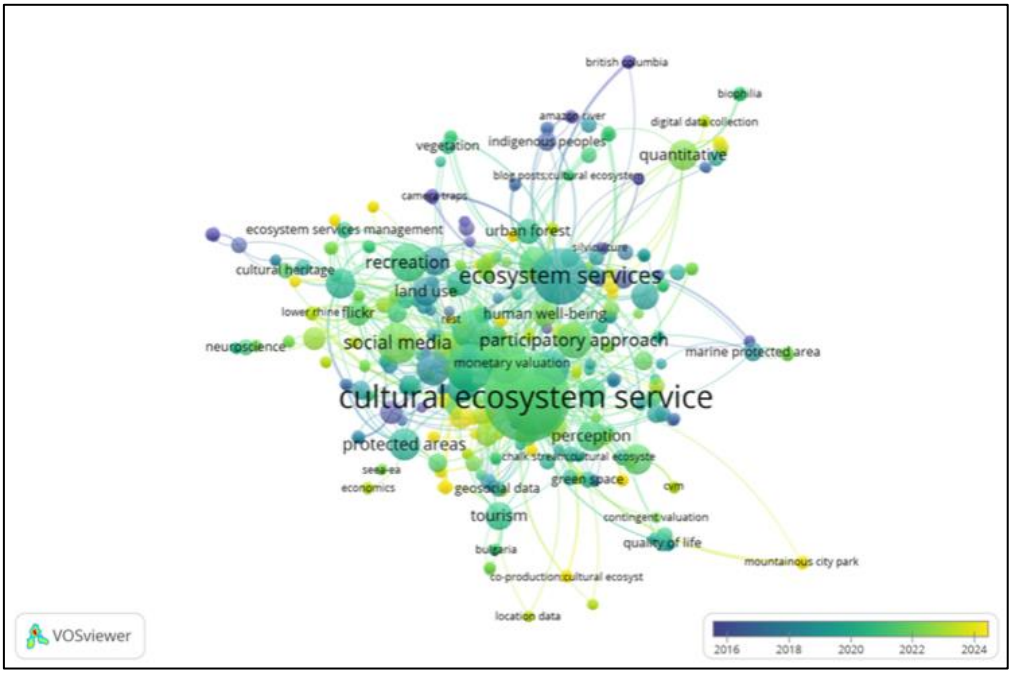

Fig. 8: Overlay network visualisation on author keywords

According to the temporal and citation impact analysis illustrated in Figure 8, these keywords began receiving attention from researchers in 2020. Figure 9 illustrates the overlay network visualisation generated in VOSviewer, where node colours represent the average publication year. The central cluster emerging from terms such as "cultural ecosystem service", "ecosystem services", "participatory approach", "recreation" and "protected area" that are frequently co-occurring, highly cited, and widely incorporated across multidisciplinary studies.

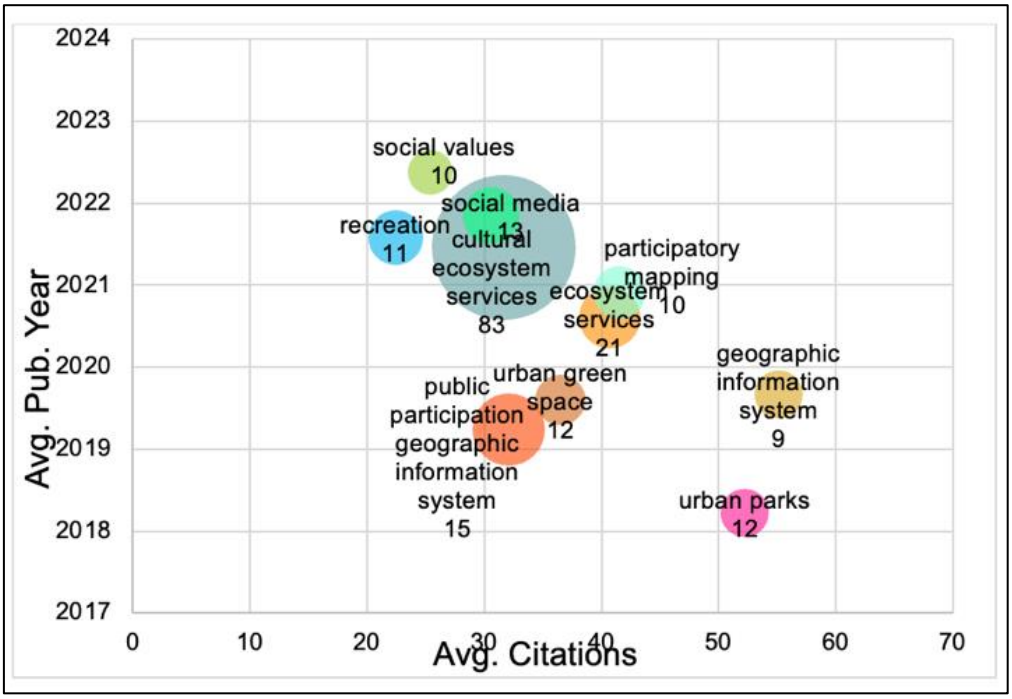

Fig. 9: Temporal and citation impacts of author keywords

5.0 CONCLUSION

The bibliometric analysis of CES research from 2015 to 2025 shows substantial growth in the field, though studies from developed countries and Southeast Asian countries remain underrepresented despite their rich cultural diversity. Current research themes focusing on urban green space, participatory mapping and social value highlight the role of CES research in urban planning strategies. Moving forward, CES research should prioritise the standardisation of methodological approaches to enable cross-study comparison, increase empirical research, and capture diverse perspectives, thereby fostering interdisciplinary collaboration among stakeholder groups that should inform decision-makers, local authorities, and communities in the formulation of sustainable urban planning strategies.

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BIBLIOMETRIC ANALYSIS AND CRITICAL REVIEW OF THE ARTIFICIAL INTELLIGENCE ADOPTION FACTORS IN CONSULTING QUANTITY SURVEYING FIRMS

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ABSTRACT

AI adoption will help Malaysian construction organisations, including Consulting Quantity Surveying (CQS) firms, cope with challenges and increase productivity. However, AI adoption by CQS firms faces adoption issues in Malaysia. Existing AI adoption studies discuss barriers in developed countries. Applying these studies' results in developing countries such as Malaysia is inappropriate, as construction industry practices and properties differ. Also, there is limited attention to factors affecting AI adoption. Existing studies on AI adoption in Malaysia are limited, and the stages of AI adoption have not been rigorously studied. The first objective of the study is to explore and categorise the factors of AI adoption and provide in-depth insights into the different AI adoption stages. The second objective is to identify 62 factors that affect the four stages of AI adoption and group them into four clusters. This study applied Systematic Literature Review (SLR) to identify and classify factor clusters based on the Diffusion of Innovation Theory and Technology Organisation Environment (TOE). The identified cluster of factors can be useful to decision-makers for conducting analyses of AI adoption stages and for formulating adoption strategies, by providing facts and observations within organisations. The review observes that factors affecting AI adoption stages vary across regions, due to governmental pressure, cultural differences, practices, and demographics.

Keywords: Artificial Intelligence (AI), Systematic Literature Review (SLR), Bibliometric Analysis, Factors, AI Adoption Factors, Consulting Quantity Surveying Firms

1.0 INTRODUCTION

The construction industry is grappling with systemic challenges spanning human resources, governance, economic pressures, and technological deficiencies, resulting in significantly hampered growth and low productivity compared to sectors like manufacturing (Aghimien et al., 2021; Oke et al., 2023). Consulting Quantity Surveying (CQS) firms, which operate at the core of project financial control and cost management, are directly impacted by this inefficiency. Construction remains one of the world's least digitalised industries, characterised by a pervasive cultural resistance to change (Blanco et al., 2023). This reliance on manual, non-digital processes complicate project management. It directly leads to inefficiencies in cost control, project delays, diminished quality, and uninformed decision-making—all core functions of CQS practices (Zulu et al., 2023). Given mounting pressures from labour shortages, the impacts of the COVID-19 pandemic, and the demand for sustainable infrastructure (Stride et al., 2023), expediting digital transformation is now a necessity for CQS firms to maintain relevance and competitive advantage.

Artificial Intelligence (AI) has emerged as a leading digital solution that drives advancements in business operations and industry productivity across various sectors (Jan et al., 2023). The adoption of AI techniques,

including machine learning, optimisation, and natural language processing, facilitates crucial automation and yields significant competitive advantages over traditional methods (Singh et al., 2023). These tools offer powerful capabilities for data-driven decision-making essential for managing complex financial scenarios. For instance, the manufacturing sector's embrace of Industry 4.0, powered by AI, has yielded substantial improvements in process efficiency, cost reduction, and sustainability (Plathottam et al., 2023). Despite facing acute project management and cost control challenges, the CQS sector has yet to fully capitalise on these substantial AI-driven benefits (RICS, 2024).

Decades of research have demonstrated the potential of AI applications in addressing construction-specific challenges, many of which directly concern the work of CQS firms. Machine learning, for example, shows promise in improving cost estimation, risk prediction, and supply chain optimisation, while knowledge-based systems could aid in tender evaluation and risk assessment (Adeloye et al., 2023). Despite these demonstrated advancements, the construction industry remains highly undigitalised (Albaz et al., 2018). Studies consistently identify numerous adoption barriers directly relevant to CQS firms: cultural resistance, high initial investment costs, concerns around data trust and security, and talent shortages (Prabhakar et al., 2023).

Consequently, the objective of this Systematic Literature Review (SLR) is to provide a bibliometric analysis and a detailed explanation of AI adoption research in CQS firms and empirically examine the factors affecting AI adoption. The contributions of this SLR are defined as follows:

- To provide a bibliometric analysis of AI adoption literature.
- To explore the major factors affecting AI adoption.
- To provide an in-depth description of the different stages of AI adoption

This SLR is organised as follows: Section 2 discusses related work and existing studies on AI adoption to provide a current state of AI in the literature. The systematic literature review protocols and methodologies are described in Section 3. Section 4 provides bibliometric analysis results. Section 5 explains the factors identified in this study. Section 6 discusses the themes in the literature and classifies them by AI adoption stage. The foundational frameworks and key contributions are presented in Section 7. Finally, Section 8 discusses the implications and future direction.

2.0 RELATED WORKS

This section discusses reviews and analyses of the existing literature on AI adoption. Several studies investigated AI adoption between 2019 and 2024, including literature reviews. Current AI adoption studies addressed the adoption barriers and drivers in the construction industry (Abioye et al., 2021; Tjebane et al., 2022; Oluleye et al., 2023; Singh et al., 2023 Zabala et al., 2023; Felemban et al., 2024; Ghimire et al., 2024; Liang, 2024; Shamsiri et al., 2024; Ugural et al., 2024). A study by Na et al. (2023) analyses factors influencing workers in construction-related companies in South Korea and the United Kingdom regarding their intention to use AI-based technologies. However, this study is culturally specific and applies only to the contexts of British and Korean construction workers. Another survey by Delgado et al. (2019) identified the challenges of robotics and automation systems in Europe. However, perceptions of small and medium design organisations are not covered. A few studies discuss AI readiness and acceptance in organisations and identify AI adoption inhibitors that hinder broader-scale adoption (Wang et al., 2021; Ghimire et al., 2024). Similarly, most studies discussed AI adoption at the individual level, such as AI adoption by architects and engineers in their individual capacity, rather than at the organisational level (Cisterna et al., 2022; Wafta et al., 2022; Shang et al., 2023). However, organisational-level AI adoption studies in CQS firms are limited. FakhrHosseini et al. (2024) investigate the existing adoption theories and propose a model to identify factors affecting recent technological advancement. A study on forefront technologies such as the Internet of Things (IoT) and smart connected objects is conducted by Attié & Meyer-Waarden (2019), which discusses that there are many stages of technology adoption, for example, awareness, interest, evaluation, and trial. These terms are confused in the literature and need clarification and definition.

In contrast to existing reviews that focused on adoption factors and barriers, which were found to be disjointed across studies, this review provides a bibliometric analysis and a more comprehensive overview of AI adoption studies in CQS firms. Furthermore, it explores and categorises the major factors affecting AI adoption at each stage of the adoption process. The other contribution of this review is the categorisation of research by technology adoption stages, such as awareness, interest, evaluation, trial, and confirmation. This SLR is intended to form the basis for future research in the AI adoption domain.

3.0 METHODOLOGY

The research methodology consisted of guidelines to follow for systematically planning and analysing the studies. This study is guided by the research methodology for conducting SLR by Kraus et al. (2022). The research methodology is followed by defining the research questions and using an appropriate search string to extract studies from databases. Also, inclusion and exclusion criteria are defined for quality assurance in SLR. The complete picture of the review strategy is shown in Figure 1.

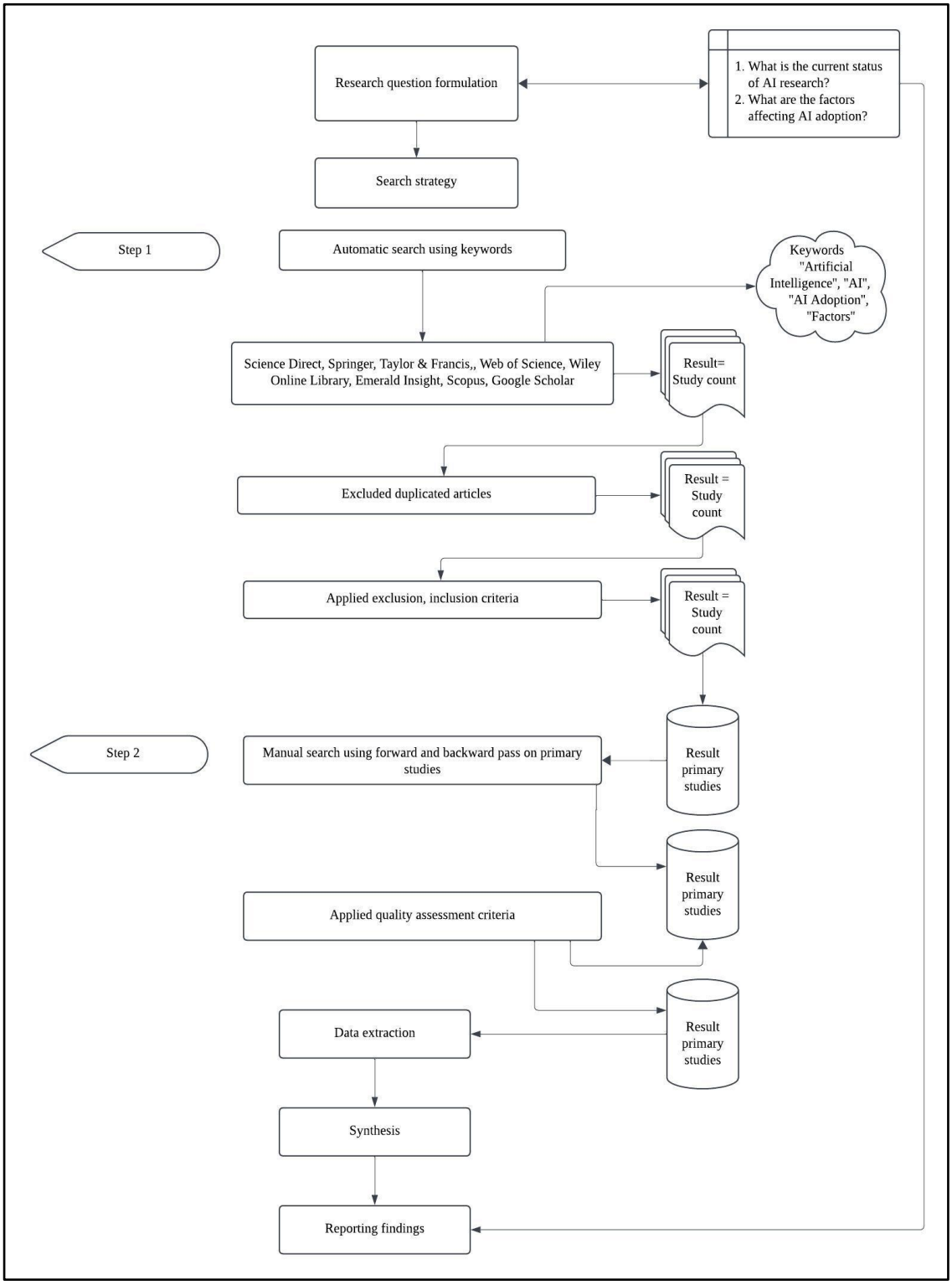

Figure 1: Review strategy of AI SLR

3.1 Data Sources

The review process began with formulating the research question, selecting databases, and analysing current studies. The methodology in this SLR also relies on the selection of study resources (such as ScienceDirect, Springer, Web of Science, Google Scholar, Emerald Insight, Taylor & Francis, Scopus, and Wiley Online Library). A list of research questions is addressed in Figure 1. It is followed by the selection of primary studies, application of inclusion criteria, and synthesis of results.

3.2 Search Strategy

This SLR covered the range of papers from 2019 to 2024. Several studies published before this period generally discuss the applications of AI in different sectors of the construction industry. Based on research questions, keywords are formulated for the search strategy. The terms 'Technology adoption', 'Artificial Intelligence', 'AI', 'AI Adoption, 'Factors', ' Challenges', 'Barriers', 'Quantity Surveying', 'TAM', 'TOE', 'UTAUT', 'DOI' are used as main keywords. The logical operators 'AND' and 'OR' are used to combine keywords. After several attempts, we use the following search string, most suitable for extracting studies: ('Artificial Intelligence' OR 'AI' AND 'Quantity Surveying' OR 'Construction Industry' OR 'Factors' OR 'Adoption Theories'). After that, a manual search is also performed as a forward pass and backward pass to include the most cited and relevant studies that were not covered in the automatic search. The extraction process is shown in Figure 2.

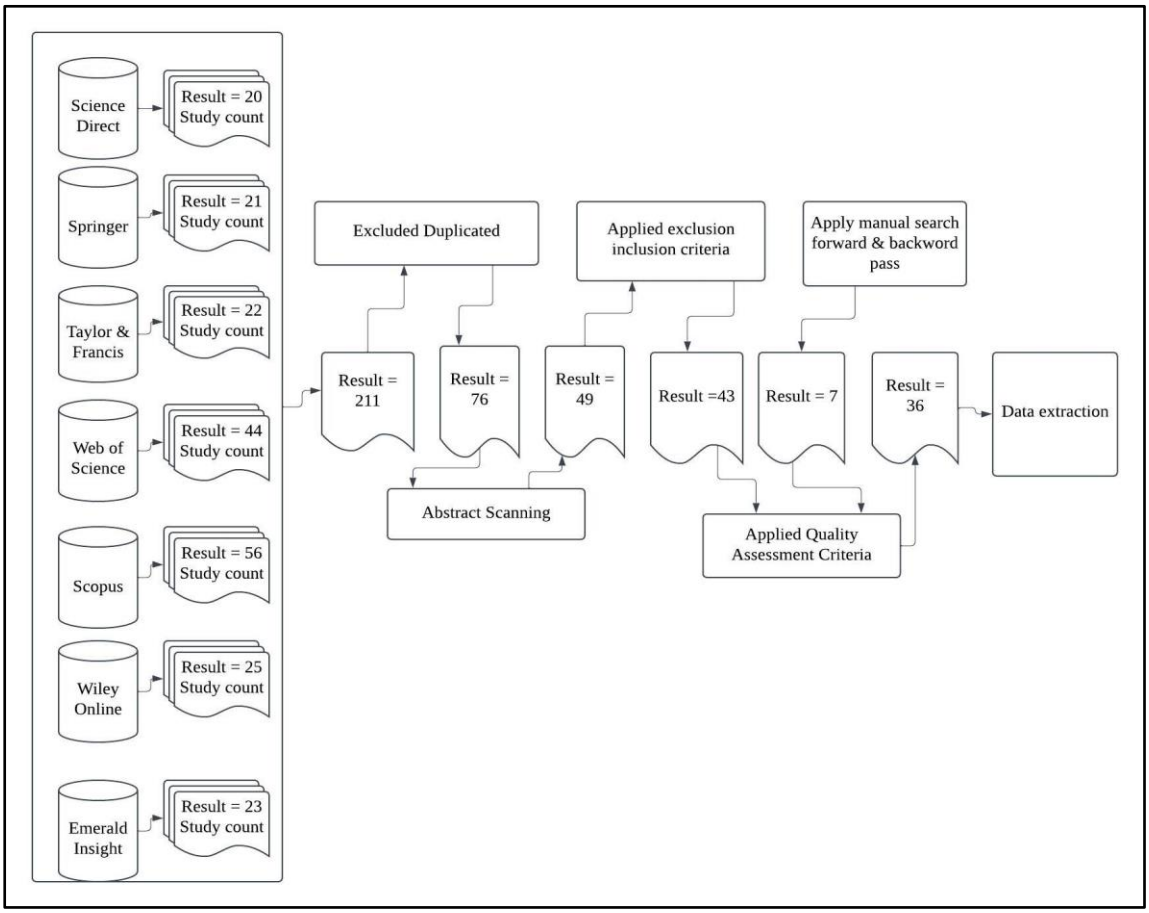

Figure 2: The review extraction process

3.3 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria specified the studies to be included in the SLR. This method ensures that relevant studies are included in an SLR and that irrelevant studies are omitted. This research study included only the studies from the AI domain within the construction industry. The research articles from reputable journals and conferences were selected for review. The duplicated studies are removed. Only studies published in English from 2019 to 2024 are included. The inclusion and exclusion criteria for this study are shown in Table 1.

