الجامعة الإسلامية العالمية ماليزيا
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
يونيفرسيتي إسلام انتارابغسا ملسيا
(Company No. 101067-P)
Garden of Knowledge and Virtue

JOURNAL OF ARCHITECTURE, PLANNING AND CONSTRUCTION MANAGEMENT

VOLUME 14 ISSUE 1
2024

JAPCM

JOURNAL OF ARCHITECTURE, PLANNING AND CONSTRUCTION MANAGEMENT

Editor-in-Chief
Prof. Ar. Dr. Abdul Razak Sapian
Kulliyyah of Architecture and Environmental Design

VOLUME 14 ISSUE 1 (2024)

JOURNAL OF ARCHITECTURE, PLANNING AND CONSTRUCTION MANAGEMENT (JAPCM) TEAM 2024 – 2025

JOURNAL OF ARCHITECTURE, PLANNING AND CONSTRUCTION MANAGEMENT
VOLUME 14: ISSUE: 1/2024

Notes for Contributors

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Published by

IIUM PRESS, Research Management Centre and Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia

ISSN 2231-9514
e-ISSN 2462-2222

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.

Prof. *Ar.* Dr. Abdul Razak Sapian
Editor-in-Chief

JOURNAL OF ARCHITECTURE, PLANNING & CONSTRUCTION MANAGEMENT
Volume 14 Issue 1, 2024 E-ISSN: 2462-2222 ISSN: 2231-9514

EVALUATION OF ECOSYSTEM SERVICES CONTRIBUTIONS ON URBAN FORESTS IN KUALA LUMPUR

Received: 17th February 2022 | Accepted: 1st April 2024 | Available Online: 30th June 2024

DOI: 10.31436/japcm.v14i1.697

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ABSTRACT

This study investigates the benefits of urban forests, focusing on the Kuala Lumpur Forest Eco Park (KLFEP), the world's oldest virgin forest, as a solution to the city's enduring challenges with urban risks and pollution. Through an analysis of ecosystem services, including supporting, regulating, provisioning, and cultural services, the research evaluates the contributions of KLFEP. Sustainable Development Goals (SDGs) achieved by urban forests are identified, with contextual insights drawn from document analysis of the Kuala Lumpur Structure Plan 2040 (KLSP2040), SDGs 2030, and related studies. Additionally, semi-structured interviews with professionals provide further perspectives on urban forest benefits and achievable SDGs. Thematic analysis is used to examine qualitative data. The findings reveal that KLFEP offers a healthy habitat, a diverse tree population, and air purification, enhancing regulating and supporting services. Its unique flora and fauna contribute to nutrient cycling, biological control, and provisioning services.

Moreover, Kuala Lumpur benefits significantly from recreation and ecotourism opportunities provided by KLFEP, contributing to cultural services. The study underscores the importance of urban forests, particularly KLFEP, as sustainable solutions to Kuala Lumpur's challenges. It aims to increase awareness about prioritising urban forests in development plans to protect remaining forest patches. Raising awareness among authorities and society about the significance of urban forests is crucial for informing landscape architecture planning and decision-making, ensuring the consideration of all urban forest benefits.

Keywords: Urban Forest, Ecosystem Services, Kuala Lumpur Forest Eco Park, Sustainable Development Goals, Forest Benefits.

1.0 INTRODUCTION

As the focal point of urban settlement, the burgeoning population in Kuala Lumpur has propelled rapid urbanisation, presenting both advantages and drawbacks to society (Kuala et al. et al., 2004). Numerous vacant lands have been repurposed to meet the needs of urban communities, facilitating rapid development of additional land, infrastructure, and amenities to accommodate the populace. Projections indicate that Kuala Lumpur's population is expected to surge from 1.73 million in 2020 to 2.3 million by 2050 (Kuala et al., 2021). However, this swift urbanisation has also adversely affected the natural environment, profoundly impacting the urban ecosystem. Makmom Abdullah et al. (2012) highlight various environmental challenges Kuala Lumpur faces, such as climate change, pollution, and water

scarcity. Despite concerted efforts to mitigate these issues, this study posits that urban forests are pivotal in addressing these challenges. Ecosystem services serve as a checklist to elucidate the benefits that urban forests can offer.

Urban forests serve as vital contributors to the urban landscape, preserving biodiversity, enhancing public health, and enriching daily life while meeting fundamental human needs (Franklin et al., 2007; Stupak et al., 2015; Sundara et al., 2021; Meyer et al., 2017). The perception of urban forests has evolved, varying across countries. Ambiguity in defining and understanding urban forests in Malaysia has impeded efforts to prioritise their preservation and sustainable development (McLean & Jensen, 2004). The Malaysian government has taken steps to address the decline of green spaces by designating urban forests under the National Forestry Act of 1984, thereby safeguarding these areas from disruptive activities. However, media reports have highlighted instances where urban forests have been degazetted to make way for development projects despite prior designation as permanently protected areas. This underscores the need for increased awareness regarding the significance of urban forests in societal and governance contexts.

Ecosystem services encompass the benefits derived from the environment essential for city sustainability, with urban forests often serving as primary providers (Nilon et al., 1999; Stupak et al., 2015). Understanding ecosystem services can inform governance and decision-making for future development (Gómez-Baggethun et al., 2010; Bayon, 2004). This study aims to delve deeper into these benefits, with two main objectives: to identify the contributions of urban forests to Kuala Lumpur city and to suggest suitable recommendations for enhancing urban forests. By elucidating the contributions of urban forests, this study intends to foster governance that recognises the importance of urban forests and paves the way for informed development that integrates urban forests as indispensable components of city planning.

2.0 LITERATURE REVIEW

History of Urban Forests in Malaysia

This study defines urban forests as any green area within urban or peri-urban regions that contains forests, tree groups, or individual trees. The evolution of urban forests in Malaysia has unfolded through distinct stages (Nowak et al., 1994; FAO, 2014; Lev, 2017). The interpretation of urban forests in Malaysia is diverse, encompassing existing forests within city areas and the deliberate integration of forests into urban design (Sundara et al., 2021; Justice et al., 1986).

Sweetheart (2017) delineates the progress of urban forestry in Malaysia across three significant periods. The first phase traces back to colonial times with the extensive planting of *Pterocarpus indicus* in Penang and Malacca (Koening, 1894; Burkill et al., 1966; Philip, 1999). The second phase took root in Kuala Lumpur through Beautification Programmes, marked by significant plantings of trees such as *Peltophorum indicus* and *Samanea saman* (Ayoub, 1989). The third phase focused on uniquely identifying the Malaysian landscape, initiated with the Landscaping the Nation Programme in 1995 (Sreetheran et al., 2011). The inception of the National Landscape Policy in 2006 aimed to conserve natural resources while enhancing aesthetics (Ahmad, 2013; Ibrahim, 2016). Amid concerns over deforestation and illegal logging, efforts to safeguard green areas intensified, leading to the National Forestry

Act of 1984 (Woon et al., 2002). This legislation facilitated the categorisation of forests into Permanent Forest Estates (PFE), preserving them based on their attributes (Yaakob, 2014). Subsequent forestry practices in Malaysia gravitated towards environmental preservation, spawning initiatives focused on sustainability, climate change mitigation, and biodiversity enhancement (Ratnasingam et al., 2011).

In Kuala Lumpur, the urban forest concept emerged with the ambition of citywide tree planting, as outlined in the Kuala Lumpur Structure Plan 1984 (Sreetheran, 2017). The Nationwide Tree Planting Campaign 1997 further bolstered this endeavour, setting a global record for the maximum number of trees planted in one minute in 2000 (BBC News, 2000; Nordin et al., 1997). In summary, Malaysia's sustained commitments to landscape and forest growth underscore the evolving understanding of urban forests. This underscores the importance of further investigation into the professional perception of urban forests, given the diverse definitions and relevance found in the data.

Underappreciation of urban forests in Kuala Lumpur

Forests have long been recognised as invaluable natural assets, providing many benefits for urban development, natural resources, and economic prosperity. Unfortunately, news of forest exploitation remains common worldwide. Malaysia recently faced a concerning incident of illegal deforestation in the Bukit Tabur rainforest, eliciting strong negative reactions from local communities and environmentalists. The state government intervened, asserting that the deforestation activities were unauthorised, and promptly ordered their cessation (Lee et al., 2021). Regrettably, forest reserves being degazetted is not uncommon in Malaysia. In 2016, the then Minister of Natural Resources and Environment, Datuk Seri Wan Junaidi, disclosed that permanent forests in Kuala Lumpur had diminished from 106.10 hectares to 68.27 hectares due to road and infrastructure developments (Abas, 2016). Even the oldest virgin forest in Kuala Lumpur, KLFEP, previously known as Bukit Nanas Forest Reserve, has a history of being degazetted for development. Initially gazetted as a permanent Forest reserve in 1906 with a total area of 17.5 hectares, it shrank to 9.3 hectares after the construction of K.L. Tower, now a prominent tourist destination in Malaysia (John. et al., 1990; JungleBoy, 2014).

The exploitation of forests has resulted in numerous environmental issues, including climate change, habitat degradation, the urban heat island effect, air and noise pollution, and water resource scarcity (Kuala et al., 2021; Abdullah, 2012). Furthermore, reducing urban forests undermines their role as carbon sinks, ecological corridors, and biodiversity assets, as emphasised in the KLSP2040. The depletion of urban forests could lead to significant losses in carbon sequestration potential by 2030. However, government efforts to safeguard natural areas, including forests and green spaces, are noteworthy. The Twelfth Malaysia Plan (RMK-12) fosters a prosperous, inclusive, and sustainable country, focusing on advancing green growth (Minister's Office of Malaysia, 2021). This plan emphasises environmentally friendly economic development, aiming to reduce carbon emissions by 45% by 2030 and achieve carbon neutrality by 2050. It also aims for 120 cities to attain sustainable city status, supported by preservation and conservation initiatives. These objectives align with the vision of the Kuala Lumpur Structure Plan 2040 (KLSP2040), which aims to create a greener city with a low-carbon approach.

In summary, despite significant urban forest losses, Malaysia is actively transitioning towards sustainable urban planning and green growth. However, continuous professional involvement in protecting urban forests remains crucial.

Understanding ecosystem services

Ecosystem services encompass humans' diverse benefits from ecosystems, supporting, enriching, and sustaining life (Bolund et al., 1999; De Groot et al., 2002; Haines-Young et al., 2018; Taylor, 2020). These services represent the outcomes of ecological processes that yield advantages for human populations, as outlined in the Common International Classification of Ecosystem Services (CICES V5.1) by Haines-Young and Potschin-Young (2018). Bolund and Hunhammar (1999) similarly highlight ecosystem services as encompassing the benefits obtained by humans from ecosystems, with the term 'services' denoting 'benefits,' emphasising the value ecosystems offer to living and non-living entities, particularly humans.

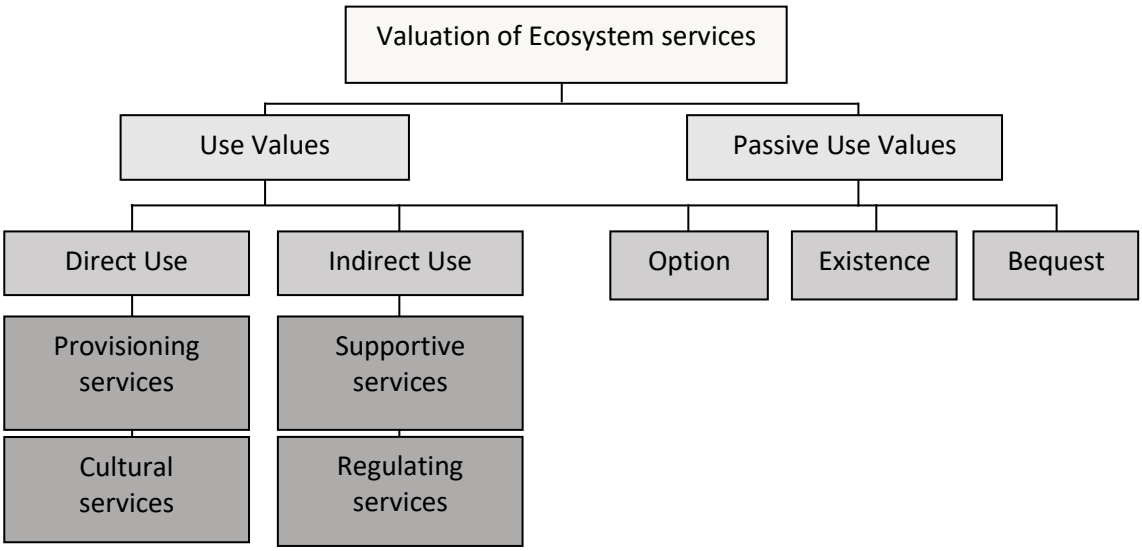

Fig 1: Valuation of Ecosystem services
(Source: https://www.millenniumassessment.org)

Valuing these ecosystem services entails considering both use values and passive use values. Use values encompass services directly or indirectly utilized by humans, categorised into four main groups: supporting services, regulating services, provisioning services, and cultural services. Meanwhile, passive use values hold significance even without direct utilisation, owing to people's awareness of their existence. These passive values encompass existence, bequest, and option values. As this study emphasises, a comprehensive understanding of ecosystem services, including their ecological, economic, and social dimensions, is essential for recognising the extensive contributions of urban forests in Kuala Lumpur. Ensuring the preservation of these services is crucial for fostering a sustainable environment, with social, economic, and ecosystem services playing pivotal roles in this research.