Table 1: Inclusion and exclusion criteria for AI SLR

Inclusion	Exclusion
Studies that clearly defined adoption variables	Study not using any technology adoption construct
Technology Adoption Studies in Artificial Intelligence	Studies that only focus on applications of AI
Included only full-text studies	Not published in a peer-reviewed journal or conference
Studies published between 2019 and 2024	Not in English
Literature only in the above-selected databases	Literature out of the selected time frame
Written in English	Duplicate studies

3.4 Quality Assessment Criteria for AI SLR

Quality assessment is critical for ensuring the worthiness of selected studies (Kraus et al., 2022). Quality instruments were developed, consisting of factors to be checked and verified through questions for each study (Kraus et al., 2020). To check the quality, four quality assessment questions are developed: (1) Is the adoption addressed related to AI in the construction industry? (2) Is the research method clearly described in the article? (3) Is the data collection method mentioned in the studies? (4) Are the data analysis procedures described in the papers? The questions described are applied to 43 extracted studies to ensure the credibility of the article selected.

3.5 Data Extraction

At this stage, data were recorded in Excel sheets, and Zotero was used as a reference manager. It includes elements of study ID, Author, year, country, and publisher; data analysis methods; adoption theories; and study-level factors. The description of the items is shown in Table 2.

Table 2: Data extraction sheet

Elements	Descriptions
Author	Name of author
Year	Year of publication
Country	Country of research
Publisher	Journal/Conference Name
Study methods	The method applied, such as a survey or an interview
Adoption theories (if any)	Adoption theory/model applied
Study level	Individual or organisational level
Factors	Factors influencing adoption

4.0 CONTENT ANALYSIS

This section discusses the findings of the bibliometric analysis. Results include the study sources, publication outlets, and year-to-year distribution of studies. Also, the country-specific distribution of studies is provided.

4.1 Publication Source

As shown in Figure 3, the majority of the studies are from high-quality journals and reputable conferences, which increases the reliability of the included studies. Thirty-four journal articles (94%) and two conference papers (6%) were included in the review. The analysis shows that the number of journal publications is increasing relative to that of proceedings.

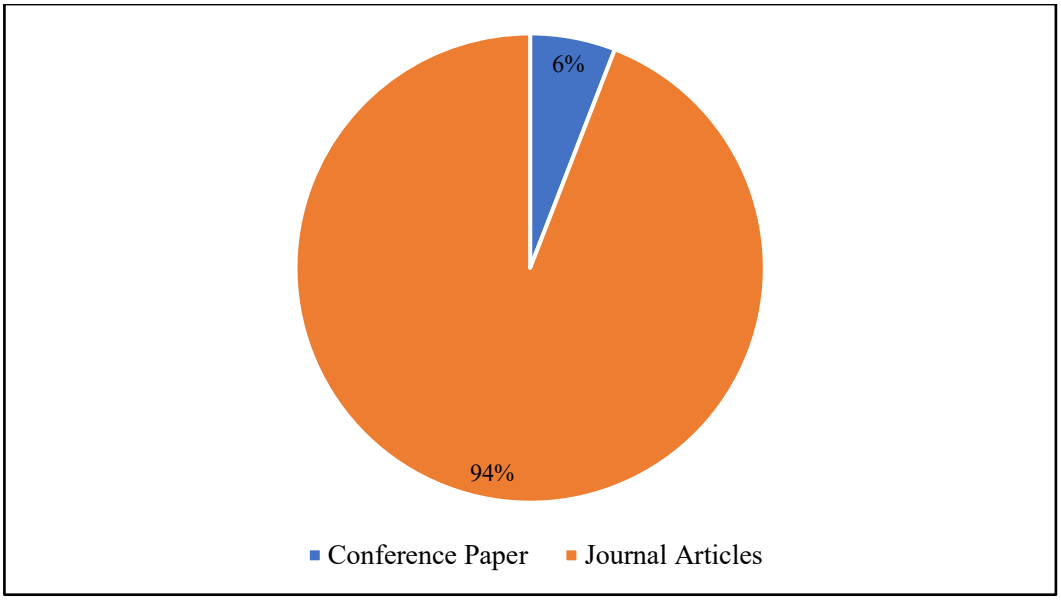

Figure 3: Publication source of AI research

4.2 Distribution of Studies Year-wise

The review includes studies ranging from 2019 to 2024. The distribution of studies is shown in Figure 4. The graph shows a gradual increase in the number of studies published from 2019 to 2024. The highest number of publications is recorded in 2024 (36%). In 2019, the number of publications was at a minimum (3%). A slight decrease in publications is recorded in 2022 (11%). The research themes covered in these studies are technology adoption, readiness, user perceptions, AI implementation, technology acceptance, and AI diffusion. Also, the year-wise publication of articles and publication sources is shown in Figure 4.

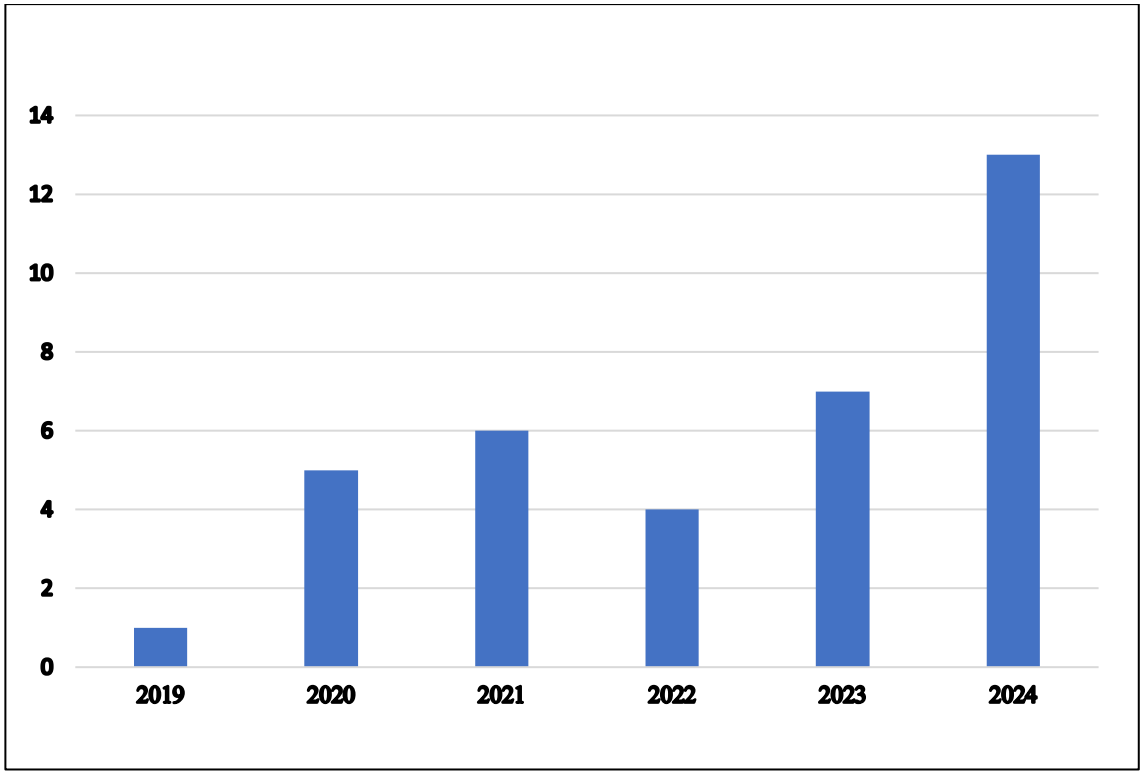

Figure 4: Publication trending of AI research

4.3 Publication Outlets

As shown in Table 3, the most AI articles are published in Automation in Construction and Building (19%), the leading journal. After that, the Building published six studies (17%), while other journals and conferences published a limited number of papers. This result shows that innovation- and sustainability-oriented journals are a priority for publishing. On the other hand, publications concerned with project management journals have the lowest percentage. This would also demonstrate a pervasive pattern in the existing literature and may be interpreted as reflecting the related priorities of the studies presented in such journals.

Table 3: Publication outlets and year-wise distribution of articles

Publication Source	2019	2020	2021	2022	2023	2024	Total
Ain Shams Engineering Journal	0	0	0	0	0	1	1
Automation in Construction	0	0	3	1	0	3	7
Building	0	1	0	0	2	3	6
Built Environment Project and Asset Management	0	0	0	0	1	0	1
Cleaner Engineering and Technology	0	0	0	0	1	0	1
Engineering, Construction and Architectural Management	0	0	0	1	0	2	3
IEEE Access	0	1	0	0	0	1	2
International Symposium on Automation and Robotics in Construction	0	0	0	1	0	0	1
Technology and Innovation in Building Designs	0	1	0	0	0	0	1
Journal of Building Engineering	1	1	1	0	0	0	3
Journal of Open Innovation: Technology, Market, and Complexity	0	0	0	0	1	1	2
Malaysian Construction Research Journal	0	1	0	0	0	0	1
Operations Management Research	0	0	0	0	1	0	1
Results in Engineering	0	0	0	0	0	1	1
Smart and Sustainable Built Environment	0	0	1	0	0	1	2
Sustainability	0	0	1	0	0	0	1
Sustainable Production and Consumption	0	0	0	0	1	0	1
Frontiers in Built Environment	0	0	0	1	0	0	1
Total	**1**	**5**	**6**	**4**	**7**	**13**	**36**

4.4 Country-Wise Publications

The country-wise overview of publications identifies the gaps in research in particular areas. The background of the research relates to the nation or area where the data is gathered. The second consideration for the study's affiliation is the place of the case tested. As depicted in Figure 5. Most of the research has been conducted in Malaysia from 2019 to 2024. After Malaysia, the maximum number of publications is from China. The majority of the listed countries have very low publication counts, with most having only one or two publications.

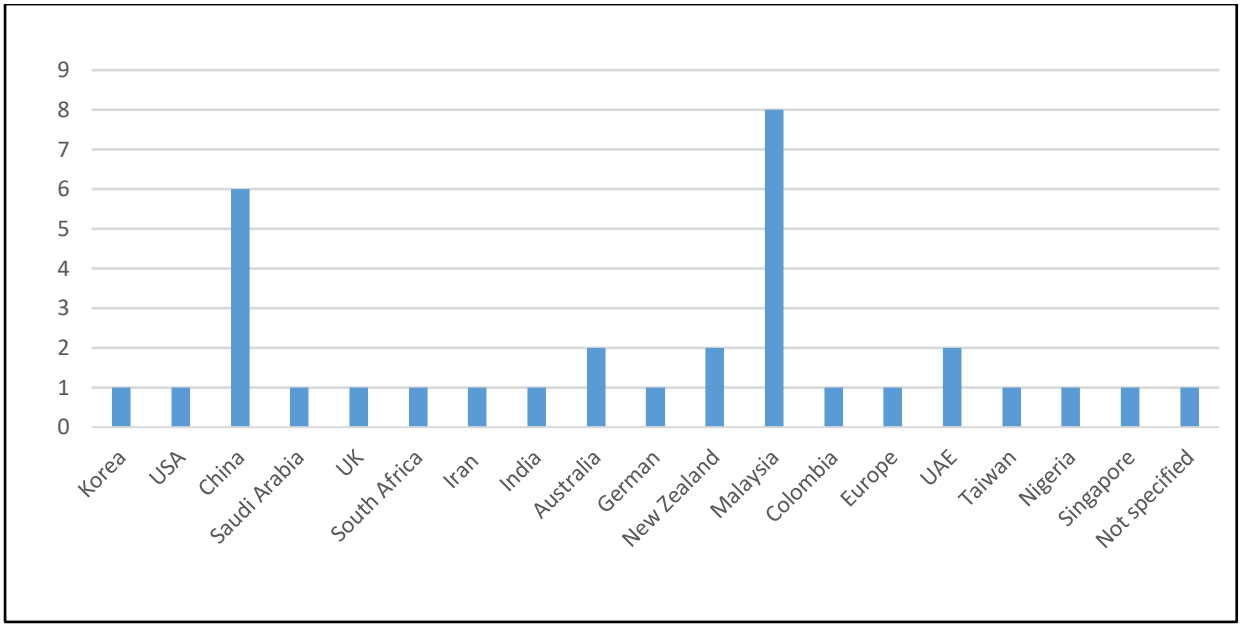

Figure 5: Country-wise AI research

5.0 ANALYSIS OF FACTORS AFFECTING AI ADOPTION STAGES

This section discusses the factors affecting AI adoption in CQS. Factors affecting AI adoption are categorised into four dimensions, including individual, organisational, technological, and environmental.

5.2 Individual Dimension Affecting Awareness and Interest in Adopting AI

Individual awareness and interest in adopting AI is a dynamic process where a person moves from basic knowledge to active engagement. It has been influenced by their perceptions of AI, their motivations for using it, their readiness to adapt, and their overall acceptance of the technology. According to the studies analysed, two factors are most strongly affecting awareness and interest in adopting AI. First is resistance to change (Abioye et al., 2021; Almatari et al., 2024; Felemban et al., 2024; Lada et al., 2023; Oluleye et al., 2021) and the second is lack of top down support (Felemban et al., 2024; Lada et al., 2023; Shang et al., 2023; Ugural et al., 2024). On the other hand, algorithmic challenges and incompatibility (Regona et al., 2022; Shamsiri et al., 2024; Singh et al., 2023; Zabala et al., 2023) are affecting AI awareness and interest, as shown in Table 4. Other important factors include social influence, perceived ease of use, perceived usefulness, lack of trust, time-consuming data entry, and fear of job loss (Na et al., 2023; Singh et al., 2023; Wang et al., 2020). The factors are summarised in Table 4.

Table 4: Individual factors affecting awareness and interest in adopting AI

Individual factors	Author
Social influence	Na et al., 2023
Perceived ease of use	Na et al., 2023, Singh et al., 2023
Perceived usefulness	Na et al., 2023
Lack of top-down support	Felemban et al., 2024, Lada et al., 2023, Shang et al., 2023, Ugural et al., 2024
Resistance to change	Abioye et al., 2021, Almatari et al, 2024, Felemban et al., 2024, Oluleye et al., 2021, Lada et al., 2023
Lack of trust	Wang et al., 2021
Incompatibility	Regona et al., 2022, Zabala et al., 2023
Time consuming for data entry	Wang M et al., 2020
Algorithm challenge	Regona et al., 2022, Shamsiri et al., 2024
Fear of job loss	Liang et al., 2024

5.3 Organisational Dimension Affecting Decision to Adopt AI

Organisational factors are related to inter-organisational processes, practices, and policies that affect AI adoption. Many factors are identified in studies on AI adoption, as summarised in Table 5. The most affecting factor is talent shortages. CQS firms struggle to find personnel with the essential blend of domain knowledge in quantity surveying and AI technical skills, slowing the development and operation of specialised AI tools for tasks such as cost estimation.

Another important factor is top management support and cultural issues. Cultural issues such as fear of job displacement, distrust of AI, and resistance to change hinder AI adoption in organisations. Without a clear, visible, and sustained mandate from senior CQS leadership (partners and directors), AI initiatives risk being treated as peripheral experiments rather than as core business strategy. Leadership commitment is essential to providing the financial security needed, championing transformation across departments, and ensuring the AI strategy aligns with the firm's long-term competitive advantage. Other factors that affect AI adoption are high initial costs, organisational readiness, and financial constraints.

Table 5: Organisational dimension

Organisational dimension	Author
Organisational competence	Na et al., 2023
Lack of infrastructure	Chen et al., 2024, Oluleye et al., 2023, Wang et al., 2021
Insufficient fund	Chen et al., 2024, Wang et al., 2021,
Top management support	Basaif et al., 2020, Felemban et al., 2024, Lada et al., 2023, Pan 2020, Shang et al., 2023, Ugural et al., 2024,
Talent shortage	Abioye et al., 2022, Akinosho et al., 2020, Almatari et al., 2024, Cisterna et al., 2022, Delgado et al., 2019, Mahusin et al., 2024, Shang et al., 2023
Cultural issue	Abioye et al., 2022, Almatari et al., 2024, Chen et al., 2024, Delgado et al., 2019, Mahusin et al., 2024, Oluleye et al., 2023,
High initial cost	Abioye et al., 2022, Delgado et al., 2019, Shang et al., 2023,
Ineffective life cycle management	Oluleye et al., 2023
Organisational readiness	Lada et al., 2023, Shang et al., 2023, Pan, 2020 Tjebane et al., 2022, Ugural et al., 2024
Firm size	Tjebane et al., 2022
Workplace relationships among staff	Tjebane et al., 2022
Information processing management	Tjebane et al., 2022
Knowledge and standard	Tjebane et al., 2022
Collaborative	Tjebane et al., 2022
Attitude to innovation	Tjebane et al., 2022
Cost to the organisation	Ghimire et al., 2024, McNamara& Sepasgozar, 2021, Tjebane et al., 2022,
Risk cost associated with the organisation	Singh et al., 2023Tjebane et al., 2022
Multi-point responsibility	Akinosho et al., 2020
Non-standardisation of construction projects	Akinosho et al., 2020
Employee adaptability	Lada et al., 2020
Easy access to labour	Delgado et al., 2019
Decision-making conflict	Liang, 2024
Resources availability	Abdul-Samad et al., 2024

5.4 Technological Dimension Affecting Implementation and Confirmation to Adopt AI

For CQS firms, the adoption of AI is heavily influenced by technological factors related to the tools themselves, with data challenges, compatibility, and relative advantage being the most critical (as detailed in Table 6). The primary hurdle is data-related challenges, which span everything from ensuring sufficient data availability (e.g., historical project costs) and data reliability to managing the complexity of data interoperability across different platforms (e.g., BIM, traditional spreadsheets).

Crucially, this category includes issues like data complexity, data transparency, and the risk of data hallucination from generative AI models. Furthermore, compatibility is paramount; AI tools for CQS must ensure that the data schemas used during model training (e.g., classifying building elements) are identical to those used during deployment for new projects, as incompatible formats will inevitably lead to errors in cost prediction and project failure.

Finally, relative advantage determines organisational buy-in, as CQS firms must clearly perceive that implementing AI offers substantial, demonstrable benefits such as faster tendering or more accurate risk assessment compared to their existing manual methods.

Table 6: Technological dimension

Technological dimension	Author
Compatibility	Na et al., 2023, Regona et al., 2020, Singaram et al., 2021
Computing power and connectivity	Abioye et al., 2022
Data availability	Aluleye et al., 2023, Akinosho et al., 2020, Wang M et al., 2020
Data maintenance	Shang et al., 2023
Exploitation by hacker	Singh et al., 2023
Data privacy	Chen et al., 2024, Liang et al., 2024, , Mahusin et al., 2024, Paneru & Jelani, 2021, Singh et al., 2023, Zabala et al., 2023
Uncertain function of the AI algorithm	Shamsiri et al., 2024, Singh et al., 2023,
Black box	Akinosho et al., 2020, Regona et al., 2020
Data protection	Akinosho et al., 2020, Liang et al., 2024, Wang M et al., 2020
Data reliability	Mc Namara & Sepasgozar, 2021, Regona et al., 2020
Data complexity	Almatari et al., 2024, Watfa et al., 2022
Unproved effectiveness	Delagado et al., 2019
Data interoperability	Ghimire et al., 2024, Singaram et al., 2021, Qureshi et al., 2020,
Data management	Ding, 2020, Shamsiri et al., 2024 Singaram et al., 2021,Shamsiri et al., 2024, Wang M et al., 2020
Data validation	Wang M et al., 2020
Data transparency	Liang et al., 2024
Data accuracy	Ghimire et al., 2024
Data generalisability	Ghimire et al., 2024
Data hallucination	Ghimire et al., 2024
Relative advantage	Chen et al., 2024, Delgado et al., 2019, Pan et al., 2020, Singh et al., 2023

5.5 Environmental Dimension Affecting AI Adoption

In the context of AI adoption by CQS firms, environmental factors, such as the external forces and conditions, introduce significant complexities. The two most dominant external concerns are cybersecurity risk and the legal environment (as summarised in Table 6). AI adoption inherently increases cybersecurity risks, exposing CQS firms to threats such as data poisoning (the compromise of historical cost data), adversarial attacks on prediction models, and the potential theft of proprietary AI models. Mitigating these threats requires CQS firms to implement robust security measures, including advanced data encryption and strict access controls to protect sensitive client and project information. Simultaneously, the legal environment poses substantial adoption challenges, including navigating evolving data privacy regulations, addressing ethical concerns about algorithmic bias in estimation and risk tools, and managing intellectual property rights for internally developed AI models. The current lack of clear legal frameworks surrounding AI operations increases the risk of legal and financial repercussions. Other crucial external considerations include managing competitive pressure from rival firms, navigating the availability of regulatory support, and benefiting from direct government support for technological transition.

Table 6: Environmental dimension

Environmental dimension	Author
Ethical guidelines	Abioye et al., 2021, Akinosho et al., 2020, Ghimire et al., 2024
Fragmented industry	Chen et al., 2023, Ghimire et al., 2024, Regona et al., 2022, Singaram et al., 2023 ,
Legal environment	Abdul-Samad et al., 2024, Almatari et al., 2024, Chen et al., 2023, Delgado et al., 2019, McNamara & Sepasgozar, 2021, Singaram et al., 2023,
Lack of interest from the client	Chen et al., 2023
Lending restrictions	Chen et al., 2023
Competitive pressure	Lada et al., 2024, Pan, 2020, Tjebane et al., 2024
External support	Lada et al., 2024
Lack of government incentives	Delgado et al., 2019
Decreasing public infrastructure budget	Delgado et al., 2019
Support of the government	Felemban et al., 2024
Government pressure	Tjebane et al., 2024
Construction regulatory	Ghimire et al., 2024, Tjebane et al., 2024,
Lack of standards	Almatari et al., 2024
Cybersecurity risk	Abioye et al., 2021, Akinosho et al., 2020, Ghimire et al., 2024, Liang et al., 2024,Regona et al., 2022, Singh et al ., 2023, Wang et al., 2021

6.0 DISCUSSION OF AI RESEARCH THEMES

This section provides detailed descriptions and categorisation of themes found across different studies, based on adoption stages, as shown in Figure 6.

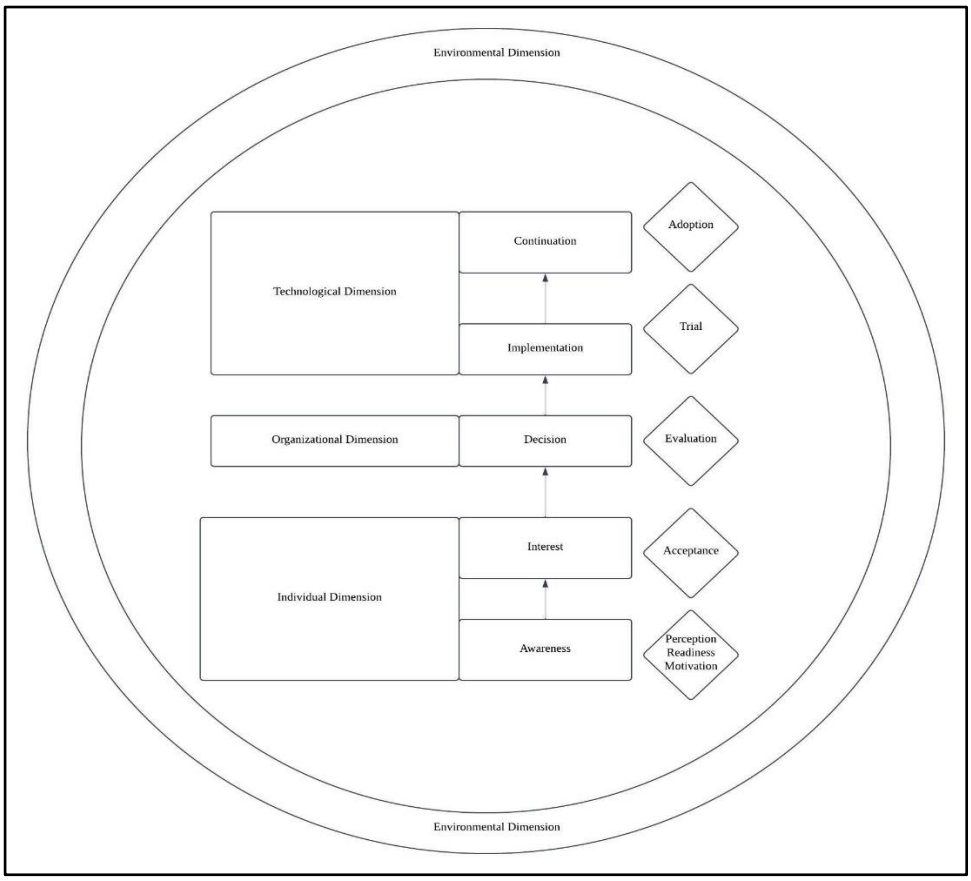

Figure 6: AI adoption research themes

6.1 AI Awareness

In the individual dimension of AI adoption, awareness serves as the foundational step, encompassing perception, motivation, and readiness. Individuals must first perceive AI's relevance and potential benefits to their tasks or lives, understanding how it differs from existing tools. This perception is shaped by clear communication and education, which dispel myths and showcase practical applications. A study by Na et al. (2023) reveals that perceived usefulness positively influences technology satisfaction and usage intention in both South Korea and the UK. Moreover, perceived ease of use positively impacts perceived usefulness and satisfaction. Not only that, but technology satisfaction significantly influences usage intention. Divergences were observed in the influence of personal competence and social factors. In South Korea, personal competence primarily affects perceived ease of use, whereas in the UK, it influences both perceived ease of use and perceived usefulness. Motivation arises from seeing AI's value in improving efficiency, productivity, or personal growth. Demonstrating how AI can solve specific problems or enhance existing workflows is crucial. A notable finding by Cisterna et al (2022) is that construction professionals with AI experience generally reported positive experiences with AI applications.

Participants reported a nearly 78% increase in efficiency due to AI use. The primary obstacle to AI implementation was identified as a lack of AI expertise. Specific AI applications, including Ensun, Neuroflash, and Oculai, were highlighted. Chat-GPT was also used despite concerns about data protection. Positive impacts of using AI included database creation, direct AI application assistance, and the elimination of repetitive tasks. Lastly, readiness involves assessing one's skills and comfort level with AI. Readiness includes providing accessible training resources and fostering a supportive environment that encourages experimentation and learning. Felemban et al (2024), in a study done in China, confirmed that organisational training and development significantly enhance employee skills, mitigate technical challenges, and cultivate a learning culture, all of which are crucial for successful AI adoption. By addressing perception through clear information, sparking motivation by showcasing benefits, and building readiness through accessible education, awareness becomes a powerful catalyst for individual AI adoption.

6.2 AI Interest

Regona et al. (2022) conducted a study to identify challenges in implementing AI in the construction industry. The study's results support market acceptance of AI practices. Also, Abioye et al. (2021) conducted a study to analyse the AI techniques adopted and identify the challenges to their implementation in the construction industry. The study conducted a critical literature review of previous research on the construction industry. Similarly, Na et al. (2022) conducted a Structural Equation Modelling (SEM) analysis to examine the influencing factors of AI-based technology acceptance in the construction industry. The study employed the Technology Acceptance Model (TAM) and Technology Organisation Environment (TOE) framework for the analysis.

6.3 AI Decision

AI-based organisational decision-making in the construction industry is studied by Chen et al. (2024). The study explores the obstacles hindering the widespread integration of digital technologies, including AI, within the construction sector. The study uses a mixed-methods approach, combining quantitative surveys and qualitative interviews to identify key barriers. The findings pinpoint industry standards, client interests, and financial needs as significant impediments. The paper also develops a framework connecting organisational attributes to these perceived barriers, offering insights for academics, practitioners, and policymakers. Ultimately, the research seeks to promote informed decision-making and strategic initiatives that will accelerate the adoption of digital technologies, including AI and improve the construction industry's overall performance and sustainability.

6.4 AI Implementation

Assessing the satisfaction levels of AI stakeholders is essential for the successful implementation of AI in organisations. Delgado et al. (2019) investigate the factors hindering the adoption of robotics and automated systems in the construction industry. Using a mixed-method approach, the research identifies challenges, categorises them into contractor-side economic factors, client-side economic factors, technical and work-culture factors, and weak business case factors, and ranks them by importance. The analysis combines a literature review, focus group discussions with industry experts, and quantitative data from questionnaires. The findings reveal that high initial costs and a lack of a clear business case are significant barriers. The paper also compares its findings with other studies and discusses implications for stakeholders, aiming to inform strategies that mitigate these challenges and encourage the integration of robotics in construction. It identifies the lack of

sufficient cost/benefit studies that stakeholders find concerning.

6.5 AI Continuation

Many factors influence the continuation of technology in organisations. Bajpai and Subhas (2022) investigate the implementation and continuation of digitalisation in the Indian construction sector. It employs a PLS-SEM approach to assess the role of various enablers, such as barriers, success factors, and perceived benefits, in the digitalisation process. The study finds that stakeholders' perceived benefits and the addressing of barriers significantly impact successful digitalisation implementation, while risk factors have less influence on its continuation. The research offers a framework for construction firms to understand and navigate the complexities of digital transformation. It emphasises the importance of a comprehensive digital plan and highlights that digitalisation is akin to innovation adoption, requiring both deployment and sustained use. A notable finding is that barriers are essential enablers for effective implementation, while success factors are important drivers of the continued success of digitalisation in the construction sector. Stakeholders' perceived benefit has a substantial role in both implementation and continuance.

7.0 CONCLUSIONS

SLR successfully provided a bibliometric analysis and a detailed explanation of AI adoption research, specifically examining the factors affecting AI adoption in CQS firms. Assessing the AI adoption process and its dynamics is vital to policymakers and adopters at the individual and organisational levels. The underlying purpose of this study is to help construction organisations, including CQS firms in Malaysia, cope with systemic challenges, increase productivity, and address the reality that construction remains one of the world's least digitalised sectors.

7.1 Foundational Frameworks and Key Contributions

Established technology adoption theories systematically guided the structure and findings of this research: the DOI Theory and the TOE framework. The SLR achieved its primary objectives by exploring and categorising the factors influencing AI adoption within this dual theoretical lens.

1. Theoretical-Based Factor Categorisation: The study identified and classified 62 factors into four distinct dimensions or clusters that affect the AI adoption process, grounding the complex reality of AI barriers within the structured domains of TOE and DOI.

- Organisational Dimension (TOE Context): Factors like talent shortages, top management support, organisational readiness, cultural issues (fear of job displacement), and high initial costs. These directly address the internal organisational context, which is crucial to the decision to adopt AI.
- Technological Dimension (TOE Context/DOI Attributes): Dominated by data-related challenges (data availability, reliability, complexity, interoperability), data privacy, and the required computing power. Core DOI concepts, such as compatibility and relative advantage (the demonstrable benefit over manual methods), are paramount here and affect the implementation and confirmation stages.
- Environmental Dimension (TOE Context): External factors such as cybersecurity risk, the legal environment (data privacy, ethical guidelines, algorithmic bias), competitive pressure, and government support. These external pressures and constraints form the environmental context influencing adoption.
- Individual Dimension (DOI Focus): Key factors affecting awareness and interest include resistance to change, perceived usefulness, perceived ease of use, lack of trust, and the fear of job loss. These factors align with individual psychological variables central to the initial phases of technology diffusion.

2. Stage-Based Adoption Framework: The review clarified and categorised research based on the sequential stages of AI adoption—awareness, interest, evaluation, trial, and confirmation/continuation. By providing an in-depth description of these stages, the SLR clarifies terms often confused in the literature, offering a clearer roadmap for CQS firms navigating digital transformation.

3. Contextual Specificity (CQS in Developing Nations): The bibliometric analysis confirmed that factors affecting the AI adoption process vary significantly by region, attributed to governmental pressure, cultural differences,

practices, and demographics. This observation is critical because it highlights why applying AI adoption study results from developed countries is often inappropriate for developing nations, such as Malaysia, where construction industry practices and proprieties differ substantially. This conclusion confirms the need to focus on organisational-level AI adoption studies within CQS firms.

8.0 IMPLICATIONS AND FUTURE DIRECTIONS

The identified cluster of factors is highly useful for decision-makers in CQS firms and the broader construction industry to analyse AI adoption stages and formulate effective adoption strategies. The findings confirm that a single AI adoption approach across all countries may not be feasible.

Given the complex nature of AI adoption identified in this study, the analysis suggests that existing technology adoption models and theories, including DOI and TOE, may need to be revised and extended to accommodate the more complex adoption process associated with AI. Future research is also recommended to utilise multiple data collection methods to gain deeper insights into AI adoption issues, recognising that the diverse nature of organisations and their structures make generalising findings difficult in this rapidly changing field.

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CREATIVE GIFT WORKSHOP AS A PLATFORM FOR ENTREPRENEURAL EMPOWERMENT

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ABSTRACT

This study adopted a practice-based qualitative approach to explore creative gift-making as a platform for skill development and entrepreneurial empowerment. The problem addressed is the lack of structured, hands-on platforms that embed entrepreneurial values within university students' learning experiences. A total of 22 undergraduate students from different kulliyyahs at IIUM Gombak, Selangor, participated in a creative gifting workshop focusing on chocolate and flower arrangements in gift boxes. The objectives were: (1) to document the step-by-step process of creative gift-making, (2) to evaluate students' achievement and progress throughout the activity, and (3) to identify students' feedback and reflections. The research employed three methods: 1) photo documentation of each stage, 2) trainer-led observation and 3) a student feedback survey. The triangulated method provided a holistic understanding of the workshop's effectiveness in enhancing technical skills, creativity, and entrepreneurial readiness through practice-based learning. This study demonstrates the potential of creative gifting workshops as a replicable model for entrepreneurship education and student empowerment in higher learning institutions.

Keywords: Creative gifting, gift arrangement, entrepreneurship, Practice-based learning

1.0 INTRODUCTION

The gifting industry has evolved beyond mere transactions, becoming a medium of personal expression, creativity, and social connection. Globally, it continues to grow, particularly in personalized and experiential gifts, as consumers increasingly value products with meaning and emotional depth (Deloitte, 2021). This trend has created opportunities for SMEs to differentiate themselves through handcrafted, non-mass-produced items.

In Malaysia and Southeast Asia, creative gifting is especially prominent during religious, festive, and cultural occasions, serving as a sustainable source of income for youth, homemakers, and local communities (Rahim & Aziz, 2020). Bouquet-making that combines chocolates, flowers, and ribbons exemplifies this trend, allowing entrepreneurs to start with low capital investment while offering flexibility in design and pricing.

Despite this potential, the sector faces significant gaps in structured training and entrepreneurial guidance. Many aspiring creators rely on fragmented online resources that lack systematic instruction in design, technique, and pricing (Ali, 2019). As a result, individuals often struggle to progress from hobby-level crafting to producing professional-quality products suitable for competitive markets.

To address these challenges, this study explores the role of creative gifting workshops as a platform for skill development, creativity enhancement, and entrepreneurial empowerment among undergraduate students. By combining hands-on practice, guided instruction, and structured evaluation, the study aims to assess how such workshops can help participants acquire practical skills, build confidence, and recognize the commercial potential of their creative work. The findings are intended to provide insights into effective pedagogical approaches for fostering entrepreneurship in the creative gifting sector.

2.0 LITERATURE REVIEW

2.1 Craft and Creative Entrepreneurship

Craft-based entrepreneurship has been recognized as a viable pathway for individuals to enter business with relatively low capital investment. Handmade products, such as creative gifts, provide opportunities for income generation while enabling personal expression and innovation (Hung, 2023). Unlike large- scale industries, craft businesses emphasize small-batch production, unique designs, and personalization, which enhance market appeal (Luckman, 2015; Fillis, 2011). Studies also suggest that craft entrepreneurs succeed when creativity is effectively merged with entrepreneurial strategies that balance passion with profit (Ratten, 2025; Noyes & Bakshi, 2022). In this regard, creative gift- making—such as chocolate and flower arrangements—offers scalable products that range from basic to premium levels, making it suitable for both small ventures and wider commercial opportunities. Craft entrepreneurship thus generates both economic and cultural value, while contributing to sustainable livelihoods.

2.2 Arts and Design Education for Entrepreneurial Skills

Arts and design education plays a critical role in equipping students with both creative and entrepreneurial competencies. Practice-based learning models allow learners to gain technical proficiency while cultivating confidence, problem- solving, and innovation skills (Asim & Yasin, 2023; Rae, 2006). Universities have increasingly embraced project-based approaches, where students engage in hands-on activities that mirror real-world challenges (Thompson & Kwong, 2016; Ahmad, 2013). Within this context, craft-based workshops, such as creative gift-making, provide platforms for students to experiment with aesthetics while acquiring marketable skills (Bridgstock, 2013). These experiences bridge the gap between academic training and entrepreneurial readiness by fostering reflective learning, peer collaboration, and applied creativity. Consequently, embedding entrepreneurship into arts and design curricula promotes holistic student development beyond technical mastery.

2.3 Creative Crafts in the Digital and Social Media Ecosystem

The digital era has transformed the landscape of craft-based entrepreneurship, enabling artisans and students to showcase their products with minimal costs. Social media platforms such as Instagram, TikTok, and Shopee provide visibility for creative products, creating opportunities for micro-enterprises to reach wider audiences (SpringerLink, 2020; Zhao & Collier, 2016). In particular, creative industries benefit from digital marketing tools that allow personalization, rapid feedback, and community engagement (Liao & Wang, 2021; Kannan & Li, 2017). For youth entrepreneurs in Malaysia, this integration has been essential for sustaining small-scale ventures such as handmade gifts and chocolate flower arrangements (Barnes, 2020). Digital ecosystems therefore extend the commercial viability of creative crafts while fostering innovation and identity within online communities.