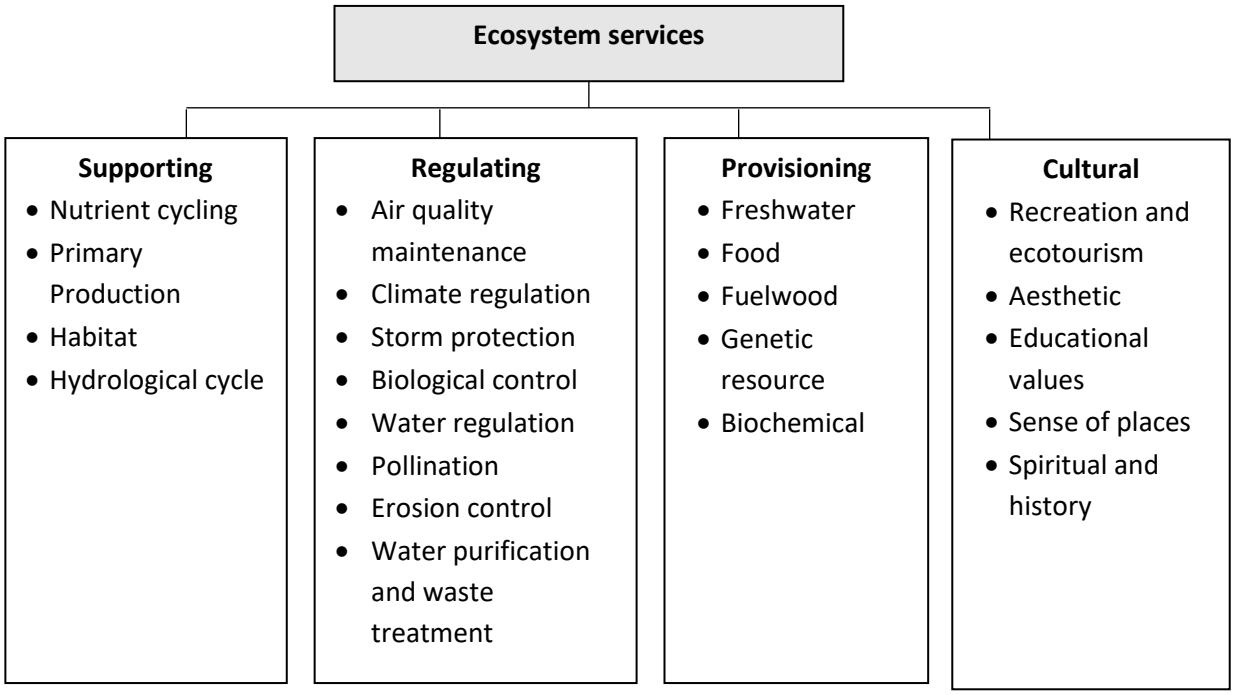

Fig. 2: Ecosystem services functions and subfunctions
(Source: https://www.millenniumassessment.org)

According to Pascual U. et al. (2010), ecosystem services are categorised into four functions: supporting services, regulating services, provisioning services, and cultural services. Supporting services are deemed the most critical, as they underpin the production of all other ecosystem services, providing long-term processes necessary for maintaining the Earth's basic form and cycles. On the other hand, regulating services are indispensable for moderating and maintaining natural phenomena through ecosystem processes, without which living organisms would struggle to sustain their existence. Provisioning services encompass the tangible benefits extracted from nature. In contrast, cultural services encompass the non-material benefits that contribute to individual and societal development, enhancing emotional, psychological, cognitive, and well-being. The benefits of urban forests will be elucidated based on these four ecosystem service functions.

Ecosystem services contribution by urban forests

In terms of supporting services, urban forests play a pivotal role in providing habitats for wildlife, which in turn fosters the retention of native species and biodiversity within urban areas (Livesley et al. et al., 2016; Alvey et al., 2006; Llausa Roe, 2012; Korpilo et al., 2018). Furthermore, urban forests serve as habitats for numerous plant species, contributing to primary production in the ecosystem. Primary production is facilitated through photosynthesis, which generates energy and oxygen crucial for sustaining life. This process is fundamental for various ecosystem services, including the nutrient cycle, which underpins regulating, provisioning, and cultural services (Larcher, 2003; He et al., 2007; Lee, 2011; Lahr et al., 2018). In protected urban forests, natural litter and organic matter enrich soil quality, stimulating nutrient cycling and supporting the production of foods consumed by animals and plants. Additionally, urban forests function as biological corridors within urban landscapes, fostering expanded ecosystem interactions (IUCN, 1994). The extensive vegetated coverage

in urban forests enhances hydrological processes, increasing water absorption and evapotranspiration rates (Lerner et al., 1990; Livesley et al., 2016; Vergopolan & Fisher, 2016).

Regarding regulating services, urban forests significantly influence microclimate balance, as trees mitigate carbon emissions and produce oxygen (Bernatzky, 1983; Givoni, 1991). Furthermore, vegetation in urban forests improves air quality by filtering pollution particles, mitigating the greenhouse effect, and reducing the need for fossil energy, thereby decreasing greenhouse gas emissions and associated costs (Svensson et al., 2002; Huang et al., 1987). Urban forests also mitigate stormwater runoff by increasing soil water absorption, thereby reducing soil erosion and retaining soil moisture and quality (Lerner et al., 1990; McPherson et al., 1997; Livesley et al., 2016). Moreover, urban forests contribute to natural stormwater harvesting, enhancing water quality and purification processes (Llorens & Domingo, 2007; Gallo et al., 2012). The biodiversity of flora and fauna in urban forests promotes species diversity and pollination, enriching the urban environment (Van Rossum & Triest, 2012).

Urban forests provide provisioning services by offering food sources and freshwater, enhancing food security for living organisms (Jahnige, 2004; Poe et al., 2013; Kowalski et al., 2019). Notably, the management of food production in urban forests is less intensive than in agriculture, as products such as fruits, timber, and biochemical resources are naturally generated without artificial habitats or technologies (Akinbamijo, 2004). Timber harvesting is also practised in urban forests, ranging from extensive areas to street plantings (Nowak et al., 2001; Padoch et al., 2008). Furthermore, urban forests harbour valuable genetic resources for conservation strategies, species restoration, seed banks, DNA banks, disease and pest studies, and sustainable forest management practices (Rajora et al., 2001; Dawson et al., 2014).

In cultural services, urban forests provide spaces for recreational activities such as exercise, jogging, hiking, picnicking, sightseeing, and learning about nature (Kleiber, 2001; Heyman, 2012). This exposure to nature fosters societal awareness and strengthens neighbourhood relationships. Additionally, the presence of nature in urban forests cultivates a sense of belonging and sentimental attachment among urban residents (Stedman et al., 2003). Urban forests also promote physical and mental well-being by providing settings for exercise and reducing ultraviolet radiation and air pollution (Dwyer et al., 1992; Bang et al., 2016). In Japanese culture, trees hold cultural and spiritual significance, with practices like "forest bathing" enhancing physical and spiritual well-being (Park et al., 2010). Moreover, urban forests preserve natural and cultural heritage, foster interest in ecotourism and enhance a city's natural identity (Liu et al., 2006; Deng, 2010; Cetin et al., 2018). Overall, urban forests offer aesthetic, cultural, and recreational values that enrich the urban environment and promote societal well-being.

3.0 METHODOLOGY

This study employed a qualitative methodology, which included document analysis and semi-structured interviews.

Table 1: Research objective of the study

Research Objective	Method	Documents/Participants
To identify the contributions of urban forests to Kuala Lumpur. To suggest suitable recommendations for enhancing urban forests.	▪ Document analysis ▪ Semi-structured interview ▪ Document analysis ▪ Semi-structured interview	▪ KLSP2040 ▪ SDG 2030 ▪ 15 Articles Regarding KLFEP ▪ KLCH (Respondent 1) ▪ JLN (Respondent 2) ▪ ILAM (Respondent 3) ▪ FDPM (Respondent 4)

Two methods were employed to achieve the research objectives. Document analysis involved reviewing three types of secondary data:

1. **Kuala Lumpur Structure Plan 2040 (KLSP2040):** This document outlines the developmental direction of Kuala Lumpur until 2040, providing insights into urban planning and its impact on ecosystem services.
2. **Sustainable Development Goals 2030 (SDG, 2030):** Extracted from the Department of Statistics Malaysia, SDG 2030 indicators were segregated to identify those relevant to ecosystem services.
3. **Articles regarding KLFEP:** Fifteen articles were selected through a Google Scholar search using keywords related to Bukit Nanas and Kuala Lumpur Forest Eco Park (KLFEP), aiming to gather data pertinent to KLFEP.

The data documents were analysed using NVivo10 software. Prior to screening, themes were identified to ensure alignment with the four ecosystem services functions: supporting services, regulating services, provisioning services, and cultural services. Themes were categorised into three sections: Kuala Lumpur planning, the contribution of urban forests, and achievable SDGs.

Participants were selected from Kuala Lumpur City Hall Council (KLCH), Jabatan Landskap Negara (JLN), Institute of Landscape Architects Malaysia (ILAM), and Forestry Department of Peninsular Malaysia (FDPM) for semi-structured interviews. The interviews aimed to gather insights on urban forests' contribution and achievable SDGs from professionals' perspectives.

Interview data underwent thematic analysis, with themes categorized based on the four ecosystem services functions. The themes were further classified into Enhancing Urban Forests and Achievable SDGs. Manual analysis was conducted, with interview responses compiled in Microsoft Excel to identify and discuss the most frequently mentioned themes.

4.0 RESULTS AND DISCUSSION

The Contribution of Kuala Lumpur Forest Eco Parks

To address the first objective, document analysis was employed as the primary method to investigate the contribution of urban forests. The data were analysed using NVivo10 to extract insights into Kuala Lumpur's future development goals and actions, particularly focusing on urban forests. KLSP2040, a strategic proposal for resource management and adaptation to environmental and socioeconomic changes, was scrutinised to understand its implications for urban forests. Additionally, fifteen articles related to Kuala Lumpur Forest Eco Park (KLFEP) were selected to glean information about its environmental, social, and economic contributions. The screening process facilitated an exploration of KLFEP's benefits for Kuala Lumpur.

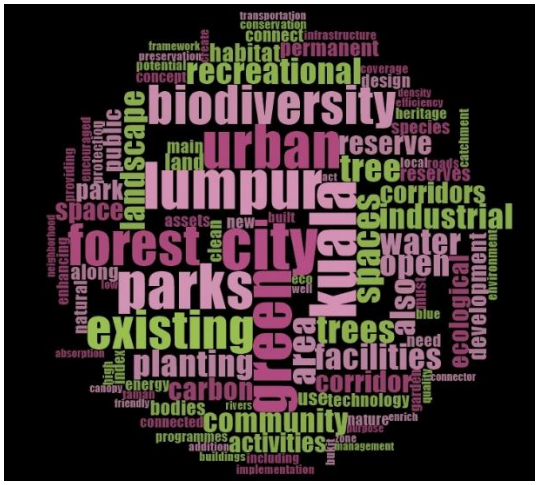

Fig. 3: Word frequency on Kuala Lumpur Structure Plan 2040 generated from NVivo

Fig. 4: Word frequency on contribution of Kuala Lumpur Forest Eco Park generated from NVivo

Figure 3 presents word clouds highlighting the planning aspects of KLSP2040, reflecting the integration of urban forests into Kuala Lumpur's development. Data from KLSP2040 underwent screening using NVivo to assess its potential benefits for urban forests. Several words frequently used in KLSP2040 are significant to urban forests. Notably, Goal 3, SV 1, "Integration of Nature in Urban Development," outlines plans to prioritise the preservation and development of forest reserves, urban forest parks, rivers, and water bodies to maintain ecological balance and biodiversity. KLSP2040 aims to preserve green reserves' width and current activity, emphasising the importance of permanent forests and developing recovery plans and guidelines.

Additionally, urban forests will be gazetted as permanent forest reserves for recreational purposes, enhancing community well-being. SV1.2 highlights connecting all green areas with blue corridors to form ecological nodes, enhancing the city's ecosystem. A biodiversity index will be established to monitor habitat and biodiversity status, while SV 1.3 focuses on increasing green intensity through tree plantings and heritage tree preservation. Furthermore, SV2.2 proposes developing void and derelict spaces into pocket parks and plazas. The word cloud in Figure 3 emphasises words such as forest, biodiversity, green, parks,

tree, planting, carbon, recreational, habitat, corridor, and ecological, aligning with Goal 3's objectives.