2.4 Entrepreneurship and Student Development in Malaysian Universities

Malaysian universities have increasingly embedded entrepreneurship into student life, recognizing its importance for employability and future readiness. Numerous initiatives, including workshops, bazaars, and cultural events, provide students with opportunities to design, market, and sell creative products (Ahmad &

Buchanan, 2015; Hashim & Morshidi, 2012). Research shows that these co-curricular platforms foster resilience, adaptability, and innovation by encouraging students to practice leadership, teamwork, and communication skills (Ismail et al., 2018; Othman & Othman, 2019). At institutions such as IIUM, entrepreneurship education has been linked to stronger entrepreneurial intentions and business readiness (Ibrahim & Mas'ud, 2016). Creative gift-making workshops can therefore be positioned as part of this ecosystem, equipping students with transferable skills that align with the national agenda of nurturing young entrepreneurs.

3.0 METHODOLOGY

This study adopted a practice-based qualitative approach to explore creative gift-making as a means of skill development and entrepreneurial empowerment. A total of 22 undergraduate students from different kulliyyahs participated in a hands-on workshop focused on chocolate and flower bouquet making. The activity guided participants through a step-by-step process including material preparation, construction, finishing, and packaging. Each stage was systematically photo-documented to capture techniques and provide a visual record for analysis and instructional purposes.

To evaluate learning outcomes, a dual-assessment strategy was employed. First, trainer observation was conducted using a structured checklist to assess whether students demonstrated technical proficiency, creative capability, and the ability to follow instructions. These areas were evaluated because they are essential for turning craft-making into a small business: technical skills affect product quality, creativity adds uniqueness, and following instructions ensures students can efficiently learn the techniques needed to produce items that meet basic commercial standards.

Second, participant evaluation was carried out through surveys and informal reflections, allowing students to share their perceptions of skill acquisition, challenges experienced, and their interest in exploring the commercial potential of creative gift-making, as well as their entrepreneurial readiness, including confidence in potentially starting a small business. These surveys and reflections were included to capture students' personal perspectives on learning and entrepreneurial potential, which cannot be fully observed by the trainer. They provide valuable insight into students' confidence, motivation, perceived challenges, and readiness to apply the skills in real-world business contexts. Combining this with trainer observation offers a more complete understanding of both skill development and entrepreneurial empowerment.

This triangulated method—combining photo documentation, trainer assessment, and participant feedback—provided a holistic understanding of the workshop's effectiveness in enhancing technical skills, creativity, entrepreneurial readiness, and value-based learning.

4.0 RESULTS

4.1 Hands-on Workshop Process

The workshop was designed as a structured, practice-based activity where participants engaged in learning through direct making. The process was divided into four key stages, each focusing on specific technical and creative aspects of bouquet construction. This structured approach not only ensured systematic skill acquisition but also enabled the trainer to observe participants' craftsmanship, creativity, and potential for entrepreneurial application. The four stages included: (1) preparation of materials, (2) preparation of bouquet parts, (3) arrangement of bouquet, and (4) finishing and presentation.

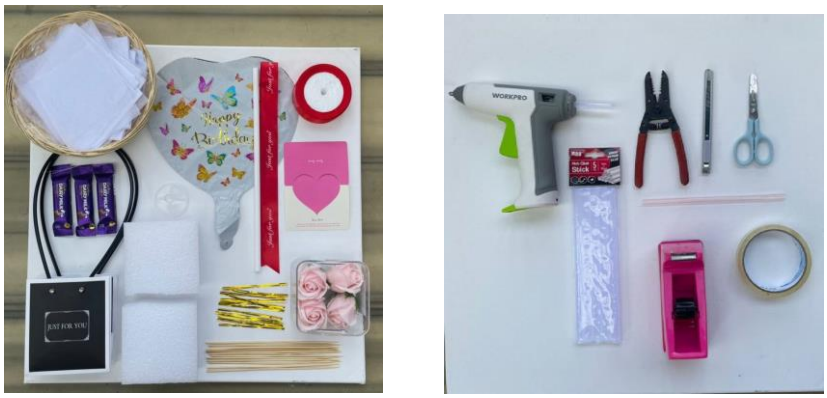

Fig. 1: Basic materials and tools for creative gift

4.2 Preparation of Materials

The first stage of the workshop focused on preparing all necessary tools and materials before beginning the hands-on activity. Students were provided with chocolates, fresh or artificial flowers, cotton wrapping paper for filler, gift boxes, ribbons, and decorative accessories. Basic tools such as scissors, cutters, wire cutters, sellotape and its dispenser, hot glue guns, and balloon pumps/straws were also introduced. This preparation stage emphasized safety and efficiency: participants were guided to pre-cut ribbons, test glue guns, and organize items in functional groups for mounting and arrangement purposes. Photographs were taken to document the layout of materials and the initial readiness of workstations, serving both as a visual record and instructional reference. (figure 1)

Fig. 2: Mounted materials and activities for preparation of bouquet parts

4.3 Preparation of Bouquet Parts

Following the material setup, students proceeded to prepare the individual components of the bouquet. This stage was designed to build modular parts that could later be combined into a cohesive arrangement. Chocolates were mounted onto wooden sticks using hot glue, after which the exposed sections were wrapped neatly with sellotape to improve stability and appearance. Artificial flowers, including soap flowers, were also mounted onto sticks and grouped together, ensuring uniform length for ease of arrangement. Cotton wrap paper filler were similarly prepared on sticks to be inserted as supportive elements around the main bouquet. Ribbons were pre-tied into bows or loops to facilitate quicker assembly. Balloons were inflated to uniform sizes and attached securely to holders, not only to create better volume within the arrangement but also to add a sense of fun and cheer for the end-user. Photographic documentation of this stage captured the mounting and bundling process, emphasizing the importance of neatness, stability, and consistency in part preparation, which directly influences the final presentation quality. (figure 2)

Fig. 3: Chocolate & Flower Bouquet in Box – arrangement process.
a) focal centre, b) filler, C) finishes

4.4 Arrangement of Materials for Bouquet Presentation

After preparing the bouquet components, participants assembled the bouquet, applying both technical and creative skills. They first established a focal center— typically a balloon, flowers, or cluster of chocolates— around which other elements were arranged in a spiral or radial form. Emphasis was placed on visual balance, height variation, and stability, with students encouraged to step back and assess their designs from multiple angles. Filler materials were inserted strategically to create depth and conceal stems or glue points. Trainers observed students' choices of color, symmetry, and spatial arrangement, noting instances of originality as well as areas where bouquets appeared cluttered or unbalanced. Photographs captured the progression from core structure to near-final forms, providing a visual reference for process and outcome evaluation. (Figure 3)

Photographs captured this stage in progression—from the establishment of the core focal structure to near-final compositions—providing a visual record of decision-making processes and serving as reference material for both instructional and evaluative purposes.

4.5 Finishing for the bouquet gift

The final stage focused on finishing touches and quality checks to complete the bouquet. Students added ribbons, cards, and other decorative details to enhance the overall presentation. Trainers guided them to review proportions, check for exposed glue points, and ensure structural stability. This stage also encouraged participants to reflect on their work, comparing their results with peers' arrangements and professional references. Photographs of the finished products captured the full transition from preparation to completed bouquet, serving as evidence of learning outcomes. (figure 3)

This stage also encouraged participants to reflect on their work, comparing their results with peers' arrangements and professional references. Photographs of the finished products captured the full transition from preparation to completed bouquet, serving as evidence of learning outcomes.

5.0 RESULT AND FINDINGS FROM TRAINER-LED OBSERVATION

5.1 Technical Proficiency and Process Discipline

The trainer's evaluation revealed that students demonstrated foundational technical proficiency with average scores ranging from 3.0–3.2. Strengths were noted in tool handling and basic arrangement skills, which shows that participants could follow the demonstrated steps. However, weaknesses were observed in ribbon tying (2.7) and achieving cohesive, balanced arrangements (3.0). In terms of process discipline, students scored moderately (3.1–3.4), showing that they were able to follow instructions and manage their time, though improvements are needed in neatness and finishing quality. (Table 1)

Table 1: Result from the trainer observation on participant performance

Category	Skill / Indicator	Mean Rating (N=22)	Trainer Observation
A. Technical Proficiency	Grasp of basic arrangement	3.2	Most students understood basic bouquet setup, but final layouts were inconsistent.
	Jointing chocolates/flowers with sticks	3.0	Students managed the jointing process, though some items lacked stability.
	Use of hand tools: glue gun	3.1	Tools were used safely, but finishing was uneven.
	Use of hand tools: balloon blower	3.4	Generally handled correctly, giving cheerful volume effect.
	Wrapping and packaging skills	3.0	Wrapping was functional but lacked polish for premium appeal.
	Ribbon making	2.7	Ribbon tying was weak, reducing product aesthetics.
	Overall cohesive arrangement	3.0	Products looked acceptable but lacked visual balance.
B. Creativity	Color combination & harmony	3.8	Students showed strong sense of color and coordination.
	Attempting unique styles	3.2	Few experimented; most followed standard patterns.
	Creative outcome of final product	3.0	Outcomes were satisfactory but not innovative.
	Balance and stability	3.0	Some arrangements appeared lopsided.
C. Following Instructions	Step-by-step adherence	3.4	Majority followed trainer guidance accurately.
	Time management	3.1	Most completed tasks on time, though some rushed.
	Neatness and visual appeal	3.0	Products were neat but lacked "market-ready" finish.

5.2 Creativity and Entrepreneurial Readiness

Creativity scores reflected stronger abilities in color coordination (3.8), suggesting an aesthetic sensibility. However, originality and innovation were rated lower (3.0–3.2), indicating that students were more comfortable replicating demonstrated designs than creating unique styles. From an entrepreneurial perspective, this shows a gap in product differentiation and value-adding skills. (Table 1)

5.3 Findings from Trainer Observation

The trainer's evaluation, conducted through a structured checklist, highlighted that students demonstrated basic technical proficiency but required further refinement in execution. Most participants managed tool handling and simple arrangements effectively, yet weaknesses were observed in ribbon tying and achieving balanced, cohesive bouquets, indicating areas for skill improvement. In terms of creativity, students showed strength in colour coordination, reflecting an understanding of aesthetics, but were less confident in producing

original or innovative designs, consistent with the assessment of creative capability in the methodology. Instruction-following and time management were generally satisfactory, showing that participants effectively absorbed the tips and techniques provided by the trainer, which is different from simply following online videos. This also demonstrates that participants successfully developed basic bouquet-making skills that can already be sold or used. However, limitations in finishing and presentation quality reduced the professional appearance of the products, suggesting that further practice is needed to achieve commercially competitive standards. Overall, these findings indicate that while students possess functional baseline skills, additional training in detailing, finishing, and creative innovation is necessary to further enhance technical competence and entrepreneurial readiness, as outlined in the dual-assessment methodology.

6.0 RESULT AND FINDINGS FROM THE STUDENTS' FEEDBACK SURVEY

Table 2: Students Feedback Survey Result

Category	Skill / Indicator	Mean Rating (N=22)	Students feedback
Skill Development	Confidence in handling materials and tools	4.3	Most students felt confident using scissors, glue guns, and balloons safely
	Ability to follow step-by-step instructions	4.2	Students followed instructions well, though some had timing issues
	Wrapping an d arrangement skills	4.3	Students rated themselves positively in wrapping and arranging
	Improvement of technical skills after workshop	4.4	Most agreed their skills improved significantly
	Overall skill development	4.3	Majority felt they gained useful technical skills
Creativity & Enjoyment	Freedom to explore new designs	4.5	Students enjoye d experimenting with colors and layout
	Enjoyment of the activity	4.6	Nearly all students reported high enjoyment
	Sense of achievement in final product	4.5	Students were proud of theiroutcomes despite imperfections
	Perceived creativity growth	4.4	Most felt more creative after the workshop
Entrepreneurial Readiness	Confidence in pricing and selling	3.8	Students felt less confident in setting product prices
	Ability to identify product value	4.0	Students recognized potential market value of their work
	Interest in pursuing as side business	4.1	Students expresse d moderate interest in entrepreneurship

6.1 Skill Development

The survey results show that students gained considerable improvement in technical aspects such as tool handling (M = 4.2), step-by-step wrapping (M = 4.3), and arrangement skills (M = 4.4). This indicates that the workshop successfully enhanced their craftsmanship and ability to execute structured design tasks. The high ratings suggest that most participants were confident in applying the techniques introduced during the training session. Students also mentioned that practicing with real materials helped them understand balance, stability, and finishing quality more effectively. (Table 2)

6.2 Creativity, Enjoyment, and Entrepreneurial Readiness

On the creative side, students rated their ability to express originality at (M = 4.1), while their enjoyment of the activity scored the highest (M = 4.6). A strong sense of achievement was also reported (M = 4.5), reflecting the satisfaction they felt upon completing their bouquets. However, when asked about entrepreneurial aspects, the responses were slightly lower: confidence in product value (M = 3.8) and interest in selling (M = 4.1). These results suggest that while students appreciated the hands-on creativity and enjoyed the process, they were less certain about translating these skills into marketable products. (Table 2)

6.3 Findings from Student Survey

The student survey results revealed that the workshop effectively supported skill development, especially in understanding step-by-step procedures and handling materials confidently. Students also expressed high levels of enjoyment and creativity, appreciating the freedom to explore different designs and colour combinations. Although the skill itself is not highly technical or difficult—and many students found it fun and easy to learn—this did not fully translate into inspiration to start a business.

While the activity sparked curiosity about entrepreneurship, students still felt uncertain about turning the skill into an actual commercial venture. This highlights a gap in entrepreneurial readiness. Overall, the findings suggest that although the workshop successfully enhanced technical learning and creative engagement, additional support in entrepreneurial mentoring, business exposure, basic budgeting, and product refinement is needed for students to confidently pursue gift-making as a sustainable business opportunity.

7.0 DISCUSSION AND CONCLUSION

This study explored the role of creative gifting workshops in fostering technical, creative, and entrepreneurial skills among undergraduate students. The hands-on activity of chocolate and flower arrangement in a gift box provided participants with a structured yet engaging platform to learn material preparation, arrangement techniques, finishing methods, and basic packaging. Using photo documentation, trainer observation, and student surveys, the workshop outcomes were holistically assessed.

The findings revealed that students successfully acquired baseline technical skills and demonstrated creativity, particularly in colour coordination and design arrangement. All participants were able to complete a bouquet, highlighting that basic bouquet-making skills are highly learnable, and the hands-on guidance effectively transmitted the trainer's tips and techniques. However, challenges in finishing, ribbon tying, and product presentation limited the professional and commercial readiness of their work. While students reported high enjoyment, creativity, and confidence in producing the items, their confidence in turning these skills into an entrepreneurial venture remained moderate, reflecting a gap in business readiness.

Beyond technical and creative learning, students developed valuable soft skills such as teamwork, patience, discipline, and appreciation for hands-on experiential learning. The activity also increased awareness of entrepreneurial possibilities, including cost management, market opportunities, and the importance of quality finishing and packaging.

Overall, the workshop proved effective as a practice-based platform for skill development and entrepreneurial empowerment, enabling students to quickly acquire practical skills while building confidence and creative

capacity. To enhance its impact, future workshops should include entrepreneurial mentoring, market exposure, basic business training, and advanced guidance in finishing and product refinement. These enhancements would better prepare students not only to enjoy the creative process but also to translate their skills into sustainable and commercially viable business opportunities.

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LED STREET LIGHTING IN MALAYSIA: PERFORMANCE EVALUATION AND BARRIERS TO IMPLEMENTATION

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ABSTRACT

Street lighting plays a critical role in enhancing city aesthetics and minimising accidents and injuries by providing crucial illumination in public spaces, especially at dawn and dusk. However, Malaysia's street lighting system faces challenges related to energy efficiency, sustainability, and technology integration, as traditional lighting technologies are known for high energy consumption and light pollution. Thus, recognizing these issues, this paper is prepared with the objective to present the outcome of comparative study between the present conventional streetlights and the newly emerging technology of light-emitting diode (LED) with specific reference to energy and performance efficiency. The study employed a qualitative research strategy that in compasses of semi-structured interview with professionals that have established knowledge, skills, and experience actively engaged in streetlight projects in Malaysia. The study outcome revealed that the LED is deemed appropriate to enhance the visibility as compared to the present conventional streetlights. The adoption of LED street lighting in Malaysia presents a strategic move toward achieving national sustainability goals, offering enhanced energy and performance efficiency compared to conventional systems. Despite higher initial costs, LEDs contribute to reduced energy consumption, lower environmental impact, and improved urban infrastructure—aligning directly with Malaysia's green agenda and the global targets of SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 11 (Sustainable Cities and Communities).

Keywords: Economic planning, Energy-efficiency, Performance, Streetlights, Sustainable.

1.0 INTRODUCTION

The Twelfth Malaysian Plan 2021–2025 (12MP) emphasises sustainable economic growth, innovation, development, and environmental well-being as key pillars to enhance national prosperity. In line with this vision, the plan highlights the importance of sustainable infrastructure development, particularly for the advancement of smart cities. One of the critical components of this initiative is the implementation of cost-efficient and environmentally sustainable street lighting systems. Despite their vital function, the role of street lighting is frequently overlooked in urban planning discourse. Adequate street lighting is essential to urban infrastructure, as it has been shown to significantly reduce traffic accidents and crime rates while simultaneously enhancing the visual and aesthetic quality of urban environments. Empirical studies support the notion that well-lit public spaces contribute to improved safety and urban attractiveness (Ng et al., 2019; Agramelal et al., 2023; Khayam et al., 2023). Moreover, the integration of sustainable street lighting technologies is aligned with the United Nations Sustainable Development Goals (SDGs), specifically SDG 7: Affordable and Clean Energy, SDG 9: Industry, Innovation and Infrastructure, and SDG 11: Sustainable Cities and Communities.

Despite their widespread use, conventional street lighting systems are major contributors to high energy

consumption, which subsequently results in increased carbon emissions and elevated electricity costs (Allwyn et al., 2021; Valetti et al., 2023). In response to these challenges, numerous countries have initiated large-scale replacement programs aimed at transitioning to more energy-efficient and cost-effective lighting solutions. Globally, approximately 300 million conventional streetlights have been replaced with light-emitting diode (LED) alternatives, yielding estimated energy savings ranging from 50% to 70% (Crimina et al., 2015). In alignment with this global movement, Malaysia has implemented similar measures, notably replacing 33,101 high-pressure sodium (HPS) streetlights with LED luminaires in the state of Penang (Kingsun, n.d.; Ding et al., 2020). Other municipalities, including Mersing, Kajang, and Kuala Lumpur, have also begun adopting LED lighting systems, although a more comprehensive and nationwide implementation remains imperative. This transition represents a pivotal advancement in the development of sustainable smart cities, as it not only supports global energy efficiency goals but also reflects Malaysia's ongoing commitment to reducing its carbon footprint and improving urban liveability through environmentally responsible infrastructure (Davidovic & Kostic, 2022). Against this backdrop, there has been a demand to comparatively examine the energy and performance efficiency of conventional versus LED street lighting technologies within the Malaysian context. In essence, this paper is prepared with the objective to present the outcome of comparative study between the present conventional and the newly emerging technology of light-emitting diode (LED) streetlights with specific reference to energy and performance efficiency.

2.0 LITERATURE REVIEW

2.1 Overview of Malaysia's Street Lighting Systems

Literature Street lighting is a critical public infrastructure system in modern nations like Malaysia, playing essential role in the daily lives of its citizens. It enhances safety by deterring criminal activities and providing a psychological sense of security (Ciriminna et al., 2015; Ibrahim et al., 2020; Sutopo et al., 2020; Gordic et al., 2021; Pardo-Bosch et al., 2021; Khayam et al., 2023). As an integral component of urban infrastructure, street lighting evolves in tandem with urbanization, reflecting the nation's progress and commitment to improve the quality of life of an individual and society (Allwyn et al., 2010; Khayam et al., 2023).

The history of street lighting in Malaysia dates back to the late 19th century, during the period of British influence on infrastructure development. The initial transition from gas lamps to incandescent bulbs marked a significant milestone in the evolution of street lighting. This was followed by the adoption of fluorescent lights, which offered improved energy efficiency and durability. The introduction of electric street lighting fundamentally transformed the urban landscape, enabling widespread installation of electric streetlights (Wenli, 2021).

The evolution of street lighting technologies has witnessed remarkable advancements, transitioning from traditional options like incandescent and high- pressure sodium lamps to more efficient and sustainable solutions such as LED technology. This shift signifies not only technological progress but also a commitment to sustainability and environmental stewardship. In the early 2000s, LED technology gained popularity for street lighting due to its sustainability and environmental benefits. Malaysia has been gradually implementing LED streetlights to reduce energy consumption and maintenance costs, resulting in significant cost savings, enhanced visibility, and a reduced carbon footprint (Abdullah et al., 2019; Omar et al., 2022; Ramli et al., 2015). This gradual but steady adoption of LED streetlights underscores Malaysia's commitment to modernizing its urban infrastructure and enhancing the quality of urban life through greener, more efficient lighting solutions.

2.2 Types of Existing Street Lighting Systems in Malaysia

2.2.1 Incandescent Light

Historically, incandescent streetlights—initially powered by gas or oil, became the standard lighting solution in Malaysia due to their affordability and widespread availability. While these systems offered a cost-effective approach during earlier phases of urban development, their long-term viability diminished with the growing demand for more reliable and sustainable lighting solutions. As urbanization accelerated, the limitations of incandescent technology, particularly in terms of energy inefficiency and short operational lifespan became increasingly evident (Green Frog Systems, n.d.; Cloud, 2023).

Beyond excessive energy consumption, incandescent streetlighting systems are fundamentally incompatible with the evolving requirements of modern urban infrastructure. They lack essential features such as adaptive

brightness control, automated operation, and integration with energy management systems—all of which are critical for smart city initiatives and sustainable development. Additionally, their inherently limited-service life leads to frequent replacements, resulting in higher maintenance costs and a larger environmental footprint due to repeated manufacturing, transport, and disposal cycles. These shortcomings collectively render incandescent lighting an unsustainable and outdated option for contemporary urban planning (Valetti et al., 2023).

In recognition of these deficiencies, Malaysia has gradually phased out incandescent streetlighting in favour of more energy-efficient alternatives, such as fluorescent and high-pressure sodium (HPS) lamps (The Edge, 2020). While these technologies represent incremental improvements in terms of energy savings, they continue to fall short in delivering optimal efficiency, lighting quality, and environmental sustainability when compared to modern LED lighting systems (Shahedah, 2015).

2.2.2 Fluorescent Light

Fluorescent streetlights have been a common feature in Malaysia since the mid-20th century, prized for their energy efficiency and extended lifespan compared to incandescent lights. These lights operate by passing electricity through a gas, which then excites a phosphor coating to emit light. Despite their energy-saving advantages, fluorescent lights still consume a substantial amount of electricity, leading to high energy bills and increased strain on the power grid. Additionally, the light quality from fluorescent lamps can be harsh and uncomfortable, causing visual fatigue and potential health issues for both pedestrians and motorists. This discomfort can make it challenging to focus on the road, thereby compromising safety (Green Frog Systems, n.d.; Abdullah et al., 2019; Wenli, 2021; Viana et al., 2022; Omar et al., 2022).

2.2.3 High-pressure Sodium (HPS) Light

High-pressure sodium (HPS) streetlights have been a popular choice for outdoor lighting due to their high luminous efficacy, warm colour rendition, and relatively long lifespan. These lights produce a bright orange or yellow glow by passing electricity through a gas mixture, making them both cost-effective and environmentally friendly compared to older technologies. HPS lamps typically last between 14,000 to 24,000 hours, offering a balance between efficiency and longevity (Green Frog Systems, n.d.; Abdullah et al., 2019; Taufik et al., 2020; Wenli, 2021; Allwyn et al., 2021; Viana et al., 2022; Omar et al., 2022; Khayam et al., 2023). However, with the advent of more energy-efficient lighting technologies, particularly LEDs, the use of HPS lights has been declining. While HPS streetlights are more efficient than incandescent lights, they still require frequent replacements and maintenance, leading to higher long-term in-use costs. Their high-power consumption also results in increased recurring expenses and a lower luminous output compared to modern LED solutions. Thus, while HPS lights have served well historically, their drawbacks are becoming more apparent in the face of superior alternatives (Viana et al., 2022; Omar et al., 2022; Khayam et al., 2023).

2.2.4 Light-emitting Diode (LED)

The adoption of emerging LED street lighting technology is increasingly recognised as a strategic initiative aligned with environmental stewardship, sustainable urban development, and national policy objectives. As highlighted by Ding et al. (2020), LED streetlights provide significant long-term cost savings due to their lower energy consumption and reduced maintenance requirements. These operational efficiencies contribute not only to fiscal prudence but also to the broader national agenda on Environmental, Social, and Governance (ESG) performance by reducing greenhouse gas emissions and environmental impact. Moreover, the implementation of LED technology supports Malaysia's commitment to several United Nations Sustainable Development Goals—namely, SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), and SDG 11 (Sustainable Cities and Communities). In addition to environmental and economic benefits, enhanced visibility from LED lighting plays a critical role in advancing road safety, contributing to national efforts aimed at reducing traffic-related accidents and fatalities through improved nighttime illumination (Research and Markets, 2025).
Comprising a semiconductor chip, heat sink, and electrical connections, LED streetlights have quickly gained popularity for their remarkable energy efficiency and longevity. These lights can last up to 50,000 hours before needing replacement, significantly lowering maintenance costs and operational disruptions. Since their introduction in Malaysia in the early 2000s, LED streetlights have revolutionized urban development by providing superior brightness, colour rendering, and directional lighting, which greatly improves visibility and safety on the roads. Despite the higher initial costs and the need for updates to existing infrastructure, the long-term benefits of LED streetlights—including lower energy consumption, reduced carbon footprint, and

enhanced public safety—make them an ideal choice for modern urban environments (Green Frog Systems, n.d.; Zin & Abdullah, 2015; Mohring, 2018; Taufik et al., 2020; Gordic et al., 2021; Allwyn et al., 2021; Omar et al., 2022; Agramelal et al., 2023; Khayam et al., 2023).

2.3 Strategies to Enhance the Implementation of LED Streetlights Application in Malaysia

The study proposes several strategic recommendations to facilitate the broader adoption of LED street lighting systems in Malaysia. Primarily, increased investment in research and development (R&D) is essential to drive innovation and reduce the manufacturing and installation costs of LED technology. Lowering these initial capital expenditures would enhance affordability and promote widespread implementation across urban and rural municipalities. In parallel, the introduction of financial incentives—such as government-backed subsidies, tax rebates, and targeted grants—can significantly offset the high upfront investment, thereby accelerating the transition to energy-efficient lighting solutions. Such fiscal support mechanisms have been recognised as critical enablers of LED adoption in global markets (Research and Markets, 2025).

Subsequently, Research and Markets (2025) in their articles stated, to support the widespread adoption of LED street lighting, strategic collaboration between government agencies and private sector entities is essential. Public-Private Partnerships (PPPs) offer a robust mechanism to harness the strengths of both sectors, enabling access to financing, shared resources, and the transfer of technical knowledge and best practices. This integrated approach can enhance implementation efficiency, promote innovation, and ensure the optimal utilisation of available infrastructure and funding. Moreover, capacity building through targeted training and workshops is crucial for the sustainable deployment of LED lighting systems. Developing comprehensive training programmes for technicians, engineers, and maintenance personnel will ensure the correct installation, operation, and upkeep of LED streetlights, thereby maximising their operational lifespan and performance efficiency.

In parallel, the reinforcement of regulatory frameworks is vital to support the transition to advanced lighting technologies. Establishing clear, standardised specifications and technical guidelines can mitigate implementation risks, reduce ambiguity during procurement and planning phases, and foster greater stakeholder confidence. Robust policy development can also address common challenges—such as interoperability, quality assurance, and long-term maintenance strategies—thus empowering municipalities, contractors, and policymakers to make informed, risk-aware decisions in the pursuit of sustainable urban infrastructure.

3.0 METHODOLOGY

This study adopted a qualitative research strategy, underpinned by a semi-structured interview approach, to comprehensively examine the implementation status and challenges associated with street lighting systems in Malaysia. The qualitative research strategy was chosen to enable a deeper exploration of expert perspectives, allowing for rich, context-specific insights that are essential when investigating complex, multi-dimensional issues such as urban infrastructure, technological transition, and policy integration.

Primary data was collected through semi-structured interviews with selected professionals that have established knowledge, skills, and experience actively engaged in streetlight projects actively involved in streetlight projects across Malaysia. Respondents were purposively sampled based on their technical expertise, professional experience, and willingness to participate, ensuring that insights were drawn from individuals with relevant and substantive knowledge. Secondary data was obtained through an extensive literature review to establish the foundational understanding of global and local practices, energy policies, and sustainable lighting technologies. The interview protocol was developed through iterative refinement, guided by themes identified in the literature. The questionnaire comprised both Likert-scale and open-ended questions. The Likert-scale items were designed to measure respondents' evaluations of streetlight system effectiveness, comparing conventional and LED technologies, as well as their perceptions of implementation feasibility and sustainability. The open-ended questions, on the other hand, facilitated the exploration of perceived implementation barriers and solicited recommendations for improving LED streetlight deployment (Ayob & Abdul Rashid, 2020; Abdul Rahman & Ayob, 2024).

Qualitative data from the open-ended responses were analysed using thematic coding. Codes were generated inductively, allowing recurring themes, patterns, and categories to emerge organically from the data. This

process supported a nuanced understanding of implementation challenges and stakeholder expectations.

For the Likert-scale data, descriptive statistical analysis was conducted. The mean (M) was used to determine the central tendency of responses, providing an average assessment across participants. Standard deviation (SD) was used to measure the degree of response dispersion, indicating the extent of consensus among stakeholders. A standard deviation classification table was employed to categorise the level of agreement or divergence: SD ≤ 0.99 was interpreted as high consensus, SD between 1.00–1.99 as moderate consensus, and SD ≥ 2.00 as low consensus. This combined analytical approach ensured a robust interpretation of both quantitative and qualitative findings, supporting data triangulation and enhancing the study's validity (Ayob & Abdul Rashid, 2020; Abdul Rahman & Ayob, 2024).

4.0 RESULTS

4.1 Background of Interviewees

Based on a comprehensive search of suitable respondents, it was found there is a limited number of potential people with established knowledge, skills, and experience actively engaged in streetlight projects in streetlight projects across Malaysia that can be invited as respondents in the interview approach. Therefore, a total of five people with diverse backgrounds and expertise were only identified that met the respondent's selection criteria used and willingness to participate as respondents in the interview approach. These include Risk Managers, Mechanical and Electrical Engineers, and a Corporate Transformation specialist. The combination of emerging talents and seasoned professionals broadens the scope of the research and strengthens the credibility of its findings. To uphold privacy and confidentiality, the anonymity of the interviewees was rigorously maintained throughout the study. Table 1 below summarises the demographic profile of the interviewees, illustrating the diversity and expertise contributing to the study's comprehensive analysis.

Table 1: Summary of the interviewees' profile data

No.	Interviewee's Name	Position	Years of Experience in Street Lighting Projects
1.	Interviewee A	Risk Manager	1 - 5 years
2.	Interviewee B	Mechanical Engineer	1 - 5 years
3.	Interviewee C	Electrical Engineer	6 - 10 years
4.	Interviewee D	Corporate Transformation	1 - 5 years
5.	Interviewee E	Electrical Engineer	1 - 5 years

4.2 The Current State of Street Lighting Application in Malaysia

The following part of interview asked interviewees to provide score to each question statement, indicating their preferences and perceptions on the cost-effectiveness of four different competing street lighting solution types, i.e. Light-Emitting Diode (LED) Street Light, High-Pressure Sodium (HPS), Fluorescent Street Light, and Incandescent Street Light. The study found that incandescent lights were the lowest-ranked choice among street lighting options, with a mean rating of 1.60, while the LED streetlights scored the highest mean score (4.40), with lowest standard deviation score (0.55), respectively. The results for each question statement are illustrated in Table 2 below:

Table 2: Efficiency of Current Street Lighting in Malaysia

Rank	Questions	Mean	SD
1	Based on your experience, could you please rate the degree of cost efficiency for the Light-Emitting Diode (LED) Street Light solution in Malaysia?	4.40	0.55
2	Based on your experience, could you please rate the degree of cost efficiency for the High-Pressure Sodium (HPS) Street Light solution in Malaysia?	3.20	0.84
3	Based on your experience, could you please rate the degree of cost efficiency for the Fluorescent Street Light solution in Malaysia?	2.40	0.55
4	Based on your experience, could you please rate the degree of cost efficiency for the Incandescent Street Light solution in Malaysia?	1.60	0.89

Evidently, the study underscores that the LED streetlights emerge as the most cost- effective option for street lighting in Malaysia, despite their higher initial costs relative to traditional incandescent, fluorescent, and high-pressure sodium lights (Abdullah et al., 2019; Lindawati et al., 2019; Gordic et al.2021; Viana et al., 2022). On this account, LED lights boast longer operational lifespans, reduced maintenance requirements, and superior environmental friendliness. Beyond financial considerations, the research delves into the psychological, quality-of-life, and environmental benefits associated with improved street lighting infrastructure. The findings also highlight a clear need for enhancing maintenance practices in Malaysia's street lighting systems. Interviewees expressed cautious optimism regarding future advancements in street lighting, particularly the ongoing shift towards LED technology. This optimism stems from the environmental advantages of LED lights and their potential to enhance urban aesthetics and safety. Overall, the study's results align closely with existing literature, affirming that LED streetlights are viewed as the most cost-effective and efficient option compared to incandescent, fluorescent, and high-pressure sodium alternatives. While interviewees generally expressed moderate satisfaction with current street lighting, they emphasised the imperative for better maintenance practices to maximise efficiency and longevity. Their positive outlook on the transition to LED streetlights reflects broader recognition of the environmental benefits driving this shift in urban infrastructure.

4.3 Recommendations to Enhance the Implementation of LED streetlights in Malaysia

In this interview part, the interviewees were asked to provide score to each recommendation statement, indicating their level of agreement on the enhancement of LED streetlights implementation from the impact of investing in research and development, providing financial incentives, collaborations between government agencies and private sectors, the importance of workshops and training, and strengthening regulations and guidelines. The results for each recommendation statement are presented in Table 3 below:

Table 3: Recommendations to Enhance the Implementation of LED Streetlights in Malaysia

Rank	Questions	Mean	SD
1	Based on your expertise, could you kindly rate the level of agreement that fostering collaborations between government agencies and private sectors to leverage expertise, resources, and funding can improve the integration of LED Street Lights in Malaysia?	4.80	0.45
2	Based on your expertise, could you kindly rate the level of agreement that strengthens the government's current regulations and guidelines can improve the integration of LED Street Lights in Malaysia?	4.60	0.55

Rank	Questions	Mean	SD
3	Based on your expertise, could you kindly rate the level of agreement that providing financial incentives can improve the integration of LED Street Lights in Malaysia?	4.40	0.89
4	Based on your expertise, could you kindly rate the level of agreement that providing workshops and training to enhance the skills of stakeholders in street lighting projects can improve the integration of LED Street Lights in Malaysia?	4.20	1.30
5	Based on your expertise, could you kindly rate the level of agreement that investing in research and development to reduce the initial expenses of LED Street Lights can improve the integration of LED Street Lights in Malaysia?	4.00	1.23

The study emphasizes the pivotal role of fostering collaborations between government agencies and the private sector in Malaysia to enhance the integration of LED streetlights (Hashim et al., 2017). This strategy received the highest mean score of 4.80 and low standard deviation score of 0.45, indicating a strong consensus established among the interviewees. Collaborations facilitate more efficient resource utilization, streamline implementation processes, and promote the exchange of best practices, thereby bolstering overall project effectiveness. Second rank mean score (4.60) is the strengthening of government regulations and guidelines, aligning with findings from Ding et al. (2020). Enhanced guidelines contribute to better planning, reduce uncertainties, and instil confidence among stakeholders in adopting new technologies. This regulatory framework is crucial for addressing common challenges and mitigating risks associated with LED street lighting projects, supporting municipalities, contractors, and other stakeholders in making well-informed decisions. Financial incentives, such as subsidies, tax rebates, and grants, were also discussed as viable strategies to accelerate the adoption of LED streetlights, although opinions varied among interviewees. These incentives aim to alleviate the high initial costs associated with LED installations, thereby fostering faster adoption rates across Malaysia. Conversely, investing in research and development to reduce the costs of LED streetlights received the lowest consensus among the proposed strategies. This highlights the need for further exploration and alignment of stakeholder priorities in advancing cost-effective LED solutions for street lighting, ensuring sustainable and efficient urban infrastructure development.

5.0 CONCLUSION

This paper has presented the outcome of comparative analysis of conventional and light-emitting diode (LED) street lighting systems in Malaysia, evaluating their performance, energy efficiency, and alignment with national sustainability goals. The study findings have established that the LED streetlights outperform traditional lighting in terms of energy savings, environmental impact, lifespan, and maintenance costs. The study underscores the importance of adopting LED technologies in achieving the three key Sustainable Development Goals, i.e. SDG 7, SDG 9, and SDG 11, and recommends policy enhancements, public-private partnerships, and workforce training as critical enablers of nationwide implementation. The outcome of the study could serve as a basis to facilitate and guide the policymakers and urban planners in developing sustainable and efficient road lighting infrastructure aligned with Malaysia's green agenda.

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Ishak, S. N. A. N. M. (2024). Advancing Sustainable Street Lighting in Malaysia: Assessing Performance and Implementation Barriers of LED Solutions. [Unpublished Degree's Dissertation], International Islamic University Malaysia.

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Professional Bodies' Perspectives on Corruption Definitions, Risks and Mitigation in the Malaysian Built Environment Sector

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ABSTRACT

The built environment sector is central to Malaysia's national the built environment sector is a critical driver of Malaysia's economic growth and societal development, yet it is widely recognised as highly susceptible to corruption. This study examines corruption risks and mitigation strategies within the sector from the perspective of professional bodies. Employing a qualitative approach, semi-structured interviews were conducted with six senior representatives from key professional bodies, which were the Board of Architects Malaysia, Board of Engineers Malaysia, Board of Quantity Surveyors Malaysia, Land Surveyors Board, Board of Town Planners Malaysia, and the Institute of Landscape Architects Malaysia. Participants were selected based on their extensive professional experience and positions of authority within their organisations, ensuring informed insights on governance, ethics, and sectoral practices. Findings indicate that corruption is multi-dimensional, occurring at all stages in the built environment, from tendering to construction and post-contract compliance. Tendering was identified as the stage most prone to integrity risks, driven primarily by large financial transactions, procedural ambiguities, and social pressures. While respondents believe that professionals are generally not the main actors in corrupt practices, they operate within a system that can enable misconduct, highlighting the importance of ethical awareness and institutional guidance. Professional bodies play a crucial role in promoting integrity, through mechanisms such as ethics-based examinations, professional development programmes, whistleblower policies, and collaborative initiatives with the Malaysian Anti-Corruption Commission. Despite their limited statutory authority, these bodies contribute significantly to safeguarding public interest and reinforcing ethical standards. The study concludes that effective corruption mitigation by the professional bodies requires integrated governance across project stages, strengthened professional ethics, and continuous collaboration between professional bodies and regulatory authorities. These findings provide practical implications for policymakers, professional bodies, and practitioners, offering insights into corruption risks and strategies to enhance transparency, accountability, and professional integrity in Malaysia's built environment sector.

Keywords: Corruption, built environment, professional bodies, risk perception, Malaysia.

1.0 INTRODUCTION

The built environment sector is a central driver of Malaysia's socio-economic development, underpinning national growth through its contribution to the economy, physical and social development, as well as environmental sustainability. As it delivers essential infrastructure, the sector supports economic productivity, enhances social well-being, and sustains Malaysia's long-term competitiveness. Yet, despite its strategic importance, the sector remains highly susceptible to corruption. This vulnerability is amplified by the inherent scale of construction projects, the technical and administrative complexity of project delivery systems, and the frequent reliance on high-value contracts involving multiple stakeholders (Sohail & Cavill, 2006; Mohd Nordin, Takim, & Nawawi, 2012).