Beyond urban forests, KLSP2040 also aims to transition Kuala Lumpur into a low-carbon city by 2050, targeting carbon neutrality. PR1 outlines efforts to reduce vehicle usage by promoting green and low-carbon vehicles and increasing green areas and infrastructure like rain gardens and permeable pavement. Community involvement and education initiatives aim to raise awareness about biodiversity richness, encouraging conservation efforts. Various recreational programs will activate community spaces, enhancing comfort and usage. Despite focusing mainly on ecosystem improvements, KLSP2040 aligns with RMK-12, although it only marginally covers urban forests.

Figure 4 depicts the word frequency of contributions offered by KL Eco Forest, as identified in articles about KLFEP. A total of 15 articles were screened, segregating data based on ecosystem services functions.

Table 2: Matrix Coding Of Articles About Kuala Lumpur Forest Eco Park With Ecosystem Services Function

Articles	A : Supporting services	B : Regulating services	C : Provisioning services	D : Cultural services
1 : Justice, C. L. (1986)	1	0	0	0
2 : Mahdzar, S. S. S. & Samsudin, I. L. (2018)	3	3	1	5
3 : Sulaiman, B., & Boyce P. C. (2010)	1	1	0	2
4 : Sarkar, S. K. (2016)	1	0	0	6
5 : Aziz, A., et. al. (2017).	8	3	4	20
6 : A. Rahman, A., et. al. (2017)	2	3	1	5
7 : Salleh, N., et. al (2017).	26	25	34	9
8 : Forest Department of Peninsular Malaysia (2019)	1	1	1	1
9 : Syafiqah, A., et. al. (2014)	0	0	0	1
10 : Aziz, I. S. A. (2018).	1	1	0	1
11 : Mariapan, M., et al (2015)	5	6	3	10
12 : Mohd-Taib, F. S., et. al. (2014)	6	5	4	0
13 : Forest Department of Peninsular Malaysia (2009)	4	3	6	8
14 : Yusop, M. Y. M., et al (2021)	3	0	4	1
15 : Sarkar, S., at. al. (2015)	2	0	1	4

Referring to Table 2, 15 articles related to KLFEP were segregated by screening the contribution of KLFEP related to each ecosystem services function. Cultural services had the highest point, followed by supporting services, indicating the substantial amount of data on the contribution of ecosystem services. Despite sharing similar data, regulating services received slightly lower points than supporting services. In contrast, provisioning services acquired a high score despite KLFEP being a protected forest where forest products are not produced.

Regarding supporting services, most of the data in the articles pertains to habitat provisioning. Two articles reported the abundance of species in KLFEP, highlighting its role as the centre of habitat and biodiversity in Kuala Lumpur (Aziz et al., 2017; Salleh et al., 2017). KLFEP, having never been logged, boasts trees that can live up to several hundred years. Primary production ranked second in data screened from the articles. One article referred to KLFEP as the green lung of Kuala Lumpur, emphasising its significance as the main source of oxygen supply to the city (Forest Department of Peninsular Malaysia, 2019). The hydrological and nutrient cycles yielded an equal amount of data screened from NVivo10.

Regarding hydrological cycling, some articles mentioned KLFEP's function as a water catchment area for Kuala Lumpur (Forest Department of Peninsular Malaysia, 2009). Nutrient cycling occurs with the assistance of living and non-living organisms in the forest. KLFEP serves as the primary site for nutrient cycling in Kuala Lumpur, attracting plants and animals for food sources. Decomposition is also prevalent in KLFEP, given the significant interaction between living and non-living organisms, making it one of Kuala Lumpur's main food providers (Mohd-Taib et al., 2014).

Regulating services garnered the highest data points concerning pollination, air purification, and climate regulation. Like supporting services, KLFEP's abundance of species attracts many animals for food, aiding in pollination (Mohd-Taib et al., 2014). Additionally, KLFEP offers the city various species of pollinators, seeds, and pollination. Regarding air purification and climate regulation, the dense tree cover in KLFEP helps purify the air, provide oxygen, and regulate temperature (Aziz et al., 2017; Forest Department of Peninsular Malaysia, 2019). Some articles also mentioned KLFEP as a water catchment area that helps purify and regulate water for living organisms. KLFEP also acts as erosion control, given the trees' ability to hold soil. While KLFEP could serve as storm protection due to its significant surface water runoff and dense tree cover, articles found did not mention it as a storm mitigator. However, one article reported a landslide in the Bukit Nanas area.

Based on the data in the matrix coding in Table 2, provisioning services in KLFEP primarily consist of genetic resources. KLFEP is home to various vegetation, including trees, rare herbs, ferns, climbers, palms, bamboo, and other native vegetation (Forest Department of Peninsular Malaysia, 2019; Mariapan et al., 2015). While some species can be used for timber, medicinal purposes, and food, KLFEP is protected from supplying forest products for economic gain. Besides serving as a home for centuries-old trees, KLFEP also houses threatened species, such as *Anisoptera costata, Shorea sumatrana, Magnolia Montana, Memecylon campanulate,* and *Shorea sumatrana*. Additionally, KLFEP harbours many interesting species, including the local endemic plant *Tarenna rudis (Rubiaceae)*, which is rare and found only in Selangor, along with various indigenous plants from ground level to emergent layers, promising a bright future for genetic resources in Malaysia.

As for cultural services, most ecosystem services collected revolve around recreation and ecotourism. The aesthetic value and natural forest heritage of KLFEP attract many visitors locally and globally for tourism purposes (Aziz et al., 2017). While few articles emphasise foreigners' attraction to KLFEP, most foreigners are drawn to the diversity of flora and the pleasing environmental views of KLFEP. Aesthetic value ranked second highest in matrix coding (Sarkar et al., 2015). Education value and sense of place were the most frequent ecosystem services subfunctions mentioned. The trails facilitate interaction between visitors and the surrounding environment, offering insights into KLFEP's vegetation while wandering inside. The amenities and facilities in KLFEP contribute to visitors' sense of place.

The contribution of Urban Forest in Kuala Lumpur based on Professional Perspective

Based on the semi-structured interview results, professionals actively working to enhance urban forests have noted several contributions to them.

Fig. 5: Contribution of Urban Forest based on professional's perspective from interview

Based on Figure 5, the urban forest contributions highlighted by professionals include air filtration, carbon reduction, temperature mitigation, and providing healthy environments for humans, flora, and fauna. The document analysis findings also revealed that respondents frequently mentioned these contributions. The second most mentioned contribution pertained to urban forests serving as a green network in the city, fostering economic growth, promoting education and awareness, and providing habitats for urban wildlife. Fewer respondents discussed the role of urban forests as sources of forest products and water filters, as many professionals believe that urban forests in Kuala Lumpur have limited capacity in these aspects. Respondent 4, representing the Forestry Department of Peninsular Malaysia (FDPM), noted that forest product extraction is prohibited in protected forests in Kuala Lumpur. Regarding the water filtration capacity of urban forests in Kuala Lumpur, some respondents argued that despite their small size, they still serve as significant water filters and basins due to their prominence among the city's green areas. Only one respondent mentioned the potential for urban forests to conserve energy, suggesting that this could be achieved by integrating green technology.

Achievable SDGs about the existence of urban forests

In order to explore the Sustainable Development Goals (SDGs) achievable through urban forests, this study compared 17 indicators from the Sustainable Development Goals 2030 (SDG2030), the contributions of urban forests identified in the literature review, and the contributions of the Kuala Lumpur Forest Eco Park (KLFEP).

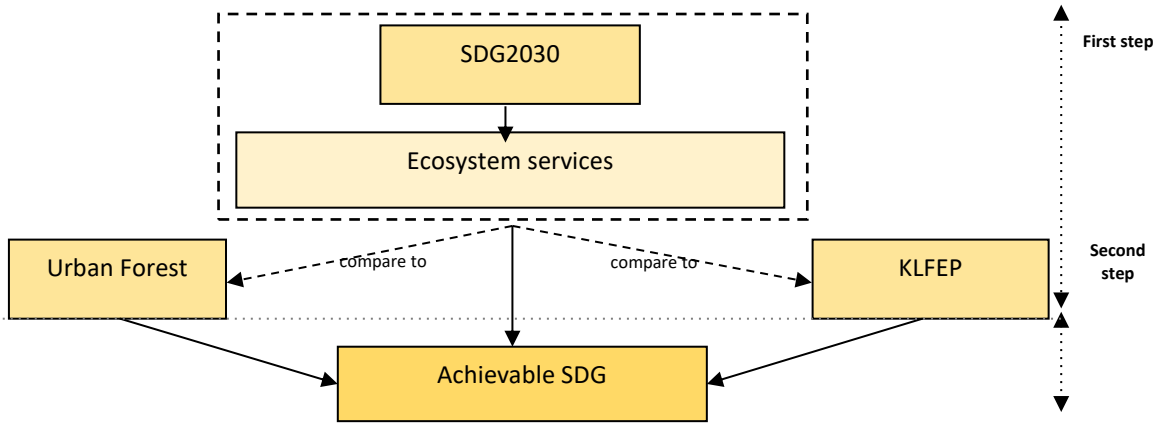

Fig. 6: Evaluation Process for Achievable SDGs

Figure 6 depicts the evaluation process for identifying achievable SDGs. Initially, 17 SDG2030 indicators were assessed alongside ecosystem services relevant to urban forests identified in the literature review and KLFEP data from document analysis. This involved screening SDG targets and indicators related to urban forests in the literature and data from KLFEP analyzed using NVivo10. The aim was to anticipate which SDGs could be realized through the presence of urban forests in a city. In the subsequent step, the SDG targets and indicators identified in the first step were compared with the contributions of urban forests and KLFEP to understand their similarities.

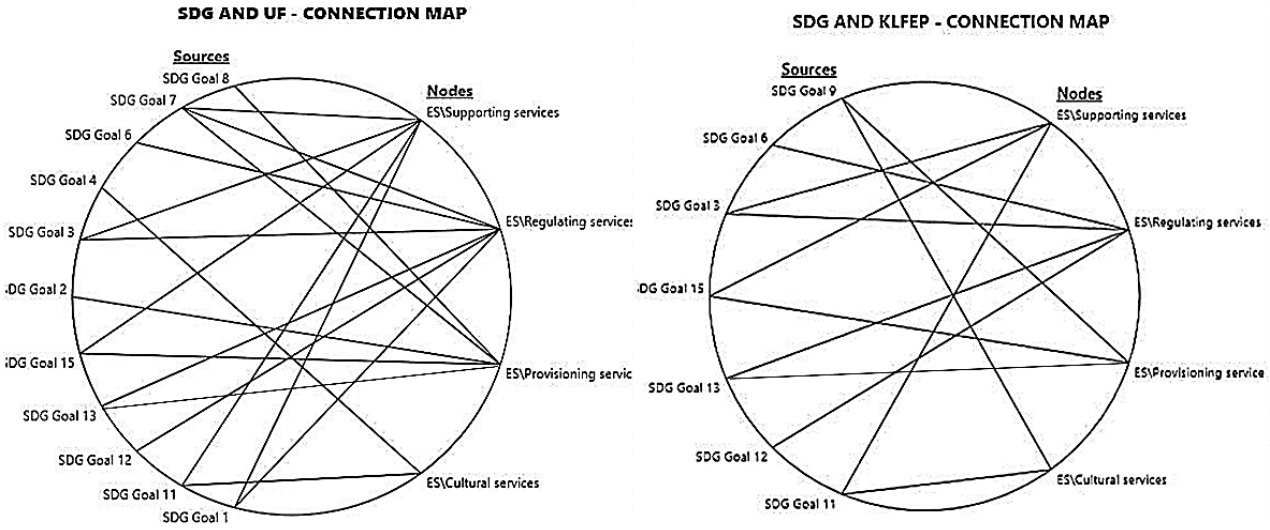

Fig. 7: Connection map of SDGs and urban forests and KLFEP generated from NVivo

Figure 7 depicts two connection maps illustrating the primary SDGs achievable through urban forests and KLFEP. For urban forests, the attainable SDGs include Goal 1: No Poverty, Goal 3: Good Health and Well-Being, Goal 7: Affordable and Clean Energy, Goal 11: Sustainable Cities

and Communities, Goal 13: Climate Action, and Goal 15: Life on Land. Meanwhile, the key SDGs that KLFEP can achieve are Goal 3: Good Health and Well-Being, Goal 9: Industry, Innovation and Infrastructure, Goal 11: Sustainable Cities and Communities, Goal 13: Climate Action, and Goal 15: Life on Land. Notably, the similarities in achievable SDGs are Goal 3: Good Health and Well-Being, Goal 11: Sustainable Cities and Communities, Goal 13: Climate Action, and Goal 15: Life on Land.

Urban forests significantly contribute to SDG 3: Good Health and Well-being by providing spaces for physical activity, enhancing mental well-being, and improving air quality. Moreover, they advance SDG 11: Sustainable Cities and Communities by conserving natural heritage and bolstering urban resilience. They also play a role in SDG 13: Climate Action by mitigating climate-related risks and reducing urban heat island effects. Additionally, urban forests contribute to SDG 15: Life on Land by fostering biodiversity, preventing deforestation, and safeguarding genetic resources.

Similarly, KLFEP has the potential to contribute to Goal 3: Good Health and Well-Being. As a prominent recreational area, it promotes community health and well-being. Moreover, its diverse range of species can help reduce illness from air pollution, aligning with Target 3.9. While KLFEP contributes to preserving natural heritage, it can improve inclusivity to align with Target 11.7. Additionally, KLFEP serves as a buffer against climate disasters, aligning with Target 13.1. Finally, KLFEP supports SDG 15: Life on Land by providing habitat for various species, aiding in ecosystem restoration, and preventing deforestation.

In summary, urban forests and KLFEP significantly contribute to achieving multiple SDGs. They promote healthier lifestyles, sustainable urban communities, climate resilience, and biodiversity conservation. Recognising these interconnected roles underscores the potential of urban forests in Kuala Lumpur to contribute to SDG 3, SDG 11, SDG 13, and SDG 15. However, addressing existing gaps, such as enhancing inclusivity, will further optimise their contribution to achieving the Sustainable Development Goals.

Achievable SDGs about the existence of urban forests

Four respondents, professionals in the landscape architecture field, were interviewed to delve deeper into the achievable SDGs with the existence of urban forests. Initially, the question focused on inquiring about ongoing efforts related to KLFEP that align with the SDGs. However, it was understood that not all respondents were directly involved with KLFEP. Consequently, the revised question aimed to gather insights into current efforts to achieve SDGs about urban forests and to compile a list of achievable SDGs. "Current efforts" refer to the ongoing projects undertaken by the respondents in Kuala Lumpur, while the list of SDGs is based on the professionals' perspectives.

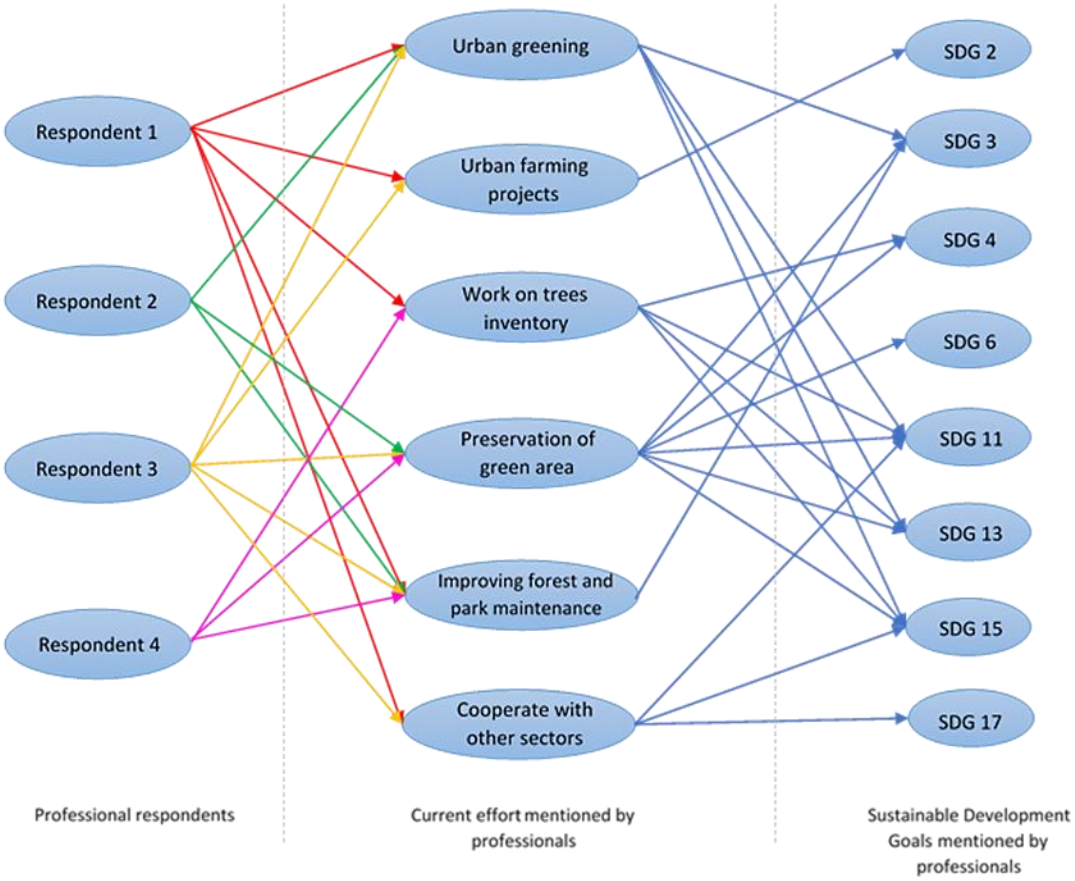

Fig. 8: Current effort of professionals in achieving SDGs relating to urban forests

Based on Figure 8, professionals are engaged in nine ongoing initiatives that align with the SDGs related to the presence of urban forests. These efforts include urban greening, entailing tree planting in vacant spaces, and urban farming to support Goal 2: Zero Hunger by planting native trees. Additionally, tree inventories are conducted to monitor and evaluate tree health and growth. Emphasis is placed on preserving green areas, with the aspiration that other cities will follow suit, contributing to Malaysia's achievement of specific SDGs such as Goal 4: Quality Education, Goal 11: Sustainable Cities and Communities, and Goal 15: Life on Land.

Urban greening, considered crucial for building sustainable cities and achieving a low-carbon society, is seen as a pathway toward SDG 3, SDG 11, SDG 13, and SDG 15. Professionals are also actively enhancing the maintenance of urban forests and parks, focusing on public safety and comfort, thereby supporting Goal 3: Good Health and Well-being. Urban farming offers potential for food production, including planting edible trees in urban areas. However, its implementation within the Kuala Lumpur Forest Eco Park (KLFEP) is constrained by space limitations. Collaboration with public and private sectors is essential for project expansion and raising public awareness, contributing to Goal 17: Partnerships to Achieve the Goal.

Despite the potential contributions to several SDGs, achieving Goal 2: Zero Hunger within the context of KLFEP is considered challenging due to restrictions on extracting forest products in the protected area. Therefore, based on these efforts, it is concluded that seven SDGs could be attained (Goal 3: Good Health and Well-being, Goal 4: Quality Education, Goal 11: Sustainable Cities and Communities, Goal 13: Climate Action, and Goal 15: Life on Land) within the context of KLFEP, with Goals 2 and 6 omitted.

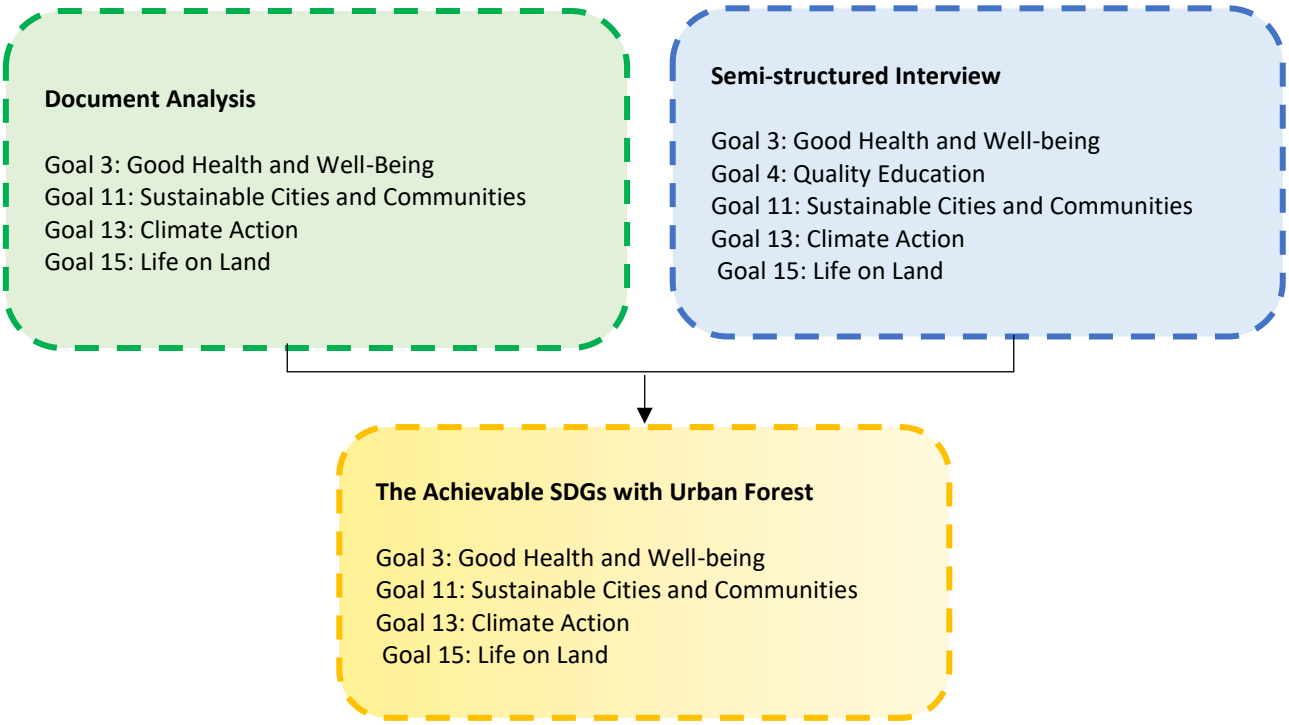

Fig. 9: Achievable SDG with the comparison of document analysis and semi-structured interview

Figure 9 compares the analysis of the attainable SDGs from document analysis and semi-structured interviews. The only disparity between both analyses is that the attainable SDGs from semi-structured interviews include Goal 4: Quality Education, as two professionals (interview respondents) are involved in efforts related to SDG 4. From both analyses, the outcomes of attainable SDGs with urban forests are Goal 3: Good Health and Well-being, Goal 11: Sustainable Cities and Communities, Goal 13: Climate Action, and Goal 15: Life on Land. Therefore, by highlighting the contribution of urban forests, particularly KLFEP in Kuala Lumpur, the focus is on achieving SDG 3, SDG 11, SDG 13, and SDG 15.

5.0 CONCLUSION

Having an urban forest in an urban area is vital for the well-being of the environment, economy, and society. This study has demonstrated that urban forests offer a multitude of contributions. Most notably, urban forests make significant contributions to ecosystem services aligned between KLFEP and studies on urban forests. The findings reveal that urban forests are crucial in advancing several Sustainable Development Goals (SDGs). They substantially contribute to SDG 3: Good Health and Well-being by providing a natural environment that encourages physical activities, supports mental health, and improves air quality.

Additionally, urban forests contribute to SDG 11: Sustainable Cities and Communities by preserving natural heritage, improving urban resilience, and creating more sustainable and livable urban environments. They also play a role in SDG 13: Climate Action by mitigating the impacts of climate change through carbon sequestration, reducing the urban heat island effect, and providing buffers against climate-related disasters. Furthermore, urban forests support SDG 15: Life on Land by promoting biodiversity within urban areas and providing

habitats for various species.

KLFEP represents Kuala Lumpur's urban forest and plays a crucial role in contributing to the SDGs. While KLFEP may not contribute significantly to provisioning services due to restrictions on forest product extraction, it excels in supporting other ecosystem services and achieving SDGs related to health, sustainability, climate action, and terrestrial life conservation. The achievable SDGs about urban forests, including KLFEP, are Goal 3: Good Health and Well-being, Goal 11: Sustainable Cities and Communities, Goal 13: Climate Action, and Goal 15: Life on Land. This underscores the importance of urban forests in achieving sustainable urban development goals.

To further enhance the contributions of urban forests to SDGs, several recommendations are proposed:

1. **Comprehensive Urban Forest Planning:** Holistic planning and management of urban forests are essential to ensuring sustainable urban development. This approach should encompass biodiversity conservation, recreational opportunities, and air quality improvement, aligning with urban forests' multifaceted contributions to SDGs.
2. **Awareness Campaigns:** Public awareness campaigns are needed to educate the community about the value of urban forests. By highlighting the tangible benefits of green spaces, such as mental health support and improved air quality, citizens can become more proactive in preserving urban forests, thereby supporting health and sustainable communities' SDGs.

3. **Urban Greening Projects, Including Urban Farming:** Promoting urban greening initiatives, including urban farming, can optimize green spaces within Kuala Lumpur. Urban farming, in particular, can contribute to Goal 2 (Zero Hunger) by introducing edible trees into urban areas and enhancing the capacity of the urban ecosystem to provide for its inhabitants.
4. **Prioritise Genetic Resource Conservation:** Conservation of genetic resources within urban forests is crucial for preserving biodiversity and supporting sustainable development goals. By prioritising the conservation of rare and valuable species, Kuala Lumpur can align with SDG 15 (Life on Land) and ensure that urban forests continue to provide genetic resources for future generations.