Although Malaysia has established comprehensive anti-corruption provisions under the Malaysian Anti-Corruption Commission Act 2009 [Act 694], corruption continues to permeate various stages of the project lifecycle. While offences such as bribery or the solicitation of gratification are widely understood, more complex and less obvious forms of misconduct, such as claim falsification, bid rigging, collusive tendering, and the abuse of public office, are often not fully recognised by practitioners. This limited understanding among professionals contributes to a persistent disconnect between the legal frameworks governing anti-corruption and the practical realities of industry operations.

Corruption in the built environment sector has been widely examined across multiple disciplinary perspectives, reflecting the sector's complexity and its susceptibility to integrity risks. Existing research highlights not only the structural and operational vulnerabilities inherent in construction and development processes but also the broader governance frameworks that shape ethical conduct within the sector. A review of the literature is therefore essential to situate this study within established theoretical and empirical debates, to identify prevailing knowledge gaps, and to clarify how professional bodies contribute to strengthening integrity in the built environment. This section synthesises existing research on corruption concepts and typologies, governance mechanisms, sector-specific risk factors, and the evolving role of professional institutions in promoting ethical practice.

Absence of a Sector-Specific Definition of Corruption

While the Malaysian Anti-Corruption Commission Act 2009 [Act 694] outlines a comprehensive set of corruption offences (Sections 16–23) and defines "gratification" in broad terms (Section 3), it does not provide a definition tailored to the unique characteristics of the built environment sector. Given the sector's diverse activities, multi-layered contracting structures, and complex regulatory landscape, these generic legal provisions may not sufficiently reflect the varied forms of corruption that could occur in practice. As a result, professionals may struggle to determine whether certain sector-specific behaviours constitute corruption, leading to ambiguity and inconsistent interpretation.

Growing Number of Corruption Cases within the Built Environment Sector

Corruption remains a persistent challenge globally, and Malaysia is no exception. Numerous studies consistently identify the built environment sector as one of the most corruption-prone domains (Hassan, Seow & Masrom, 2023; Mohd Nordin et al., 2023; Shafien & Sarpin, 2023; Yap et al., 2022; Lee, 2019). Former MACC Chief Commissioner Dato' Abu Kasim Mohamed previously emphasised the scale of corruption in this sector, describing it as severe and systemic ("Rasuah Dalam Industri Pembinaan Serius: SPRM", 2009). Although MACC's annual arrest statistics do not disaggregate cases by sector, overall corruption cases have risen markedly, increasing by 20% in a single year, from 909 reported cases in 2022 to 1,137 in 2023 (MACC Community Education Division, 2023). Given the sector's size, complexity, and high financial stakes, it is reasonable to infer that the built environment may constitute a substantial share of this increase.

Underutilised Role of Professional Bodies in Corruption Mitigation

Professional bodies govern the standards, competencies, and ethical conduct of practitioners across the built environment sector. Their strategic position enables them to shape professional norms, strengthen accountability mechanisms, and promote integrity-driven practices. Yet, their roles in corruption mitigation remain underexplored and, in some contexts, underutilised. Understanding how these bodies perceive corruption risks and their responsibilities in addressing them is therefore essential for strengthening governance across the sector. This study seeks to fill this gap by examining professional bodies' perspectives on corruption risks and mitigation efforts within Malaysia's built environment.

In overall, the existing body of literature underscores that corruption in the built environment sector is shaped by a combination of structural vulnerabilities, governance gaps, and varying levels of professional awareness. While prior studies have provided valuable insights into corruption typologies, sectoral risk factors, and institutional frameworks, limited attention has been given to the specific role of professional bodies as custodians of ethical standards and gatekeepers of professional conduct. This gap highlights the need for empirical inquiry into how these bodies perceive corruption risks and how they interpret their responsibilities in strengthening integrity within the sector. The subsequent section outlines the research methodology adopted to address this gap and to systematically examine these professional perspectives.

Given these gaps, there is a pressing need to better understand how professionals within the built environment perceive corruption risks and how they interpret their roles in upholding integrity. Professional bodies, as regulators of professional conduct and custodians of ethical standards, hold an influential position in shaping sector-wide governance. This paper therefore examines corruption risks and mitigation strategies in the Malaysian built environment sector from the perspective of these professional bodies.

The objectives of this paper are threefold:

i. To identify the perceptions of professional bodies regarding corruption risks across the built environment sector
ii. To assess the perceived roles and responsibilities of professional bodies in curbing corruption within the sector; and
iii. To examine the perspectives of professional bodies on corruption definitions and offences under Act 694.

2.0 LITERATURE REVIEW

Corruption within the built environment sector has been widely examined across global, regional, and disciplinary perspectives due to the sector's structural vulnerabilities, financial magnitude, and extensive stakeholder interactions. Existing research highlights that corruption risks are embedded not only in project delivery systems but also in broader governance arrangements that regulate professional conduct and institutional accountability. To situate the present study within these wider debates, this literature review synthesises scholarship on corruption typologies, conceptual definitions, the characteristics of the built environment sector, and the governance roles of professional bodies. Together, these themes provide the conceptual grounding for analysing corruption risks and mitigation strategies from the perspective of professional institutions in Malaysia's built environment sector.

2.1 Corruption in the Built Environment: A Global Perspective

Internationally, corruption in the construction and built environment sector is recognised as a pervasive and persistent problem. The sector has long been regarded as one of the most corruption-prone due to its large-scale, capital-intensive projects and their reliance on long, complex chains of decision-making involving clients, consultants, contractors, suppliers, and regulators (Kenny, 2009). Such characteristics create significant opportunities for misconduct at all stages of the project lifecycle, from planning and procurement to implementation and operation, and ultimately undermining project value, public confidence, and governance structures (Sohail & Cavill, 2006). Studies from emerging economies further demonstrate that corruption inflates project costs, compromises construction quality, leads to delays, and contributes to incomplete or abandoned projects (Doraisamy, Akasha, & Yunus, 2014; Lee, 2019). Empirical findings from Nigeria (Oyewobi et al., 2011), South Africa (Bowen, Edwards, & Cattell, 2012), China (Le, Ming, Chan, & Hu, 2014), and Malaysia (Yap, Lee, Rose, & Skitmore, 2022) collectively illustrate that corruption has become deeply entrenched in the culture and operation of the built environment industry in many countries.

2.2 Definition of Corruption

Scholars classify corruption in the built environment into several identifiable forms, each representing different mechanisms through which unethical behaviour may occur. Bribery and kickbacks involve payments or rewards aimed at influencing contract awards, approvals, or regulatory decisions. Collusion and bid rigging refer to covert arrangements among contractors or suppliers to manipulate tender processes. Fraud and misrepresentation

include inflated claims, falsified documentation, or diversion of project funds. Other forms include cronyism, nepotism, and abuse of office, all of which reflect the misuse of power or influence for personal or organisational gain. These typologies collectively demonstrate that corruption extends beyond simple monetary transactions and encompasses broader systemic misuse of authority, discretion, and professional judgement (Transparency International Malaysia, n.d.; IMF, 2019).

The concept of corruption itself has been defined in various ways by legislation, international organisations, and academic scholars. In general, corruption is understood as misconduct or the abuse of entrusted power for personal benefit. Malaysia's Act 694 does not provide a single overarching definition of corruption but instead defines it through specific offences outlined in Sections 16 to 23. The Act also provides an expansive definition of "gratification," which covers any item of value, service, favour, or advantage that may influence an individual's actions (Section 3).

Internationally, Transparency International Malaysia characterises corruption as the abuse of entrusted power for private gain, whereas the International Monetary Fund conceptualises it as a secretive exchange between two parties, typically involving fraud, misappropriation, or manipulation of authority in return for promised benefits. Academic perspectives build on these views by highlighting the contextual and behavioural dimensions of corruption. Lee (2019), for example, associates corrupt practices with the erosion of integrity influenced by economic incentives and institutional weaknesses. Collin et al. (2009), as cited in Yap et al. (2022), argue that corruption is shaped by individual morals, societal norms, personal incentives, and social relationships. Other scholars, such as Cazurra (2015) and Sohail and Cavill (2006), emphasise that corruption is not confined to political and governmental contexts but may arise in private firms, non-profit organisations, and across a range of professional environments, manifesting in diverse forms including embezzlement, extortion, nepotism, fraud, and conflicts of interest.

2.3 Built Environment Sector

Understanding corruption within the built environment sector also requires establishing a clear conceptualisation of the sector itself. The built environment refers broadly to human-made surroundings created to support and enhance human activities, encompassing buildings, infrastructure, public spaces, and facilities (Valence, 2019; Croome, 2004). As a sector, it encompasses the planning, design, construction, management, and operation of these spaces, reflecting a highly integrated system involving multiple professional disciplines (Croome, 2004; Valence, 2019).

Public perceptions commonly associate the built environment with visible structures such as housing and infrastructure, but the sector more broadly represents a society's developmental aspirations and socio-economic goals. It is dynamic and continually evolving in response to changes in societal needs, environmental conditions, technological advancements, and regulatory frameworks.

The delivery of built environment projects is inherently complex, requiring coordination among a diverse range of professionals, including planners, architects, engineers, surveyors, project managers, legal advisors, financial institutions, material suppliers, and regulatory authorities (Valence, 2018; Pearce, 2003). This complexity underscores why the sector is particularly vulnerable to corruption, where the involvement of multiple actors and institutions increases the number of potential areas where discretion may be exercised and exploited.

2.4 Built environment professional body

Within this context, professional bodies play a central role in regulating practice and ensuring ethical conduct across the built environment sector. A professional body is typically a statutory or regulatory institution established under a specific act or legal provision, mandated to oversee the standards, competencies, and ethical conduct of practitioners within a profession. In Malaysia, such bodies include the Board of Architects Malaysia, Board of Engineers Malaysia, Board of Quantity Surveyors Malaysia, and Board of Town Planners Malaysia. These bodies were established under their own act to regulate training, oversee accreditation, maintain professional registers, enforce codes of practice, and administer disciplinary mechanisms.

International literature highlights that professional bodies are crucial custodians of public interest and professional integrity. In jurisdictions such as the United Kingdom, Australia, and Singapore, professional

institutions play a strong role in developing ethical standards, issuing practice guidelines, and disciplining members involved in misconduct (Greenwood & Hinings, 1996; Abbott, 1988). Increasingly, professional bodies are recognised as key actors in anti-corruption governance, responsible for embedding ethical norms, providing continuous professional development in integrity, mediating between industry and government, and reinforcing accountability across project delivery systems.

However, their effectiveness varies across countries, often limited by resource constraints, weak enforcement mechanisms, or insufficient integration with national anti-corruption strategies (Amaratunga & Haigh, 2011). The literature also suggests that in many emerging economies, including Malaysia, the potential of professional bodies to influence anti-corruption outcomes remains underexplored and, in some cases, underutilised.

2.5 Built environment professional body

Corruption risks within the built environment sector manifest across multiple points in the project life cycle, reflecting the sector's inherent complexity, multiplicity of actors, and high transaction value. As highlighted by Sohail and Cavill (2006) and Mohd Nordin, Takim, and Nawawi (2011), construction projects move through a series of decision-intensive stages, each involving specialised expertise, professional discretion, and information irregularities. These characteristics create varying levels of vulnerability to integrity breaches. A clearer understanding of when and how such risks occur is therefore essential for strengthening governance systems and designing more targeted mitigation strategies.

Procurement and Tendering

The tendering stage is widely regarded as one of the most sensitive components of project delivery, given its reliance on fair competition, transparency, and adherence to procedural integrity (Le, Ming, Chan, & Hu, 2014; Yap, Lee, Rose, & Skitmore, 2022). Activities such as bid preparation, tender evaluation, and award processes involve significant financial decision-making and interactions among contractors, consultants, and procuring authorities or clients. Corruption risks at this stage may arise from limited transparency, uneven access to project information, or ambiguous procedural guidelines. Importantly, not all irregularities stem from deliberate misconduct; adjustments to tender specifications, preferential treatment, or sole reliance on familiar contractors may arise from administrative constraints, tight timelines, or established working relationships.

Malaysia has introduced a range of procurement governance reforms in response to these sensitivities. Initiatives such as e-procurement platforms, the Integrity Pact mechanism, and the public disclosure of awarded contracts aim to enhance transparency and reduce opportunities for discretionary bias. Ongoing capacity building, as well as consistent enforcement of procurement rules, remains crucial for strengthening public trust and ensuring equitable participation within the tendering environment.

Construction Stage

As projects progress to the construction stage, the complexity of on-site operations amplifies the potential for monitoring challenges and information gaps. This phase typically involves multiple subcontractors, suppliers, and consultants, each contributing to activities that must be coordinated in real time. Such fragmentation increases the likelihood of corruption risks associated with cost variations, material quality, documentation accuracy, and change order management (Mohd Nordin et al., 2011; Kenny, 2009). Many of these risks may emerge unintentionally due to unclear contract provisions, communication breakdowns, or inadequate supervision. Nonetheless, they create vulnerabilities that, if exploited, can escalate into more severe compliance issues.

Technological solutions have begun to reshape the governance landscape at this stage. Tools such as Building Information Modelling (BIM), real-time project monitoring systems, and performance-based auditing frameworks enhance transparency and support early identification of anomalies. These innovations provide more robust oversight mechanisms and reduce opportunities for administrative errors or deliberate manipulation of project records.

Certification and Compliance

Certification and compliance constitute the final stage of the project cycle, where built assets are evaluated for conformity with design, regulatory, and safety requirements. Because this stage relies heavily on professional judgment, technical assessments, and official endorsement, it plays a central role in upholding sectoral integrity

(Lee, 2019). Common risks include delays in approvals, inconsistent interpretation of regulations, and procedural inefficiencies that may lead to perceptions of unfairness or prompt informal attempts to expedite endorsements. Addressing these vulnerabilities requires clear regulatory guidelines, transparent documentation practices, and efficient approval workflows.

Malaysia's implementation of the Certificate of Completion and Compliance (CCC) represents a significant institutional shift toward professional accountability. By placing responsibility on principal submitting persons, the CCC aims to streamline processes while reinforcing ethical duties. To maintain its credibility, however, the system must continue to be supported by ethics-oriented professional training and digital record-keeping mechanisms that minimise discretion and improve traceability.

2.6 Interconnected Risks and Institutional Considerations

The literature underscores that corruption risks should not be viewed as isolated incidents confined to specific project stages. Rather, they are interdependent and often cumulative (Sohail & Cavill, 2006). Weaknesses in tendering and procurement may create pressures that surface during construction, while poor construction oversight can complicate certification and compliance processes. Effective preventive strategies therefore require an integrated governance perspective that strengthens transparency, documentation, and ethical competence across the entire project cycle.

Recent studies further highlight that improving integrity in the built environment sector cannot be achieved through legislation alone. Transparency International's findings (as cited in Yap et al., 2022) and evidence from field-based professional engagements point to the need for stronger institutional collaboration, particularly involving professional bodies that regulate conduct within the sector. Professionals generally express support for clearer ethical guidelines, more rigorous institutional monitoring, and user-friendly reporting channels to encourage consistent interpretation and application of integrity standards.

Table 1: Summary of Key Corruption Risks and Governance Opportunities Across Construction Project Stages

Project Stage	Potential Integrity Challenges	Underlying Factors	Recommended Governance Enhancements
Procurement & Tendering	Limited transparency, uneven access to information	Complex procedures, time constraints, reliance on discretion	E-tendering, Integrity Pacts, capacity training for evaluators
Construction	Cost variations, supervision gaps, reporting inconsistencies	Project complexity, multi-tier subcontracting, communication gaps	BIM-based monitoring, third-party audits, improved reporting standards
Certification & Compliance	Delay in approvals, differing interpretations, potential favouritism	Manual processes, overlapping responsibilities, procedural ambiguity	Digital certification, ethics awareness, standardised approval criteria

Overall, the literature establishes that corruption in the built environment sector is shaped by interconnected factors, including structural vulnerabilities, governance frameworks, institutional pressures, and the ethical standards upheld by professional actors. While considerable research has explored corruption typologies, sectoral risks, and international governance frameworks, empirical studies focusing on the role of professional bodies, particularly within the Malaysian context, remain limited. This gap highlights the need to examine how professional institutions understand corruption, how they perceive associated risks, and how they interpret their regulatory and ethical responsibilities in strengthening integrity across the sector. The subsequent section outlines the research methodology adopted to address these gaps and to systematically capture the perspectives of built environment professional bodies in Malaysia.

3.0 METHODOLOGY

This study employed a qualitative research design, using semi-structured interviews to gather in-depth insights from representatives of professional bodies within the built environment sector. The study focused on six key professional bodies in Malaysia, which were selected for their regulatory and governance roles over practitioners in the sector. These bodies included the Board of Architects Malaysia, Board of Engineers Malaysia, Board of Quantity Surveyors Malaysia, Land Surveyors Board, Board of Town Planners Malaysia, and the Institute

of Landscape Architects Malaysia.

Interview respondents were nominated by each professional body, subject to criteria established by the researchers. To ensure the provision of informed and representative perspectives, respondents were required to be registered members who currently hold, or have previously held, senior positions within their respective professional bodies. This selection criterion was intended to guarantee respondents' familiarity with the governance, operational procedures, and initiatives of their organisations, as well as their ability to articulate collective institutional viewpoints. One representative from each professional body participated in the study, resulting in six interviewees in total.

Data collection was conducted through online interviews between 19 July and 8 August 2024. A total of six interview sessions were completed, corresponding to one session per professional body. Semi-structured interview protocols were employed to ensure a consistent framework across sessions while maintaining flexibility to explore emerging themes. Respondents were asked questions regarding their awareness and understanding of corruption definitions and offences as outlined in the Malaysian Anti-Corruption Commission Act 2009 [Act 694], their perceptions of corruption risks across different stages of construction projects, and the roles and responsibilities of professional bodies in mitigating corruption within the built environment sector.

All interview data were analysed using thematic analysis, a method well-suited for identifying patterns, concepts, and insights across qualitative datasets. Through this approach, the study sought to uncover both shared and divergent perspectives among the professional bodies regarding corruption risks and governance practices. The thematic analysis enabled a systematic interpretation of the qualitative data, providing a foundation for subsequent discussion of findings, implications, and recommendations.

4.0 DISCUSSION AND FINDINGS

The study engaged six representatives from key professional bodies within Malaysia's built environment sector, all of whom currently hold, or have previously held, high-ranking positions such as Chairman, Registrar, or Council Member in the selected professional bodies. These respondents also occupy senior or mid-level roles, such as architects, engineers, planners, quantity surveyors, and project managers, in their respective employment organisations, with active involvement in both public and private sector projects. Their professional experience ranges from five to over twenty-five years, providing a broad and nuanced understanding of ethical practices, governance, and operational realities in project management.

The respondents represented a balanced age distribution, with younger professionals (under 35 years) contributing perspectives on emerging challenges and contemporary awareness of ethical issues, while senior practitioners (above 45 years) offered insights grounded in long-standing industry practices. This diversity allowed the study to capture multiple perspectives on corruption risks, professional ethics, and governance across technical, managerial, and regulatory contexts.

i) Awareness and Perceptions of Corruption

Respondents indicated that defining corruption in the built environment sector is inherently complex, as its manifestations vary according to context and circumstance. Many emphasised that even minor actions, such as a meal or token gift, could be construed as corrupt under certain conditions. Based on the Malaysian Anti-Corruption Commission Act 2009 [Act 694] and their respective professional bodies' Acts, respondents defined corruption broadly as offering or accepting any commission or benefit deemed illegal by the disciplinary committees of the professional bodies. Members are prohibited from providing or receiving advantages to secure work, and breaches of these rules constitute professional misconduct. Several respondents also described corruption in behavioural terms, as seeking excessive profit through improper means, including non-compliance with prescribed requirements or persuading others to overlook breaches. These interpretations highlight both the statutory and ethical dimensions of corruption within the professional context.

The respondents also observed that awareness of corruption among professionals is uneven and often dependent on generational factors, previous exposure to governance training, and professional experience. Younger respondents highlighted emerging ethical challenges, such as pressures from digital procurement systems and client demands for accelerated project delivery, which may create subtle forms of inducement or

expectation. In contrast, senior respondents reflected on systemic risks embedded in long-standing industry practices, including legacy relationships and entrenched informal networks that may influence decision-making. Collectively, these perspectives underscore the need for continuous professional development and institutional guidance on recognising and responding to corruption risks.

ii) Corruption Risks Across Project Stages

Respondents overwhelmingly agreed that corruption has become a normalised risk within the built environment sector. The Public Works Department was specifically noted as being among Malaysian Anti-Corruption Commission's (MACC) top ten high-risk agencies. While professional bodies do not typically handle corruption cases directly, since such matters are reported to MACC, some cases involving professionals have nonetheless proceeded to prosecution.

Respondents observed that professionals themselves are seldom the principal actors in corrupt activities, as they generally lack ultimate authority, whereas developers, often described as "paymasters," are central to the process.

Corruption risks were identified across all stages of project delivery. During the pre-contract phase, vulnerabilities arise in procurement, project approvals, cost estimation, and tender documentation. Respondents highlighted that tendering processes are particularly prone to corruption due to the large financial stakes and discretionary powers involved. During construction, risks emerge in areas such as expediting payments, obtaining the Certificate of Completion and Compliance (CCC), labour approvals, and phase completion endorsements. Post-contract risks include contractor compliance, adherence to specifications, interim payments, variation orders, misuse of certificates, and verification of payments. Respondents emphasised that these risks are interconnected, with weaknesses in earlier stages often amplifying vulnerabilities in subsequent stages. This finding aligns with the literature, which emphasises that integrity risks are cumulative and systemic rather than isolated (Sohail & Cavill, 2006; Yap et al., 2022).

iii) Factors Contributing to Corruption

Respondents identified multiple factors contributing to corruption within the built environment sector. Financial incentives, particularly large monetary transactions, were consistently cited as the primary driver. Other contributing factors include personal negligence, procedural lapses, intense competition, and life pressures that may motivate individuals to compromise ethical standards. Some respondents highlighted that corruption often begins when professionals take on projects below the prescribed fee scale, resulting in insufficient resources and creating pressure to cut corners or accept inducements to maintain project viability. The respondents also noted that corruption may originate from either contractors or authorities, and in the private sector, bribery is often used to secure projects from clients. Zoning decisions in the public sector, such as converting agricultural land to industrial land, were cited as specific opportunities for corrupt activity, particularly when influenced by political or economic interests.

The respondents further observed that the complexity of construction contracts contributes to systemic vulnerabilities. Full compliance with regulatory and contractual requirements is often difficult to achieve, and shortcuts or bribes are sometimes used to expedite project completion. These observations highlight the multi-dimensional nature of corruption in the sector, encompassing financial, procedural, and social factors.

iv) Roles and Responsibilities of Professional Bodies

Regarding the role of professional bodies in mitigating corruption, respondents agreed that their authority is limited to what is explicitly prescribed in their establishing Acts. Core functions include member registration, management of disciplinary cases, enforcement of ethical standards, and ensuring public and environmental safety. Professional bodies act only on offences explicitly covered in their Acts, typically following the submission of formal complaints. While these Acts do not explicitly define corruption, they encompass principles of integrity, professional governance, misconduct, public interest, and conflicts of interest. Terms such as "misconduct" and "malpractice" are considered sufficiently flexible to safeguard the profession while protecting public interest, and most respondents questioned the need for additional anti-corruption clauses, given the coverage already provided under Act 694.

Professional bodies have implemented various initiatives to foster ethical behaviour and mitigate corruption risks. These include annual roadshows and seminars on legislation, governance, and professional ethics, often supplemented by real-case illustrations to enhance practical understanding. Integrity-related webinars, typically held in conjunction with Integrity Day, provide additional awareness-raising opportunities. Most professional bodies have introduced whistleblower policies that guarantee confidentiality and encourage reporting of misconduct, while collaboration with MACC further strengthens monitoring and education efforts. Membership criteria, professional examinations, and ethics courses collectively reinforce the emphasis on professional integrity, ensuring that practitioners are adequately equipped to navigate complex ethical and governance challenges. Through these measures, professional bodies actively promote a culture of transparency, accountability, and professional excellence.

Integration with Literature

The findings from this study corroborate prior research on corruption in the built environment sector, which emphasises the sector's susceptibility due to high financial stakes, multiple stakeholders, and complex governance arrangements (Kenny, 2009; Sohail & Cavill, 2006; Yap et al., 2022). The respondents' perspectives extend the literature by providing an insider view of the ethical challenges faced by professionals, including the interplay between institutional regulations, individual conduct, and systemic vulnerabilities. In particular, the emphasis on interconnected risks across project stages and the centrality of professional bodies in safeguarding integrity provides practical insights into effective governance strategies.

6.0 CONCLUSION

This study explored corruption risks and mitigation strategies in Malaysia's built environment sector from the perspective of professional bodies. The findings indicate that corruption is pervasive and multi-dimensional, occurring across all stages of project delivery, from procurement and tendering to construction and post-contract compliance. While professionals themselves are generally not the principal actors in corrupt activities, they operate within complex systems in which financial incentives, procedural ambiguities, and social pressures create opportunities for unethical behaviour. Tendering processes were identified as particularly vulnerable, reflecting the high monetary stakes and discretionary powers inherent in these stages.

Professional bodies play a critical, albeit constrained, role in promoting integrity and ethical practices. Their authority is limited by statutory provisions, yet their initiatives, such as ethics-based professional examinations, continuous professional development programmes, whistleblower policies, and collaborative programmes with MACC, demonstrate a proactive approach to fostering transparency, accountability, and professional excellence. While explicit anti-corruption clauses are not included in their Acts, the broader coverage of misconduct, malpractice, and integrity principles provides sufficient scope to safeguard public interest and guide professional conduct.

The findings also highlight the importance of viewing corruption risks as systemic and interconnected. Weaknesses in one stage of the project cycle often amplify vulnerabilities downstream, underscoring the need for integrated governance mechanisms that combine regulatory enforcement, institutional oversight, and professional ethics. Moreover, generational and experiential differences among professionals suggest that awareness-raising and targeted capacity-building initiatives remain essential to reinforce ethical norms and reduce tolerance for corrupt practices.

Based on these insights, the study offers several recommendations. First, professional bodies should continue and expand collaborative initiatives with regulatory authorities, particularly MACC, to enhance understanding, awareness and education on corruption risks, and ethical and legal obligations. Second, ethics and integrity modules should be further integrated into professional development programmes, targeting both early-career and senior practitioners to ensure consistent awareness across generations. Third, professional bodies should explore the use of technology-enabled monitoring systems, including digital record-keeping, automated reporting tools, and project-tracking platforms, to strengthen transparency throughout project delivery stages.

Fourth, maintaining flexibility within disciplinary frameworks while ensuring clarity of ethical expectations can help professional bodies respond effectively to emerging forms of corruption without overly complicating their

governing Acts. Fifth, professional bodies are encouraged to enforce and monitor strict adherence to their professional codes of conduct among registered members, thereby ensuring that high standards of integrity are consistently maintained across the sector.

Finally, professional bodies should develop and implement their own Organisation Anti-Corruption Plan (OACP) to systematically address weaknesses in organisational governance, integrity, and anti-corruption practices. The OACP can serve as a strategic platform for internalising anti-corruption values within both the professional body and its members, promoting a culture of ethical behaviour, accountability, and transparency throughout the organisation.

In conclusion, corruption in the built environment sector is a persistent challenge, shaped by structural, procedural, and behavioural factors. Professional bodies are uniquely positioned to mitigate these risks through regulation, education, and governance, thereby safeguarding public interest and enhancing professional accountability. The insights from this study contribute to a better understanding of sector-specific corruption risks and highlight the practical measures that can be undertaken to strengthen integrity governance in Malaysia's built environment sector.

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DESIGN AND MANAGEMENT CHALLENGES IN CREATING CHILD-FRIENDLY MASJID: PARENTAL PERSPECTIVES FROM MALAYSIA

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ABSTRACT

The masjid should be an inclusive and welcoming space for all, including children as integral members of the jamāʿah (congregation). In Malaysia, while acceptance of children in masjids has improved, many parents still face challenges related to design inadequacies, management gaps, and social attitudes. This study aims to explore parental experiences and identify the key design and management challenges in creating child-friendly masjids. Semi-structured interviews were conducted with twelve parents who regularly bring their children to the masjid. The interviews were transcribed, translated, and analysed using NVivo 12 through a deductive thematic approach to categorise emerging challenges. Findings indicate that parents' struggles cluster into three interconnected domains: physical – inadequate spatial layout, lack of child zones, and poor safety features; social – negative perceptions and intolerance among some congregants; and management – inconsistent policies, weak supervision, and insufficient facilities. Despite these obstacles, parents remain dedicated to introducing their children to religious life, underscoring a strong commitment to nurturing faith and communal belonging. The study concludes that effective masjid design must integrate child-friendly features such as designated yet visually connected zones, safe circulation, and acoustic treatments, complemented by responsive management and community engagement. These strategies can enhance the masjid's function as a nurturing space for families, reinforcing its role as both a spiritual and social hub. These findings contribute to developing inclusive design and management guidelines that promote holistic community participation.

Keywords: parental challenges, spatial planning, user experience, facility management, semi-structured interview

1.0 INTRODUCTION

Child-friendly masjid is a recurring topic of public interest that often arises during the month of Ramadhan. Many blogs and social media posts highlight this issue because the number of children attending the masjid is particularly high at this time. In response, several masjids in Malaysia have begun preparing dedicated areas or rooms and organising activities for children while their parents perform the night prayer (*tarāwīḥ)*. Thirteen masjids in the Klang Valley are recognised as child-friendly, encouraging parents to bring their children. These masjids even provide special nurseries during *tarāwīḥ*. Various writers acknowledge such proactive efforts by masjids' management (Musleh, 2019).

However, beyond Ramadhan, most masjids discontinue these facilities. Nurseries and play activities for children

are no longer available when parents participate in congregational prayer and other programs. Other *jamā'ah* may also expect children to remain silent and disciplined, which can lead to tension. Consequently, many parents continue to face challenges when bringing their children to the masjid. Social media is filled with parents' accounts of unfortunate experiences, such as receiving unwelcome gestures from other congregants, having their children scolded, or even being asked to leave the main prayer hall altogether (Shameem, 2012; Ghafar, 2018; Azmi, 2019). These experiences highlight how social attitudes intersect with physical and managerial aspects of the masjid environment. Such incidents indicate that the issue is not merely behavioral but reflects deeper design and management shortcomings within masjid environments.

Despite growing public discourse, there remains a lack of systematic, empirical research that examines these design and management challenges through structured investigations in the Malaysian context. Masjid design plays a crucial role in shaping user comfort, safety, and inclusivity, and thoughtful space planning is essential to ensure that children and families can participate without causing disruption. Therefore, this study aims to explore the design and management challenges experienced by parents when bringing their children to the masjid, focusing on how spatial, social, and managerial factors influence the inclusivity and functionality of these sacred community spaces.

2.0 LITERATURE REVIEW

Khalīfah can be described in two ways. *Khalīfah* means deputy or steward, and it is also translated as vicegerent (Oxford Islamic Studies Online). This general description indicates that everyone is a *Khalīfah* commanded by Allah SWT in verse 30, Surah Al Baqarah. *"And [mention, O Muhammad], when your Lord said to the angels, 'Indeed, I will make upon the earth a successive authority.' They said, 'Will You place upon it one who causes corruption therein and sheds blood while we declare Your praise and sanctify You?' Allah said, 'Indeed, I know that which you do not know'.* Therefore, every person is to hold the responsibility to care for humankind and the environment. Secondly, *Khalīfah* is also used to address the head of state in a Caliphate era (www.vocabulary.com). After the passing of Prophet Muhammad (PBUH), the Muslim community leaders were called *Khalīfah*. They carried specific duties - political, administrative, and military. In Islam, shaping a child is the responsibility of the parents first, and then the society. How to shape a child is clearly outlined in the Al Quran, in Surah Luqman. Ten pieces of advice from Luqman (Quran for Kids) to his son can be excerpted from this surah, as shown in the following Figure 1.

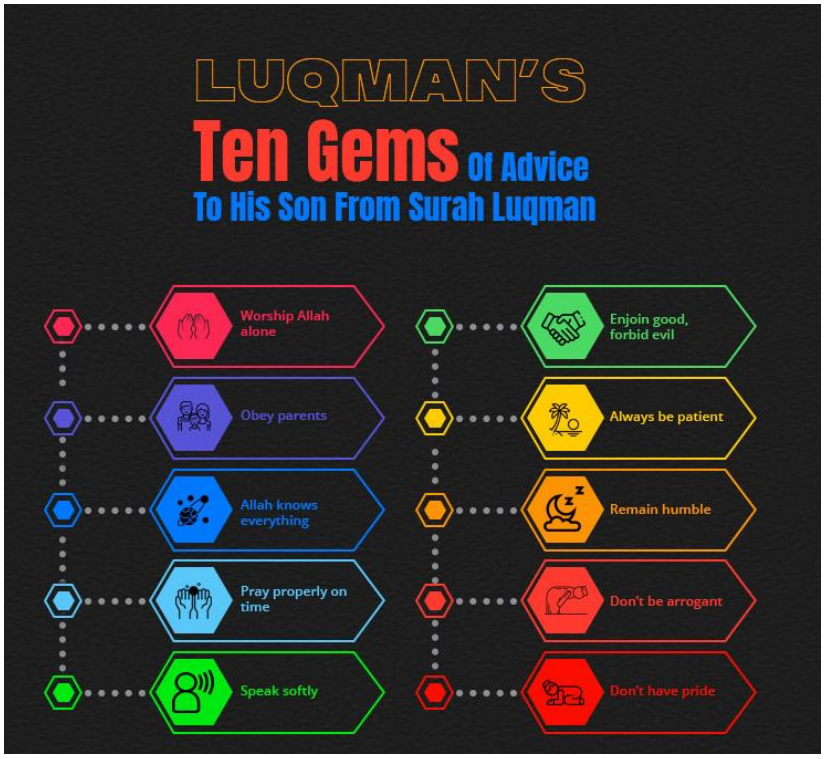

Fig. 1: Ten gems of advice from Luqman to his son
(Source: https://quranforkids.com/ten-advice-of-luqman/)

They are the fundamentals in shaping the faith (*'aqīdah*) and behaviour (*akhlāq*) of a child. *'Aqīdah* is very important to be established for a child to understand his/her purpose in life. Good *akhlāq* would help to achieve the mission of a *Khalīfah*.

Parents must educate their children to know Allah SWT's greatness, and nothing can be associated with Allah. Cultivating the right *'aqīdah* (creed), building and strengthening the children's faith and belief in the Oneness of Allah SWT should be done. Hence, parents must prepare their children with the proper knowledge that will allow them to know the commands of Allah SWT and the Prophet (SAW). Such knowledge is known as *farḍ al-'ayn* knowledge (knowledge obligatory upon every Muslim). The *farḍ al-'ayn* knowledge is not limited to only reading Al-Quran, but it also encompasses knowledge of *'aqīdah* and all the aspects of *Fiqh* (Islamic Jurisprudence) in the *farḍ al-'ayn* category.

With the basics of *'aqīdah*, children then need to be taught and trained to practice good *akhlāq*. One of these obligatory deeds is the establishment of prayers. Prayer is one of the five pillars of Islam. Prayer is the act that connects the young *Khalīfah* to his God and is also a form of protection against disobedience (Hassan, 2007). One of the perfect ways to foster these values is by exposing the children to the masjid. Congregational prayer at the masjid will help the children familiarise themselves with the routine. Thus, child-friendly masjids allow children to participate in religious activities and provide a space for learning etiquette and religious values (Dahlan, 2024).

In conclusion, the most critical aspects of children's education as future *Khalīfah* are installing the right *'aqīdah* and *akhlāq.* Children should be taught how to be religious and to encourage religiosity and goodness within others. Being religious, doing good to others, and encouraging others to do so is in line with the concept in Islam known as *ṣāliḥ wa muṣliḥ*. A *Khalīfah* that embraces this concept will be successful in this mortal world and the hereafter.

Dr Abdullah Nasih Ulwan – the leading Muslim scholar on children's early education-mentioned three physical places for children's education: home, masjid, and school (Nasih Ulwan, 2015). As mentioned earlier, the responsibility for shaping a child is first the task of the parents and then the society. A home is the parents' domain, while the masjid and school are the domain of society. These three places must be well coordinated in support of the development of young *Khalīfah* as envisioned by Islam. Thus, there is a need to integrate child-friendly designs into the masjid as it is one of the public facilities to make the masjid more inclusive (Sudirman et al., 2024).

There are several studies found concerning the masjid and its practices in Malaysia. However, these researchers are not relevant because the focus is not on the practices or policies for accommodating families with children. They were on financial management (Mohamed Adil et al., 2013; Said et al., 2013), facilities management in supporting mosque function and propose the key drivers for an effective FM practice for mosque (Sapri et al, 2016), innovative management strategies for income generation effectiveness in organizing community engagement activities towards poverty alleviation and inclusion in their *qaryah* or locality (Ismail et al., 2024), and digitalization in mosque tourism management (Sutrisno et al., 2022). There is a study in Indonesia about maximizing mosques' contributions to the development of Muslim households, helping the government achieve the Sustainable Development Goals (SDGs), especially those that relate to a healthy, prosperous living and high-quality education (Muchtar and Billah, 2022). It may seem similar to the nature of child-friendly masjid research, however it is not. Thus, it can be established that there is a gap in the literature that requires child-friendly masjid research to be conducted.

3.0 METHODOLOGY

To explore the challenges faced by parents when bringing their children to the masjid, a set of semi-structured interviews often employs a mix of closed and open-ended questions with follow-up probes such as *why* or *how* (Adams, 2015). With the right questions, the interview can develop naturally, enabling respondents to share deeper insights in a conversational yet focused manner. The relatively informal nature of this approach helped respondents feel comfortable and encouraged open sharing of experiences.

Respondents were identified through a criterion-based purposive sampling approach, focusing on parents who regularly attend the masjid with their children. Two complementary strategies were employed. First, the

researchers contacted the management of selected masjids to identify congregation members known to frequently bring their children to prayer and community activities. Second, on-site observations were carried out to identify parents who attended the masjid with their children. These parents were approached and briefly asked about their attendance patterns and willingness to participate. They expressed strong motivation to be involved, eager to share the challenges they faced when bringing their children to the masjid and driven by a desire to contribute towards improving the masjid environment for families. Through this combined approach, a total of twelve parents who met the selection criteria consented to take part in the study. The total of twelve respondents was considered sufficient in capturing thematic depth in a focused and small-scale study of this kind due to the qualitative and exploratory nature of the semi-structured interview method, which lies in obtaining rich, detailed, and contextual data. Data saturation – the point at which no new themes emerge – was observed within the twelve interviews.

Fig. 2 Sony IC Recorder

The interview was conducted in the Malay language and recorded using a Sony IC Recorder (ICD-PX440) - figure 2. The recorded interview was transcribed using online software (otranscribe.com) – *ontranscribe*. The translation from Malay to the English language was done verbatim, along with the analysis process.

The questions prepared are based on the literature review conducted. They cover the reasons for bringing children to the masjid; the frequency of attending masjid with their children; masjid's facilities; the behaviour of children; *jamā'ah's* perception on the children; their consciousness on the importance of children going to the masjid in their young ages; children's safety; the roles of the parents concerning children at the masjid; and others which are related to children and masjid. Respondents are allowed to communicate more freely and to provide more detailed descriptions. Through the in-depth and semi-structured interview, additional questions were asked based on the answers and responses. The NVivo software is used to analyse the data, as the interview data is qualitative (Dicicco-Bloom & Crabtree, 2006).