In conclusion, by implementing these recommendations, Kuala Lumpur can maximize the potential of its urban forests to advance sustainable development goals, creating a more harmonious and resilient urban landscape.

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JOURNAL OF ARCHITECTURE, PLANNING & CONSTRUCTION MANAGEMENT
Volume 14 Issue 1, 2024 E-ISSN: 2462-2222 ISSN: 2231-9514

THE CHALLENGES OF THE INTERNET OF THINGS (IoT) IN THE CONTEXT OF CONSTRUCTION COST MANAGEMENT

Received: 16th November 2023 | Accepted: 19th February 2024 | Available Online: 30thJune 2024

DOI: 10.31436/japcm.v14i1.836

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ABSTRACT

The construction industry faces significant challenges related to cost overruns, project delays, and inefficiency. Traditional cost management methods rely on manual processes and limited data sources, but the advent of technology and the Internet of Things (IoT) offers innovative solutions. This research explores the application of IoT in construction cost management, starting with a literature review that highlights the limitations of current methods and areas where IoT can enhance value. The study aims to identify IoT applications and challenges in construction cost management. It employs a mixed-method approach, including a questionnaire survey of 47 respondents and interviews with four construction stakeholders. The research finds that IoT sensors provide real-time data, addressing historical inefficiencies and improving project outcomes. However, it also reveals challenges such as additional budget for acquiring IoT technologies and poor collaboration among construction parties. In summary, IoT promises to transform construction cost management but requires addressing budgetary and collaboration issues to maximize its potential.

Keywords: Application, Challenges, Construction cost management, Internet of Things (IoT)

1.0 INTRODUCTION

The Construction 4.0 Strategic Plan (2021-2025) was formulated collaboratively by the Ministry of Works, the Construction Industry Development Board of Malaysia (CIDB), and the Construction Research Institute of Malaysia (CREAM) to foster digitalization in the construction industry. This plan seeks to position the construction sector as a leader in Construction 4.0 within Southeast Asia, and it employs agile governance to engage stakeholders comprehensively (Ahmad Farhan et al., 2022). As the construction industry approaches the fourth industrial revolution (IR 4.0), there has been a surge in construction technology innovation. Among the nine pillars of this revolution, the Internet of Things (IoT) is recognized as a key element that can boost productivity (Farah Salwati Ibrahim et al., 2019). IoT is characterized by integrating sensors, devices, and systems into physical environments, enabling real-time data collection and exchange (Papageorgiou and Demetriou, 2019). The utilization of IoT devices is growing rapidly, with projections indicating that up to 75.44 billion devices will be integrated into IoT networks. However, the construction industry currently faces multiple challenges, including material shortages, environmental concerns, safety

issues, varying technology adoption rates, escalating material costs, a shortage of skilled labour, inadequate design processes, high transportation and energy expenses, and delays in technology adoption (Qi et al., 2021).

Moreover, the construction industry has largely relied on manual labour, extensive machinery, and an outdated business model, which has not seen significant updates for decades (Khurshid et al., 2023). Fakunle et al. (2020) emphasize that revenue losses and production delays stem primarily from inadequate building specifications and enforcement of regulations. Amidst this backdrop, the realm of Construction Cost Management stands at the forefront of these challenges, demanding innovative solutions that enhance efficiency and transparency (Shen et al.,2001). Historically, cost management in construction has been entrenched in traditional methods that heavily rely on manual processes, spreadsheets, and limited data sources (Hegazy et al., 2020). However, IoT technology offers a transformative solution to longstanding challenges in the construction industry, potentially tracking, measuring, and optimising project processes and reducing time and costs (Tang et al., 2019). Ghosh et al. (2020) highlight that IoT can save between 22 and 29 per cent of total construction costs, equivalent to $75 to $96 billion in annual benefits. Furthermore, IoT is expected to become indispensable for various aspects of the construction industry, including waste management, cost reduction, maintenance and repair, safety improvements, and tenant requirement management (Khurshid et al., 2023).

2.0 LITERATURE REVIEW

2.1 Internet of Things

The Internet of Things (IoT) is a groundbreaking concept first introduced by Kelvin Ashton in 1999 within the realm of supply chain management (Ashton, 2009, as cited in Yaser Gamil et al., 2020; Ghosh et al., 2020; Evdokimov et al., 2019). Alzubi et al. (2020) define IoT as the interconnection of trillions of electronic devices, each equipped with sensors that regulate various aspects of human existence (Alzubi et al., 2020). Kim et al. (2018) and Syamsul H. Mahmud et al. (2018) describe IoT as a technological framework where intelligent items, including sensors, communication devices, and computer equipment, are networked via wired and wireless communication networks, enabling information collection, sharing, and utilization without human intervention. Balaji et al. (2019) define IoT as a dynamic network structure merging the real and virtual worlds through the Internet for communication and data transmission. IoT envisions a future where every day physical objects connect to the Internet and communicate with other devices to self-identify (Laghari et al., 2021). Originally, IoT was closely associated with radio frequency identification (RFID), a technology introduced in 1945 and considered a precursor to IoT (David R., 2014, as cited in Laghari et al., 2021). In addition to RFID, various technologies contribute to IoT, as mentioned in Figure 1, including WSN, Electronic Product Code (EPC), Bar Code, ZigBee, and Bluetooth, with Bluetooth gaining popularity due to its low energy consumption and convenience (Laghari et al., 2021).

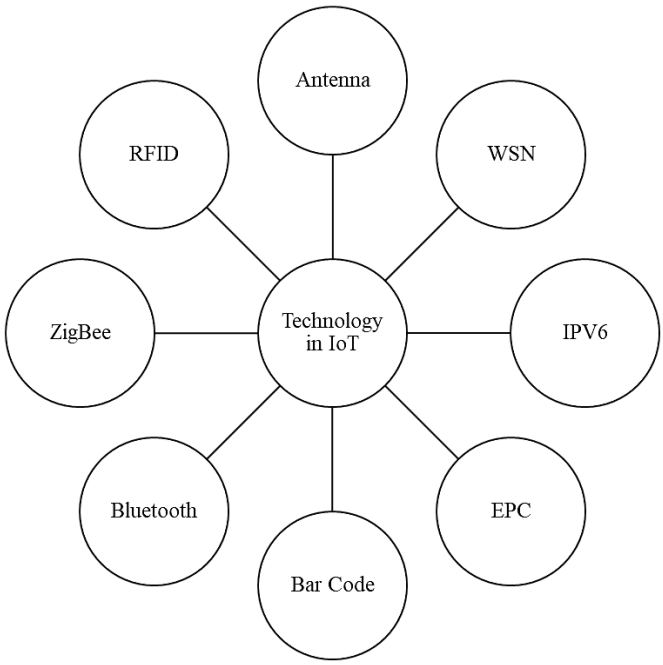

Fig. 1: Technology in the Internet of Things (IoT).
(Source: Balaji et al., 2019)

2.2 Construction Cost Management

Construction cost management is a critical aspect of the construction industry, ensuring that projects are completed within budgetary constraints and financial goals are met. It involves various processes such as budgeting, estimating, cost control, and financial reporting (Ashworth & Hogg, 2007). It is utilised to manage project costs (Miri & Khaksefidi, 2015), and its purpose is to ensure that projects are completed within the approved budget and on schedule (Igwe et al., 2020). Meanwhile, according to Herszon (2017, as cited in Vigneault et al., 2019), cost management encompasses estimating all activities and efforts required to complete the project. Accurate cost management is essential to avoid cost overruns, significantly impacting project profitability and sustainability. It requires a systematic approach to assess and allocate resources effectively, covering both direct and indirect costs associated with construction projects (Faten Albtoush et al., 2020). Figure 2 shows the RIBA Plan of Work, a comprehensive blueprint for project management in the construction industry, encompassing stages from inception to post-occupancy. Among its key stages are the Design and Construction phases, with prominent cost management activities.

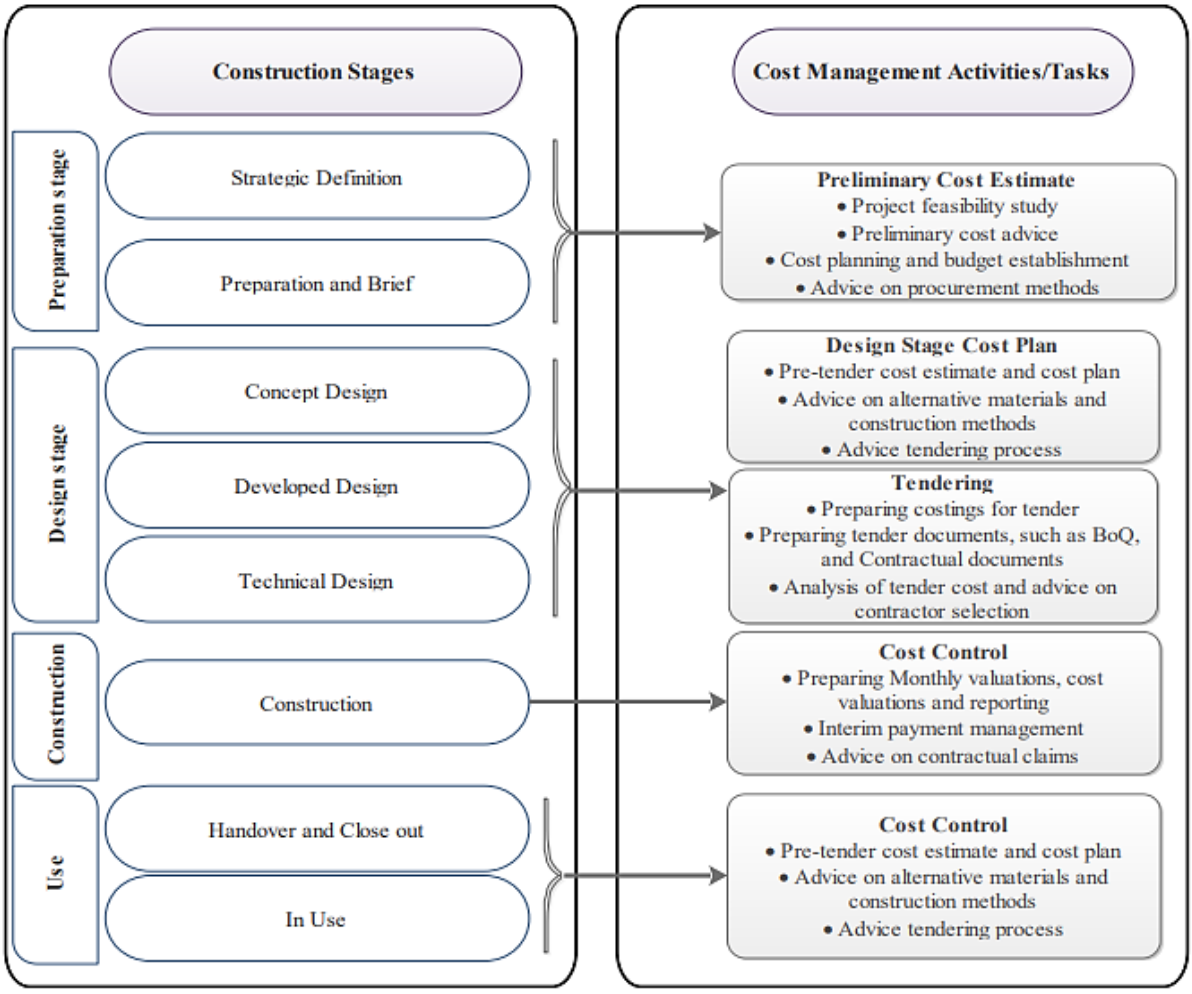

Fig. 2: Overview of the Cost Management activities within the RIBA Plan of Work framework.
(Source: Malkanthi et al., 2017)

2.3 Application of IoT in Construction Cost Management

Information and Communication Technology (ICT) in construction can significantly benefit various aspects, including construction planning, cost control, financial planning, and facilities management. However, the adoption of ICT for cost management in construction projects still needs to be improved. The complexity of modern constructions makes cost management increasingly challenging, and more than conventional approaches may be needed for effectively managing costs in competitive and complicated projects. One promising application of the Internet of Things (IoT) in construction cost management is addressing cost overruns, a prevalent issue in project management. Inaccuracies in quantity take-offs, project cash flow forecasting, and inadequate cost management often cause these overruns. Accurate cost estimation is crucial, and IoT, integrated with other IT innovations such as Big Data and Artificial Intelligence (AI), can automate certain traditional roles, including cost estimators. IoT can also be applied to supply chain monitoring in construction, where material costs constitute a significant portion of the total project cost. IoT technologies, including Radio Frequency Identification (RFID), enable tracking material data throughout construction,

optimizing material management and cost accounting. Often arbitrary and needing more standardization, traditional material management practices can hinder proper cost management.

Table 1: Application of IoT in construction cost management

No.	Application of IoT in Construction Cost Management	Citations									
		Igwe et al. (2022)	Vigneault et al. (2019)	Evdokimov et al. (2019)	Woodhead et al. (2018)	(Ding, Nemati, Ranaweera, & Choi, 2020)	Zhang et al. (2021)	Shen (2022)	Ha (2021)	Ghosh et al. (2020)	Khurshid et al. (2023)
1.	Cost estimation		✓	✓	✓				✓		
2.	Real-time monitoring and control of project expenses	✓				✓	✓	✓			✓
3.	Transparency and visibility into cost data										✓
4.	Early identification and mitigation of cost overruns		✓								
5.	Streamlined communication and collaboration among project stakeholders	✓									
6.	Connected project site enables easy and fast communication of project information, saving cost, time and energy	✓									✓
7.	Project monitoring and control resources	✓				✓		✓			✓
8.	Waste management								✓		✓

During the construction stage, various technologies such as Building Information Modeling (BIM), Augmented Reality and Virtual Reality (AR&VR), Mobile Technology, IoT, Artificial Intelligence and Machine Learning (AI & ML), Drones, Robotics, and Predictive Analytics play vital roles in cost management. These technologies enable real-time monitoring and control, accurate cost estimation, and efficient project management. Implementing IoT systems for construction site safety can yield significant cost savings compared to manual and sensor systems. Additionally, IoT technology can effectively reduce procurement lead time and project expenses by utilizing real-time data, project stock levels, and environmental conditions to facilitate efficient decision-making. RFID technology and sensors integrated into construction materials provide valuable information regarding material quality and characteristics, enhancing market research and reducing costs. IoT has the potential to

significantly impact the construction industry by improving cost management, reducing overruns, enhancing material procurement, and increasing transparency, as mentioned in Table 1. The financial benefits are substantial, with potential cost savings of 22% to 29% of total costs annually. IoT's ability to improve communication, process control, and data analysis at a micro level position it as a transformative technology in construction cost management (Ghosh et al., 2020; Kiran Khurshid et al., 2023).

2.4 Challenges of applying IoT in construction cost management

The application of IoT in construction cost management offers significant advantages but encounters several challenges across various dimensions. These challenges encompass technology, database management, operational, administrative, legislative, and knowledge-related barriers. Understanding and addressing these challenges are crucial for the successful integration of IoT in construction cost management practices. Table 1 summarises the challenges faced in IoT applications for construction cost management, as documented by various authors.

2.4.1 Technology barrier

Integrating the Internet of Things (IoT) into construction cost management offers significant benefits, including real-time data collection, enhanced project monitoring, and improved decision-making (Kiran Khurshid et al., 2023). However, several technology barriers must be addressed for successful implementation. One challenge arises from the limited advancement in research and development in IoT and Construction 4.0, often necessitating adjustments to architectures and technologies, impacting the market (Kiran Khurshid et al., 2023). Scalability is another crucial factor, as IoT deployments must accommodate diverse project sizes and complexities (Wu et al., 2022). The absence of unified standards in the construction industry limits flexibility, potentially hindering vendor switching and scaling operations (Zhong, 2022). Additionally, IoT technology complexity may disrupt existing workflows and processes, with resistance from construction teams due to perceived complexity and time constraints for learning and managing new technologies (Farah Salwati Ibrahim, Muneera Esa & Rahimi A. Rahman., 2021). Intricate IoT device installation processes can lead to delays and disruptions on construction sites (Laghari et al., 2021).

2.3.2 Database barrier

Database barriers in construction cost management pertain to data organization, storage, management, and utilization challenges. These barriers significantly impact cost tracking and control efficiency. IoT devices generate substantial and diverse data, including sensor readings, equipment data, and environmental conditions (Farah Salwati Ibrahim, Muneera Esa & Rahimi A. Rahman., 2021). Conventional database systems may need help to handle the volume and diversity of IoT data, resulting in performance degradation and slow query execution. Managing complex data relationships within IoT data, which includes sensor data linked to locations and timestamps, presents additional challenges (Farah Salwati Ibrahim, Muneera Esa & Rahimi A. Rahman., 2021).
Moreover, IoT service providers who need more comprehensive knowledge of construction industry requirements may develop solutions that align with cost management needs (Wu et

al., 2022). Integration of IoT data with construction cost management systems is vital for successful implementation but can be hindered by providers' limited data analytics capabilities (Zhong, 2022). Data privacy concerns arise due to weak user authentication and access control mechanisms in IoT systems, potentially leading to unauthorized access, data manipulation, and compromised decision-making (Balaji et al., 2019). The continuous collection and transmission of sensitive data by IoT devices heightens the risk of unauthorized access and breaches when data security measures are insufficiently robust (Kiran Khurshid et al., 2023).

2.3.3 Operational barrier

The implementation and operation of IoT technology within the construction industry encounter several operational barriers that stem from the challenges associated with deploying, managing, and maintaining IoT devices and systems in construction environments. One of the primary challenges is the low cost-benefit ratio of IoT implementation. The upfront investments required for IoT hardware, software, connectivity infrastructure, and skilled personnel can be significantly high, potentially discouraging construction companies from adopting IoT solutions. Moreover, the uncertainty in estimating the return on investment (ROI) for IoT implementations in construction cost management poses a hurdle (Balaji et al., 2019; Waqar et al., 2023). Additionally, an extra budget for IoT technology can strain project funds, especially when ROI is not guaranteed or immediate (Farah Salwati Ibrahim, Muneera Esa & Rahimi A. Rahman, 2021). Energy and device management poses another set of challenges. IoT devices require a consistent power supply, which can be challenging in remote or temporary construction sites with limited access to power sources. Managing the finite lifespans and frequent monitoring and replacement needs of battery-powered IoT devices can be time-consuming and costly (Balaji et al., 2019).
Furthermore, implementing IoT technology introduces inherent safety risks for collecting and transmitting sensitive project data. Inadequate security measures can lead to unauthorized access, data breaches, and potential legal and financial repercussions (Kiran Khurshid et al., 2023). Integrating IoT technology with existing construction processes may also result in operational disruptions, errors, or malfunctions, causing inefficiencies and delays (Yaser Gamil et al., 2020).

2.3.4 Administrative and Legislative Barrier

Administrative and legislative barriers further complicate IoT implementation in construction. The need for more training centres for IoT can hinder effective implementation, leading to inefficiencies or project failures (Farah Salwati Ibrahim, Muneera Esa & Rahimi A. Rahman, 2021). A lack of government support, in the form of financial resources or grants, can be a significant barrier, especially for financially constrained construction companies (Das & Abhijit Rastogi, 2023). Additionally, the absence of documented standards for implementing IoT can create uncertainties surrounding compliance with data privacy, security, and other regulations, posing risks of data breaches and unauthorized access (Kiran Khurshid et al., 2023). Legal issues related to IoT-generated data ownership and sharing agreements among multiple stakeholders can also lead to disputes (Khurshid et al., 2023). The lack of an IoT knowledge management system can further impede adoption and utilization of IoT solutions (Laghari et al., 2021; Gbadamosi et al., 2019).

2.3.5 Knowledge barrier

Knowledge barriers within the construction industry also play a significant role in hindering IoT adoption. Many professionals in the construction sector may resist IoT technology due to their familiarity with traditional cost management methods. A lack of knowledge about IoT's potential benefits may lead to reliance on conventional approaches. Additionally, the unfamiliarity with IoT technology and its operational systems can result in a reluctance to adopt new technologies and difficulties performing maintenance duties (Khurshid et al., 2023; Gamil et al., 2020). Concerns about the complexity of implementation, potential faults, and negative impacts on existing projects may further discourage IoT adoption (Khurshid et al., 2023; Gamil et al., 2020). Lack of collaboration can fragment knowledge and experience, hindering the development of a comprehensive understanding of IoT technology's advantages and applications (Khurshid et al., 2023; Yaser Gamil et al., 2020; Das & Rastogi, 2023).

Table 2: Summary of Challenges Applying IoT in Construction Cost Management

No.	Challenges		Citations
1.	Technology barriers	Limited IoT technology implementation in construction scope	Khurshid et al. (2023), Wu et al. (2022), Zhong (2022), Gamil et al. (2020)
2.		Lack of unified technical standards and specifications	Zhong (2022), Waqar et al. (2023), Das & Abhijit Rastogi (2023)
3.		Complexity of use/not user-friendly of IoT technology	Farah Salwati Ibrahim, Muneera Esa & Rahimi A. Rahman. (2021) Laghari et al. (2021), Zhong (2022), Gamil et al. (2020)
4.	Database barrier	The complexity of the data architecture in IoT	Farah Salwati Ibrahim, Muneera Esa & Rahimi A. Rahman (2021), Waqar et al. (2023), Oke et al. (2020)
5.		Lack of IoT service providers' capabilities	Zhong (2022), Gamil et al. (2020), Das & Abhijit Rastogi (2023), Wu et al. (2022), Das & Abhijit Rastogi (2023)
6.		IoT technology can lead to data privacy concerns for users.	Balaji et al. (2019), Khurshid et al. (2023), Waqar et al. (2023), Gamil et al. (2020), Das & Abhijit Rastogi (2023), Alzubi et al. (2020),
7.	Operational barrier	Requirement of extra budget to acquire IOT technologies	Khurshid et al. (2023), Farah Salwati Ibrahim, Muneera Esa & Rahimi A. Rahman (2021), Das & Abhijit (2023), Igwe et al. (2022), Gamil et al. (2020),
8.		IoT has a low-cost-benefit ratio.	Waqar et al. (2023)
9.		Implementing IoT requires energy and device management	Waqar et al. (2023)

No.	Challenges		Citations
10.		Implementation of IoT technology carries inherent safety risks.	Gamil et al. (2020), Khurshid et al., (2023)
11.	Administrative and legislative barrier	Lack of government support for IoT implementation	Das & Abhijit Rastogi (2023), Farah Salwati Ibrahim, Muneera Esa & Rahimi A. Rahman (2021)
12.		Shortage of training centres for IoT	Gamil et al. (2020)
13.		Lack of documented standards for implementing IoT	Gamil et al. (2020), Das & Abhijit Rastogi (2023)
14.		Legal issues about IoT	Gamil et al. (2020)
15.		Lack of an IoT Knowledge management system	Gamil et al. (2020), Khurshid et al., (2023)
16.	Knowledge barrier	Players in the construction industry are hesitant to adapt.	Khurshid et al. (2023), Lo et al. (2021)
17.		Lack of awareness among construction industry players regarding the benefits available to them	Khurshid et al. (2023), Gamil et al. (2020), Lo et al. (2021)
18.		Lack of IOT knowledge	Khurshid et al. (2023), Gamil et al. (2020), Lo et al. (2021)
19.		Lack of expertise in IoT technology	Khurshid et al. (2023), Gamil et al. (2020), Lo et al. (2021)
20.		Fear of failure when attempting to implement IoT technology	Khurshid et al. (2023), Gamil et al. (2020)
21.		Unfamiliarity and lack of IOT experience	Khurshid et al. (2023), Gamil et al. (2020)
22.		Poor collaboration among construction parties	Khurshid et al. (2023), Yaser Gamil et al. (2020), Das & Rastogi (2023)

3.0 METHODOLOGY

The research employed a mixed-methods approach to comprehensively investigate the application of IoT in construction cost management. This multifaceted methodology combined both quantitative and qualitative data collection methods. A questionnaire survey was conducted to gather quantitative data from various sectors within the construction industry. A sample of 47 respondents participated in the survey, providing insights into their experiences, perceptions, and attitudes regarding the use of IoT in construction cost management. The survey responses were subjected to statistical analysis to identify trends and patterns. In addition to the quantitative data, qualitative insights were obtained through interviews with four key stakeholders in the construction industry, representing diverse

perspectives and roles, including project managers, contractors, and technology experts. Semi-structured interviews were conducted to delve deeper into their experiences and perspectives on the challenges and benefits of implementing IoT in construction cost management.

The questionnaire is organized into five distinct sections: A, B, C, D, and E. Data analysis for sections A, B, C, D, and E was also conducted using Statistical Package for Social Science (SPSS), version 29.0. In this study, the mean values obtained for each impact have been organised in descending order, from the highest mean value to the lowest mean value. The Likert scale (Table 4.8) is the primary measurement tool, proving an effective and straightforward data collection and mean analysis method. In this study, the mean analysis for each effect has been organised in descending order, from the highest mean value to the lowest minimum value.

Table 3: Average index (AI) for the Likert scale

Scale	Item	Average index (AI)
1	Strongly disagree	0.00<AI<1.50
2	Disagree	1.50<AI<2.50
3	Neutral	2.50<AI<3.50
4	Agree	3.50<AI<4.50
5	Strongly agree	4.50<AI<5.00

The data from the Interview will be analysed by content analysis. Content analysis systematically identifies patterns, themes, and meanings within qualitative data, such as interview transcripts. It requires a methodical approach to classifying and interpreting data to draw meaningful conclusions (Bengtsson, 2016).