4.0 RESULTS

NVivo version 12 is used to analyse the interview data, which is qualitative. The objective of the analysis is to identify the challenges faced by parents while bringing their children to the masjid.

4.1 Analysis approach

In analysing semi-structured interview data, the deductive analysis approach is considered the most appropriate (Hyde, 2000). Deductive analysis analyzes some general ideas into specific terms or themes (Pellissier, 2008). All data collected will be organised into the particular codes, and usually, codes or themes are prepared in advance. The summary of the deductive analysis process involved in the study is shown in Figure 3.

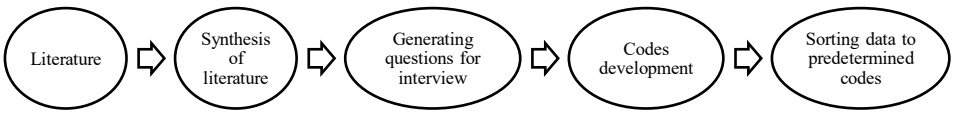

Fig. 3 The process of deductive analysis

There are three stages involved in this research. The first stage includes transcribing and translating the interview data. The second stage is inserting the transcription into the NVivo software, and this stage is where all the free codes develop into main themes. The third stage is managing and organising the codes to cross-reference all the codes created before. Figure 4 shows the details of the process.

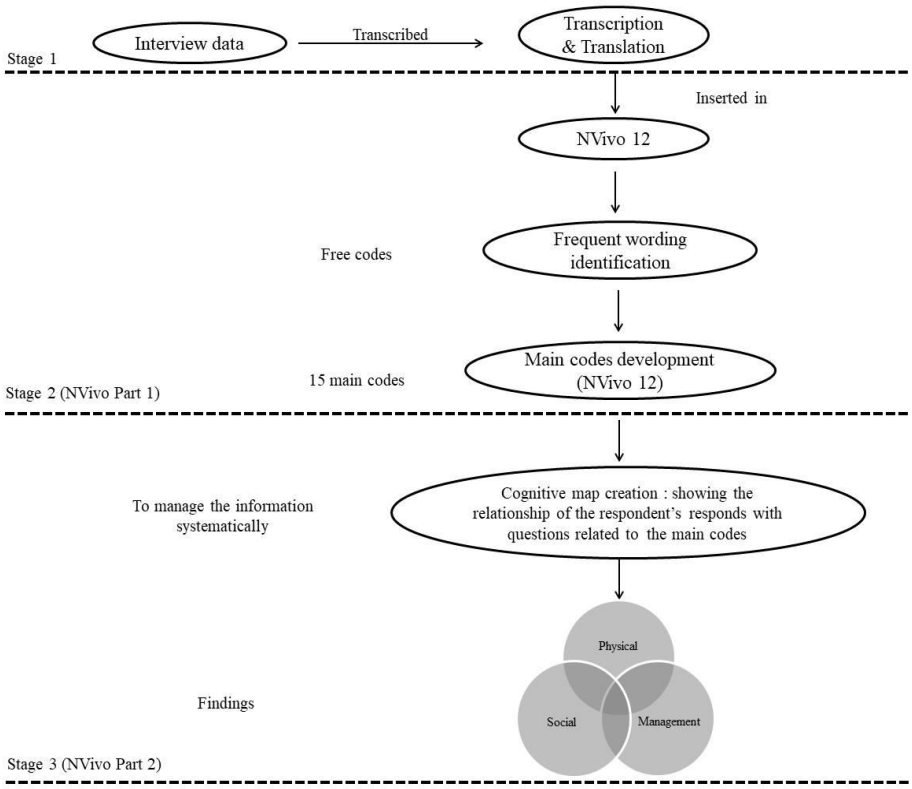

Fig. 4 Analysis process

The interview transcripts were inserted into the NVivo 12 (Figure 4 - stage 1). Free codes were listed before the codes before the related child codes (sub-nodes) were clustered to the main codes (main themes) in stage 2. Stage 3 involves the result of the analysis. It is presented using cognitive mapping and diagrams that served to identify the challenges faced by parents while bringing their children to the masjid.

The example of the coding development used in the analysis process is shown in Figure 5. The transcripts were filtered to analyse the content of the interview. Significant statements were captured and coded to represent the idea or information derived from the interviews (the deductive process).

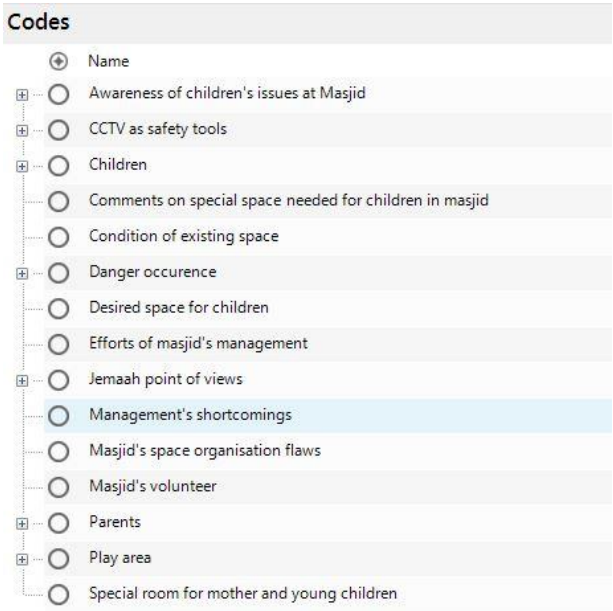

Fig. 5: Summary of code development

There are **15 main codes** identified in the study, which are:

1. Awareness of children's issues at the masjid
2. CCTV as a safety tool
3. Children
4. Comments on the particular space needed for children in the masjid
5. Condition of existing space in the masjid
6. Danger occurrence in the masjid
7. Desired space for children
8. Efforts of the masjid's management
9. *Jamā'ah 's* point of view
10. Management's shortcomings
11. Masjid's spatial organisation and flaws
12. Masjid's volunteer
13. **Parents**
14. Play area
15. Special room for mother and young children

The main code no.13 (parents) is taken as a sample to explain the analysis process since the process is repeated. The part of the analysis process for code 13: Parents is shown in Figure 6. This process takes place in stage 2.

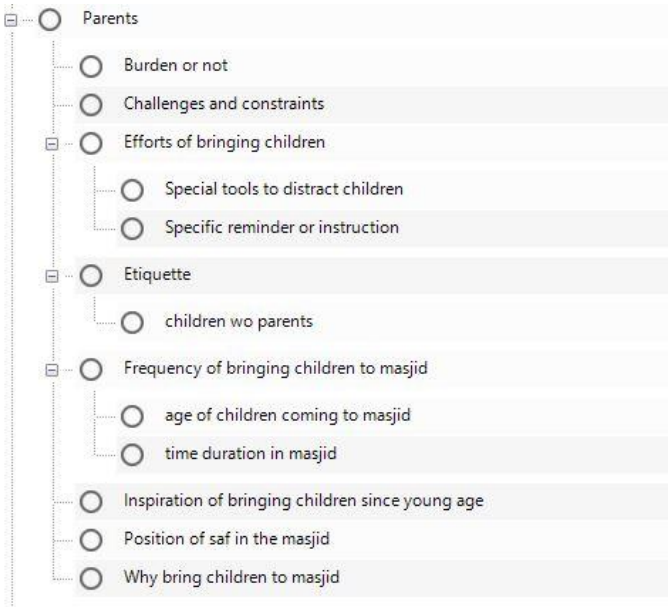

Fig. 6 Subcodes (child codes) for the Main code: Parents

There are eight sub-codes under this main code: Parents. These codes were developed throughout the screening process of each interview transcript. They show the most frequent topic being raised by the parents in the masjid. In order to summarise the data concisely, a framework matrix is created. Table 1 shows part of each respondent's detailed responses under Subcode: Efforts of parents, under child code: Specific reminder or instruction to children.

Each respondent's perceptions are outlined in the framework matrix to compare and contrast further. Table 1 shows some of the respondents' efforts in reminding their children to behave at the masjid. This study shows that parents are not ignoring their children at the masjid. They have prepared their children with advice and instructions. It can be seen that parents admit their children can cause disturbance to other *jamā'ah*. Therefore, they always remind their children how to behave at the masjid. Nevertheless, other *jamā'ah* and masjid management also need to help the parents with children at the masjid by welcoming and tolerating each other.

Table 1: Example of framework-matrix for Subcode: Efforts of parents, under child code: Specific reminder or instruction to children

Respondents	Comments
1	*Dalam kereta lagi dah briefing. Contohnya, kita nak pergi masjid, jangan buat bising dimasjid. Kalau nak apa-apa, datang bisik jangan menjerit. Kalau bosan, datang mama bagi gadjet duduk dibelakang. Jangan suka-suka nak lintas ke ruang solat lelaki, jangan main pintu. Ambil wudhu', baca Quran.*
2	*Selalu masa atas motor memang saya akan pesan saya bawa kamu ke masjid ni jangan bising jangan main-main Okey Kamu baca buku ke kamu duduk di belakang kalau nak main diam-diam sahaja*
3	*Saya pesan jangan kacau orang solat jangan lalu depan orang tengah solat kalau tengah solat duduk diam*
4	*Kakak kena jaga kelakuan sebab semua orang nak solat, kita pun kena solat jgk sama2. Masjid bkn tmpt berlari, nanti petang kita main di taman.*
5	*1. jangan jauh dari umi atau walid.* *2. jangan berlari dan menjerit ketika orang solat* *3. jangan langgar jemaah lain* *4. salam apabila orang tegur.* *5. solat apabila orang solat*

4.2 Thematic visualization using cognitive mapping

A cognitive map can structure unsystematic or complex data. It is also used to arrange ideas and identify a relationship. The study's cognitive map is an outcome of a detailed analysis of the interview data in NVivo 12. Each code identified from this study produced one cognitive map. Figure 7 shows one of the fifteen examples of a cognitive map: PARENTS.

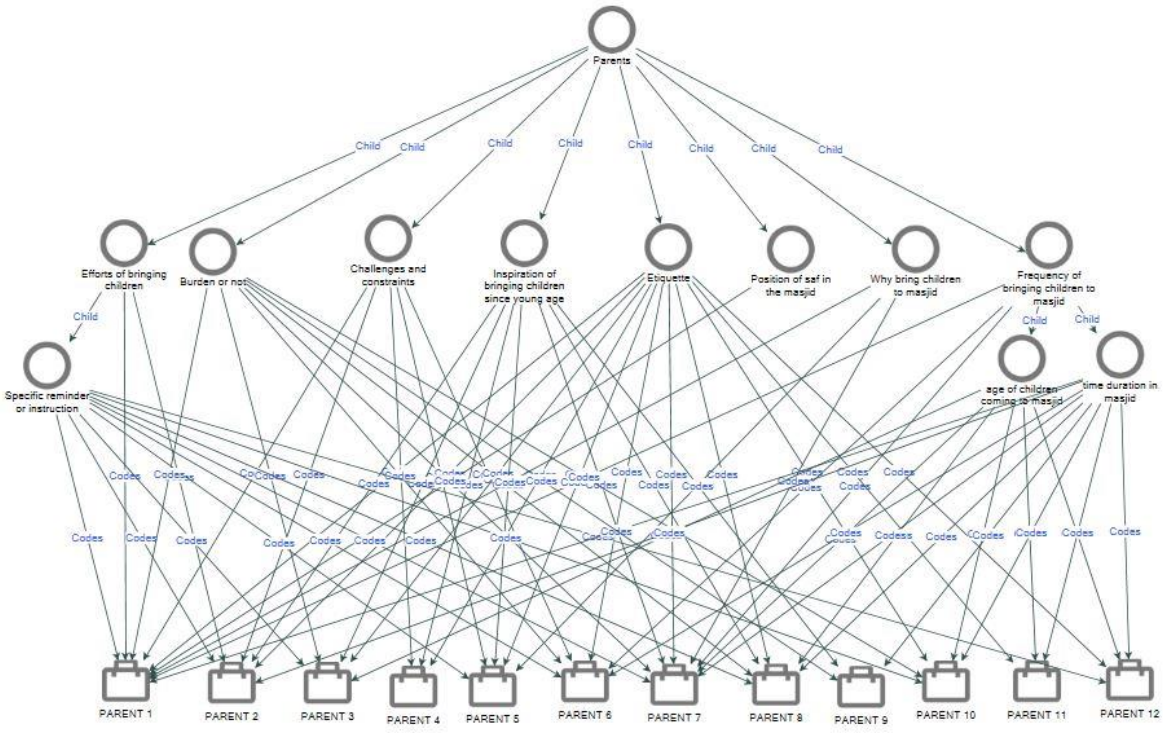

Fig. 7 Cognitive map of main code: Parents.

The cognitive map for *Parents* (Figure 7) reveals that parental experiences at the masjid are shaped by interconnected relationships between motivation, preparation, social perception, and spatial context. The relationships among the subcodes reveal a complex yet coherent picture of parents' adaptive behaviour and their aspirations to raise their children as part of the j*amā'ah*. Parents' intrinsic religious commitment serves as the central driver, motivating them to bring their children despite various challenges. This motivation translates

into proactive behaviours such as briefing children beforehand, setting clear behavioural expectations, and providing distractions to maintain calmness during prayer. However, these efforts are constrained by the lack of suitable child-friendly spaces, inconsistent management support, and varying levels of tolerance among the *jamā'ah*. Parents must constantly balance between fulfilling their own worship and supervising their children, reflecting the dual burden they carry. Social acceptance from other congregants plays a decisive role in sustaining their confidence, while inadequate facilities often intensify emotional strain. Nevertheless, parents demonstrate resilience and perseverance rooted in faith, illustrating that their commitment to nurturing their children's religiosity persists despite structural limitations. Overall, the cognitive map highlights the interdependence of spiritual motivation, social understanding, and environmental design in shaping inclusive parental experiences within the masjid.

This interconnected network highlights that effective child-friendly masjid design must not isolate parental agency from spatial and managerial systems, but rather integrate them through supportive environments that acknowledge parents as both worshippers and educators.

5.0 FINDINGS

The results are summarised based on the fifteen cognitive maps generated from the interview analysis. Challenges and struggles of parents at the masjid are identified. The fifteen codes developed when results are categorized in three main categories: physical features (e.g, spatial layout, safety features, accessibility), social attributes, and the masjid's management (policies and operational planning) (Figure 8). Figure 8 shows the result of the overlaying codes within the three categories.

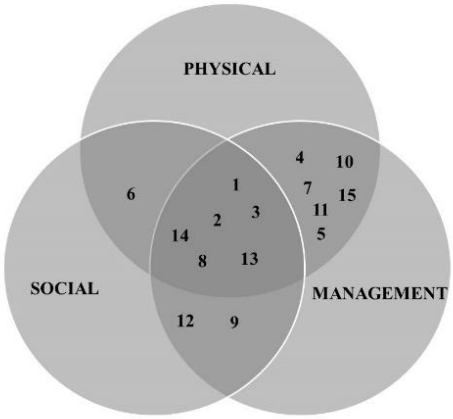

Fig. 8: Summary of the 15 main codes categorization

None of the codes falls under only one category. It implies that the challenges faced by parents are interrelated between categories. The number of codes that fall under each category is as follows. Social: 9, physical: 13, and management: 14. It can be said that more challenges are related to the physical and management categories. When the categories are combined, it is fascinating to see that only code 6 intertwines between social and physical. Twelve codes are intertwined between physical and management categories. When the three categories overlap, six codes are intertwined. Hence, it can be suggested that the challenges faced by parents when bringing their children to the masjid are more related to physical and management issues than social issues.

6.0 DISCUSSIONS

The findings of this study support the initial proposition that the challenges faced by parents when bringing children to the masjid are multidimensional, spanning physical design, management practices, and social concerns. These three domains are closely intertwined, and together they shape parental experiences. Parents remain committed to nurturing their children as future *Khalīfah,* a motivation deeply rooted in religious teachings and the advice of Luqman (Quran for Kids, n.d.; Hassan, 2007), yet they encounter barriers arising from spatial inadequacies, inconsistent management, and unsupportive community attitudes. This confirms earlier assertions that parental struggles cannot be reduced to individual discipline or behaviour issues alone.

The results further highlight how physical and managerial aspects dominate the parental challenges compared to social attitudes. This finding is consistent with prior studies that emphasised the absence of child-friendly facilities such as nurseries, play corners, pr safe circulation spaces (Musleh, 2019; Yahya, 2016). It also extends the discussion by showing how inadequate policies, weak enforcement, and a lack of systematic management exacerbate parental stress. Unlike earlier accounts that framed child-related disruptions primarily as a matter of tolerance among congregants (Shameem, 2012; Ghafar, 2018; Azmi, 2019), this study demonstrates that architecture design and operational management play equally significant roles in shaping inclusivity within the masjid.

In contrast with idealised portrayals of the masjid as a centre of children's education and moral formation (Nasih Ulwan, 2015), the parents interviewed revealed that current design and management shortcomings often undermine the masjid's potential to nurture young worshippers. For example, while parents consistently reminded their children to behave and prepared them with instructions before prayer (Table 1), their efforts were frequently insufficient in environments lacking safe spaces, effective supervision, or noise-mitigation measures. This gap between parental intentions and institutional support underscores the urgent need for masjid authorities to adopt holistic approaches that integrate spatial planning with facility management.

This study also contributes new insights by framing the issue of child-friendly masjids within the discourse of the built environment. While much of the existing discussion has focused on social acceptance or religious obligations (Shameem, 2012; Ghafar, 2018), this research positions spatial planning, acoustics, and circulation design as critical mediators of social harmony within communal worship spaces. In doing so, the findings bridge religious, social, and environmental perspectives, offering a more comprehensive framework for understanding inclusivity in the masjid context.

Practically, the results suggest that masjid committees and designers should prioritise integrated strategies to accommodate families. This includes providing designated child-friendly spaces without isolating children from the main prayer hall, ensuring visual connectivity for parents, applying acoustic treatments to reduce noise, and establishing clear circulation routes to minimise disruptions (Musleh, 2019; Yahya, 2016). From a management perspective, consistent policies, volunteer training, and communications with parents are essential for reinforcing these physical interventions. Theoretically, the study contributes to expanding the discourse on religious space design by emphasizing how built environment considerations can advance inclusivity, resilience, and community well-being.

Finally, it is important to recognise the limitations of this study. The sample size of twelve parents provides in-depth but context-specific insights, which may not reflect the full diversity of experiences across Malaysia. Future research could adopt comparative studies across regions or examine the perspectives of masjid managers, volunteers, and the wider congregation to build a more holistic understanding. Despite these limitations, this study provides a valuable foundation for advancing the discourse on child-friendly masjids, moving it beyond ad hoc or temporary solutions towards systematic and sustainable strategies for the future.

7.0 CONCLUSION

This study underscores that the challenges faced by parents bringing their children to the masjid are closely intertwined across physical, social, and managerial dimensions. From a built environment perspective, the findings, derived from twelve in-depth interviews, are considered sufficiently robust, as the semi-structured format allowed for rich, detailed narratives that reached thematic saturation. These insights provide a comprehensive understanding of parental experiences within the masjid context. The study highlights practical recommendations for architects, designers, masjid managers, etc. Architects should prioritise child-friendly and inclusive spatial layouts, incorporating visually connected zones, safe circulation paths, and acoustic treatments that preserve the sanctity of worship while supporting family participation. Masjid committees and administrators must strengthen management practices through clear policies, volunteer training, and family-oriented programmes to foster mutual understanding among congregants. Meanwhile, religious authorities and local councils can translate these insights into planning standards and design guidelines that promote inclusivity and consistency in future masjid development and refurbishment projects. By embedding child and family-oriented considerations in both design and management, masjids can better fulfil their holistic role as spaces for worship, learning, and community cohesion that nurture future generations spiritually, socially, and emotionally.

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