4.0 RESULTS

4.1 Application of IoT in Construction Cost Management

4.1.1 Questionnaire survey

Table 4: Areas or aspects of the construction industry would benefit the most from IoT application

Areas or aspects of the construction industry would benefit the most from IoT application.	Mean
Supply chain management and material tracking	4.2340
Construction project management and planning	4.1915
Equipment and asset tracking and maintenance	4.1489
Safety monitoring and risk mitigation	4.1064
Building design and energy management	4.0000

All the available choices of domains or facets of the construction sector would get significant advantages from implementing IoT, as indicated by their high scores, which surpass a value of 4.0 on the AI scale. The findings indicate that the mean values of the variables do not differ considerably. The variable with the lowest mean value is building design and energy management, with a score of 4.00. In contrast, the variable with the greatest mean value is supply chain management and material tracking, with a score of 4.23. Construction project management and planning had the second-highest AI value, with a recorded score of 4.19. Subsequently, implementing equipment and asset tracking, maintenance and safety monitoring, and risk reduction achieved AI values of 4.14 and 4.11, respectively.

Table 5: Benefits of using IoT in construction cost management

Benefits of using IoT in construction cost management	Mean
Improved accuracy and efficiency in cost estimation	4.2766
Real-time monitoring and control of project expenses	4.2766
Connected project site enables easy and fast communication of project information, saving cost, time and energy	4.1277
IoT is greatly used for project monitoring and control of resources	4.1064
Enhanced transparency and visibility into cost data	4.0851
Early identification and mitigation of cost overruns	4.0851
Streamlined communication and collaboration among project stakeholders	4.0638
It has great applications in waste management	3.9787

Table 5 shows the benefits of using IoT in construction cost management. From Table 5, all the options that answer to the potential benefits of using IoT in construction cost management are high, as the average index for all benefits is more than 3.9. The highest potential benefits are Improved accuracy and efficiency in cost estimation and real-time monitoring and control of project expenses, which recorded 4.28 AI value. The connected project site follows this, which enables easy and fast communication of project information, saving cost, time and energy (AI=4.13), and IoT is greatly used for project monitoring and control of resources (AI=4.11). Enhanced transparency and visibility into cost data and early identification and mitigation of cost overruns have similar A. I value 4.09. The next benefit is streamlined communication and collaboration among project stakeholders, scoring a 4.06 AI value. The lowest AI value of the potential benefit is 3.98, indicating IoT has significant waste management applications.

4.4.2 Interview

This section comprehensively discusses IoT's practical application and challenges in construction cost management through in-depth interviews with industry professionals. Table 6 will delineate the similarities and differences in data about the benefits of IoT in construction cost management, as derived from both the questionnaire survey and interview responses.

Respondent 1
"…especially drones because we would like to have the aerial view of our sites so that you could give a better view or better picture of the site progress as time goes."
"… BIM and Cost X. In JKR, we have an application called Cost X, which we have been using to generate all these costs as part of the project. And then we have JKR e-tender that also accommodates the system."

Respondent 2
"…Autodesk and then even from Glodon, a good software. From the design stage, you can monitor up to operation. So, at least people can use software instead of Excel because Autodesk and Glodon have software that helps the organisation monitor the budget.

"…maybe we can apply these IOT sensors on smart or intelligent buildings, which is not new. Some have done it. It's just that it may not exist in Malaysia. So, from the application of IoT on smart building, from there we can develop an IoT-based construction cost prediction."

"…you have to come up with an algorithm, and you get that input, and then you put it in the algorithm, and then from the algorithm, you will get an analysis where you can predict so that we can optimize each parameter in the building itself. So that we don't waste, one thing we can optimize is revenue cost. In return, you will get a cost control and cost prediction model for intelligent building. So, that's what we want to get. In terms of integrating IoT in the CCM process itself."

Respondent 3
"…in terms of CCM, estimate, what potential development cost and implementation can differ real-time cost which includes VO
"…process of CCM. From an earlier stage, there is value engineering, and in the execution, value engineering also cuts down costs.
"…benefits of IoT in CCM; if there is an IoT with the same environment, which all parties in one environment, cost estimate might be great, example like BIM that includes all M&E, architects, engineers in one drawing, QS can make work easy, all the information is there, just the accuracy of the info that BIM provide has to be tied back with updated cost data. In terms of project management, easy to track all work related to tendering and designing has progressed as an all-in-one environment."

Respondent 4
"Application of IoT in construction cost management is a game-changer. By integrating IoT devices and sensors into various elements of a construction project, we can gain real-time insights into resource usage, equipment performance, and project progress.
"…IoT can help us optimize resource allocation, prevent costly delays, and respond promptly to potential overruns."
"…IoT-enabled project tracking allows us to monitor progress in real-time real-time, ensuring that we stay on schedule and within budget."

Table 6: Similarities and differences data of benefits of using IoT in construction cost management from questionnaire survey and Interview

	Questionnaire Survey	Interview
Improved accuracy	Ranking no. 1	Respondent 1,2,3
Real-time data	Ranking no. 2	Respondent 1,3,4
Connected project site enables easy and fast communication of project information, saving cost, time and energy.	Ranking no. 3	Respondent 1,2,3,4

4.2 Challenges Implementing IoT in Construction Cost Management

4.2.1 Questionnaire survey

Table 7 below shows the challenges compiled according to the ranking. The average score for all IoT challenges rated by respondents is high, with only one barrier scoring a moderate average index. The requirement of extra budget to acquire IOT technologies is rated as the most challenging challenge to implement IoT in CCM. Moreover, the lowest-rated challenge is IoT's low-cost-benefit ratio.

Table 7: Summary of all challenges of implementing IoT in construction cost management

Ranking	Challenges	Mean
1	Requirement of extra budget to acquire IoT technologies	4.3404
2	Poor collaboration among construction parties	4.2979
3	Lack of expertise in IoT technology	4.2766
	Unfamiliarity and lack of IoT experience	4.2766
4	Lack of awareness among construction industry players regarding the benefits available to them	4.2553
	Lack of IOT knowledge	4.2553
	Lack of unified technical standards and specifications	4.2553
5	Implementing IoT requires energy and device management	4.2340
6	Limited IoT technology implementation in construction scope	4.1489
7	Lack of government support for IoT implementation	4.1277
8	Players in the construction industry are hesitant to adapt	4.1277
9	Shortage of training centres for IoT	4.0851
10	Lack of an IoT Knowledge management system	4.0851
11	Fear of failure when attempting to implement IoT technology	4.0426
12	Lack of documented standards for implementing IoT	4.0213
13	Lack of IoT service providers' capabilities	3.9787
14	IoT technology can lead to data privacy concerns for users	3.9362
15	Complexity of use/not user-friendly of IoT technology	3.8298
16	Legal issues about IoT	3.8511
17	Implementation of IoT technology carries inherent safety risks	3.7872
18	Complexity of the data architecture in IoT	3.7447
19	IoT has a low-cost-benefit ratio	3.4255

4.2.2 Interview

Based on the result below in Table 8, the biggest challenges mentioned by all respondents are a requirement for an extra budget to acquire IOT technologies, a lack of expertise in IoT technology, and players in the construction industry hesitant to adapt. The least challenging challenges mentioned by the respondents are the need for unified technical standards and specifications, limited IoT technology implementation in the construction scope, no enforcement from the government, and the complexity of the data architecture in IoT. These interviews were conducted to validate the findings from the questionnaire.

Table 8: Summary of challenges mentioned by respondents.

No.	Challenges	Respondent
1	Requirement of extra budget to acquire IOT technologies	1,2,3,4
2	Poor collaboration among construction parties	1,2,4
3	Lack of expertise in IoT technology	1,2,3,4
4	Unfamiliarity and lack of IOT experience	1,4
5	Lack of awareness among construction industry players regarding the benefits available to them	1,4
6	Lack of IOT knowledge	1,3,4
7	Lack of unified technical standards and specifications	4
8	Implementing IoT requires energy and device management	1,2,4
9	Limited IoT technology implementation in construction scope	4
10	Lack of government support for IoT implementation	3,4
11	Players in the construction industry are hesitant to adapt	1,2,3,4
12	No enforcement from the government	1
13	Lack of an IoT Knowledge management system	3,4
14	The complexity of the data architecture in IoT	4
15	IoT has a low-cost-benefit ratio	3,4

5.0 DISCUSSIONS

5.1 Application of IoT in Construction Cost Management

The study's findings indicate that most respondents know the term "IoT" and demonstrate awareness of its application in the construction industry. The limited utilization of IoT in the construction industry needs to be more effectively utilized. The findings presented in Table 6 and respondent from the Interview highlight that implementing IoT technology offers significant benefits to the supply chain sector, positioning it as the top-ranked area to benefit from such applications. The study by Ali et al. (2020) highlights the potential of IoT technology in supply chain management, specifically in reducing costs. The highest-ranked application of IoT technology in CCM is its ability to improve accuracy and efficiency in cost estimation and enable real-time monitoring and control of project expenses, as indicated in Table 6.

Moreover, Reja & Varghese (2019) have the same viewpoint that IoT-driven real-time monitoring in construction sites utilizes strategically embedded sensors to collect data on equipment operations, worker activities, and material movement, resulting in improved project efficiency and cost avoidance, which also connected to the point no.2 on the Table 5.

From the findings, the IoT has the potential to enhance accuracy and efficiency in cost estimation by providing real-time real-time and precise data. Based on the researcher's findings, it can be inferred that the implementation of the Internet of Things (IoT) in construction cost management is not fully maximized despite the awareness of its potential benefits in this field.

5.2 Challenges of Implementing IoT in Construction Cost Management

The primary issue in integrating IoT in CCM is the need for more financial resources to procure IoT technologies, which is the most significant demand. Singh et al. (2022) conducted a study which found that the primary obstacle to implementing IoT is the cost or budgetary constraints. Furthermore, as seen in Table 2, numerous authors have highlighted cost as a significant obstacle in IoT technology.
Furthermore, the lack of effective coordination among various stakeholders in the construction industry is seen as one of the major obstacles, which is consistently observed among the top five issues, albeit sometimes in different order. In this study, the issue of poor teamwork is ranked second, as indicated by Kissi et al. (2022), but it is ranked fifth in another source. According to researchers, inadequate collaboration can lead to suboptimal integration of IoT devices, inconsistent data formats, and challenges in developing a cohesive data gathering and analysis framework.

Furthermore, one of the primary issues associated with the Internet of Things (IoT) is its low-cost-benefit ratio. Based on the findings shown in Table 6, the researcher noted that a significant number of respondents demonstrated awareness of the advantages associated with utilising Internet of Things (IoT) technology, as indicated by their responses to the section B question. Nevertheless, the IoT can provide a favourable cost-benefit ratio in certain circumstances. Conversely, in other situations, the initial expenses associated with establishing IoT devices may surpass the immediate benefits.

6.0 CONCLUSION

In conclusion, the application of IoT in construction cost management holds great promise for revolutionizing the industry. Providing longstanding challenges such as cost overruns and project delays enables real-time data collection, analysis, and decision-making capabilities in the construction sector to optimize project outcomes and enhance efficiency. However, challenges such as additional budget allocation and improved collaboration among stakeholders must be addressed for IoT to reach its full potential in construction cost management. As technology advances, embracing IoT in construction cost management is not just an option but a necessity for staying competitive and efficient in the modern construction landscape. It is a transformative tool that can lead to more transparent and streamlined processes, ultimately benefiting industry professionals and project stakeholders.

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JOURNAL OF ARCHITECTURE, PLANNING & CONSTRUCTION MANAGEMENT
Volume 14 Issue 1, 2024 E-ISSN: 2462-2222 ISSN: 2231-9514

ENHANCING DAYLIGHT IN DEEP-PLAN OFFICES FOR NIGERIA'S TROPICAL CLIMATE: A LIGHT PIPE APPROACH

Received: 4thJanuary 2024 | Accepted: 5th February 2024 | Available Online: 30th June 2024

DOI: 10.31436/japcm.v14i1.860

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ABSTRACT

This research addresses the challenge of maximising daylight provision in deep-plan office buildings in Nigeria's tropical wet and dry climate. It investigates the effectiveness of horizontal light pipes at 5m, 10m, and 15m, employing a mixed-method approach that combines case studies and computer simulations.
The study utilises Climate Studio for Rhinoceros 3D as the simulation tool to assess light distribution uniformity and illuminance levels in deep-plan offices. Statistical analysis includes applying ANOVA tests to ascertain the significance of differences between various light pipe configurations. Findings reveal that the 10m light pipe configuration consistently outperforms the 5m and 15m options, providing superior uniformity of light distribution and higher illuminance levels, thereby maximising daylight provision.
The study recommends the 10m light pipe configuration as optimal for maximising daylight provision in deep-plan office buildings within Nigeria's tropical wet and dry climate.

Keywords: Daylighting, Light Pipes, Deep-Plan Office, Tropical Wet and Dry Climate, Uniformity, Illuminance, ANOVA.

1.0 INTRODUCTION

Modern businesses increasingly favour office layouts in middle and high-rise buildings that incorporate spacious floor plans. These designs, known for their considerable depth, provide flexibility and economic advantages, making them a preferred choice (Afroz, 2015). While this configuration is commonly favoured, particularly for daytime operations, it has a notable drawback. Daylight penetration naturally extends to about 5 meters from the perimeter opening (Garcia-Hansen & Edmonds, 2003). Nadal (2005) highlights that this results in an uneven illumination distribution, with higher levels near openings and significantly reduced lighting in the deeper core. Visual comfort plays a significant role in shaping the satisfaction and well-being of individuals within indoor settings (Frontczak & Wargocki, 2011).
Numerous studies have explored the relationship between daylight distribution, visual comfort, and productivity in office environments. Turan (2020) investigates the economic value of natural light in office spaces. The study finds that spaces with high amounts of daylight (55% spatial daylight autonomy) have a 5-6% value premium over spaces with less daylight. Despite the dense urban environment, tenants value high daylight, independent of other buildings, neighbourhood, and contract characteristics. The study concludes that

daylight is a key design driver and should be considered in design, policy, planning, and project financing. This suggests that the social benefits of daylight translate into economic value.

Wong (2017) comprehensively reviewed daylighting design in modern buildings. The study focused on the methods of predicting and measuring daylight levels and the various daylighting technologies available. Despite the wide range of developed and commercially available daylighting systems, their applications have been limited due to a lack of studies on their utilisations and high initial costs.

Carlucci et al. (2015) conducted a comprehensive review in Italy, emphasising the significance of balanced light distribution for occupant well-being. Loe et al. (1994) analysed 18 lighting conditions in The Bartlett, University College London, which is in the temperate maritime climate, identifying crucial visual interest and luminosity perception variables. Zhang et al.'s (2022) investigation into illuminance, uniformity, and colour temperature in China's humid continental climate highlighted the importance of optimal lighting design for comfort and energy efficiency.

Lu et al. (2020) delved into subjective evaluation, task performance, and physiological responses to different illuminance and colour temperature combinations in China's temperate monsoon climate. Their findings reinforced the profound impact of lighting conditions on visual comfort and mood. Kompier et al. (2021) explored the temporal dynamics of abrupt illuminance and colour temperature changes in the Netherlands' moderate maritime climate, indicating the immediacy of response to lighting conditions alterations.

1.1 Problem Statement

Office spaces with inadequate and uneven light distribution can have areas that are either too dim or excessively bright, affecting the workspace's overall visual comfort and functionality. This can aggravate eye strain, create discomfort, and make reading and monitoring screens difficult. Ultimately, this can result in less productivity, more mistakes, and a slower task completion rate. In many climate zones, the value of daylight in the workplace has been emphasised, and the problems associated with inadequate daylight have been extensively studied. Thus, methods for increasing daylight penetration are essential, particularly in spaces with little window light.
Nigeria has two distinct seasons: a wet season with lots of rainfall and a dry season with less precipitation. Understanding this climate pattern is essential for tailoring architectural solutions to harness and optimise available natural resources, such as daylight, in a manner that aligns with the unique challenges posed by the local climate (NIMET, 2023).

Nigeria has a large population of about 200 million, with about 51 million working at least 40 hours a week in the workforce (UNDESA, 2019). Nigeria stands to benefit significantly from improved daylighting in office buildings. However, there is a need for research on daylighting and using light pipes in office buildings within Nigeria's Tropical and Wet Dry climatic zone. This research aims to fill this gap with this study and give designers and the country important information on improving daylight utilisation in large office spaces.

1.2 Aim and Objectives

This research aims to maximise daylight provision using light pipes in the design of deep-plan office buildings for Nigeria's tropical wet and dry climate according to the Köppen Climate classification. The research tests the performance of horizontal light pipes with depths of 5m, 10m, and 15m. The specific objectives achieved by the study are:

i. Compare the uniformity of light distribution achieved by the horizontal light pipes with depths of 5m, 10m, and 15m throughout the deep-plan office space.
ii. Compare the illuminance levels (lux) achieved in different areas of the deep-plan office buildings using horizontal light pipes with depths of 5m, 10m, and 15m.

1.3 Research questions

i. How does the uniformity of light distribution vary among horizontal light pipes with depths of 5m, 10m, and 15m within deep-plan office spaces?
ii. Are there significant differences in illuminance levels (lux) achieved in different areas of the deep-plan office buildings when using horizontal light pipes set at depths of 5m, 10m, and 15m?

1.4 Hypotheses

i. Null Hypothesis (Ho): There are no significant differences in light distribution uniformity within the office space among horizontal light pipes set at 5m, 10m, and 15m depths. Alternative Hypothesis (H1): There are significant differences in light distribution uniformity within the office space among horizontal light pipes set at 5m, 10m, and 15m depths.
ii. Null Hypothesis (Ho): There are no significant differences in illuminance levels (lux) across different areas of the deep-plan office buildings when using horizontal light pipes set at 5m, 10m, and 15m depths. Alternative Hypothesis (H1): There are significant differences in illuminance levels (lux) across different areas of the deep-plan office buildings when using horizontal light pipes set at 5m,10 m and 15 m depths.

1.5 Research design

The research design for this study integrates exploratory and experimental approaches to maximise daylight utilisation in deep-plan office buildings within Nigeria's tropical wet and dry climate. In the exploratory phase, representative case studies, like the Centre of Excellence at Ahmadu Bello University and the Bank of Industry in Abuja, were selected to understand existing daylighting strategies and quantify daylight levels. The subsequent experimental phase employs computer simulations using Climate Studio for Rhinoceros 3D to assess the effectiveness of horizontal light pipes, with inferential statistical tests for hypothesis evaluation. Data collection procedures ensure accuracy, while quantitative metrics, including uniformity and illuminance levels, gauge the horizontal light pipes' performance. Multiple office models systematically explore the impact of light pipe configurations, allowing for a comprehensive investigation into daylight provision in these specific office environments.

2.0 LITERATURE REVIEW

A good indoor environment that encourages visual comfort is essential for employees to perform efficiently and maintain good health (Fisk, 2011).

2.1 Daylight and Light Pipes

Rosemann and Kaase (2005) found that efficient daylight utilisation in buildings can be achieved through hollow light guides, as examined in the European research project ARTHELIO. The use of these light guides to allow daylight into deeper parts of a building's interior was examined in this project carried out by the Lighting Research Institute at Technical University Berlin. The process consists of harvesting daylight by using heliostats to guide it through hollow light guides and releasing it into the building's interior. In this study, a goniophotometer was built to measure the distribution of the light intensity of these pipes. Demonstration sites have shown that this method effectively reduces the energy consumption of electricity lighting, indicating an efficient strategy.

Jenkins and Muneer (2003) examined the benefits of using sunlight to light homes and businesses, highlighting its advantages in terms of economy and environment as opposed to electrical lighting. The use of lighting pipes is a simple approach to maximising natural daylight. They proposed a model to predict the illumination level based on pipe dimensions to evaluate the effectiveness of lighting pipes. Their report described a method to predict the luminous flux produced by light pipes and offers approaches for calculating illuminance derived from overcast skies. This method is intended to help optimise the use of sunlight in buildings and demonstrate its potential for reducing reliance on traditional lighting resources. Shin et al., 2011 introduced a performance prediction method for the light pipe system that focused on daylight coverage and resulted in energy savings due to reduced reliance on electric light. A model of this type was assessed against an existing prediction model in Korea's climate conditions to assess its reliability and robustness. To determine the energy savings potential of using a light pipe system, the study considered various artificial lighting control methods, namely on/off control, two-step control, and dimming control. The results showed that, on average, installing light pipes could save up to 30% in energy consumption. Shin et al. have suggested that the findings from this study may encourage wider use of light conduit systems in Korea, especially in high-rise buildings where natural daylight might be limited. This approach would allow architects to be more flexible in their design and contribute to energy-efficient building practices.

Using the HOLIGILM tool, a study assessed the efficiency of straight lighting pipes and their illuminance distribution under ceilings. The researchers found that, except at low sun angles, the transmittance of light tubes increases with solar altitude. To measure photon redistribution at the base of the light pipe, they used an asymmetry parameter, "g." They noted that lower " g " values indicate a more uniform light distribution, especially at solar elevations between 10 and 30. By calculating the luminous intensity solid, the team determined the illuminance distribution at a working plane, with the bright ring's peak intensity and intensity gradient providing a way to evaluate the optical properties of various light pipes in different climates. This approach provides valuable insight into the design of light guide systems in various latitudes and sky luminance conditions (Tsang et al., 2018).

Heng et al. (2020) investigated how different light pipe transporter shapes affect daylighting in open-plan office spaces. The study used computer simulations with an Integrated Environment Solution Virtual Environment (IESVE) and validated results with a physical scale-model experiment, achieving high Pearson correlation coefficients (0.9170-0.9544). Testing under overcast and intermediate sky conditions showed that all light pipe configurations

improved daylighting, with a semicircle transporter featuring two openings providing the best results. The semicircle design, which indicated possible savings in material costs and additional space for wire and ducts, had 14% less surface area than a standard round transport vehicle. The study also found that the shape of the light pipe transporter influences efficiency, although changes in the number of polygon shapes and side heights have little effect if the overall height has not been altered.

2.2 Daylight in Nigeria's Office Buildings

Haggai and Maina (2017) investigated user comfort within office spaces, juxtaposing comfort levels across the Architecture and Quantity Surveying Departments of Ahmadu Bello University, Zaria, Nigeria, and subjecting the buildings to comprehensive physical evaluations. Participants conveyed their perceptions of office environments by eliciting insights through questionnaires, highlighting factors influencing heightened comfort. Employing rigorous analytical tools, including IBM SPSS v. 21 and Microsoft Excel, the study emphasised users' control over indoor environmental quality in shaping comfort. While both departments excelled in acoustic comfort, a notable challenge arose from thermal comfort, impacting overall user satisfaction. The research emphasised the significance of creating private spaces, strategic building orientation, and thoughtful zoning in future office designs, specifically within academic contexts.

Research conducted within Nigeria by Joshua et al. (2012) highlights the inadequacy of natural lighting in many government office spaces, emphasising the need for innovative solutions to achieve energy efficiency. Similarly, Muhammad (2019) investigated the effects of building height on daylight distribution in mid-rise office buildings within the Nigerian climate, demonstrating the influence of various factors on daylight penetration. The study concluded that, for mid-rise office buildings in Nigeria's tropical wet and dry climate to meet the daylight requirements based on international standards, there is a need to look at their building forms, orientations, WWR, and building heights.

Ademola and Michael (2015) assessed the daylight intensity in office buildings. They concluded that the ratio of operable window area to total room volume of 0.0273 would be required for an acceptable indoor daylight intensity of 400 lux in East-Facing Office Buildings with 5mm clear glass windows in Jos, Nigeria.

3.0 METHODOLOGY

This section outlines the comprehensive methodology employed in this research, which encompasses a mixed-method approach combining exploratory and experimental elements. The overarching goal is to optimise daylight utilisation within deep-plan office buildings in Nigeria's tropical wet and dry climate by strategically applying horizontal light pipes.

3.1 Exploratory and Experimental Approach

i. Exploratory Phase: Case Study Selection: Multiple case studies were meticulously selected during the exploratory phase to represent a diverse range of deep-plan office buildings. Selected cases included the Centre of Excellence at Ahmadu Bello University, Zaria, and the Bank of Industry in Abuja, chosen to comprehensively understand daylighting strategies and quantify existing daylight levels within these structures.

ii. Experimental Phase: Simulation Using Climate Studio: The subsequent experimental phase involved computer simulations using Climate Studio for Rhinoceros 3D. This approach facilitated the assessment of the effectiveness of horizontal light pipes in enhancing visual comfort and maximising daylight utilisation.
iii. Inferential Statistical Tests for Hypotheses Testing: Experimental research involving hypotheses testing necessitated the application of inferential statistical tests. Specifically, the analysis of variance (ANOVA) test was employed to evaluate the significance of differences between multiple groups, such as the various configurations of horizontal light pipes.

3.2 Sampling

This study employed a purposive sampling approach to select participants strategically and case studies that align with the research objectives. Purposive sampling involves deliberately choosing individuals or cases with specific characteristics relevant to the study, ensuring a focused and targeted investigation. The selection criteria were designed to capture diverse perspectives within the chosen context, encompassing occupants from different roles and functions in the Centre of Excellence at Ahmadu Bello University and the Bank of Industry in Abuja. This method facilitated a nuanced exploration of daylighting effects on various occupant groups in distinct office settings. The purposive sampling strategy aimed to enhance the relevance and applicability of the study's findings to the specific context under investigation, contributing to a more comprehensive understanding of the relationship between daylighting and office environments.

3.3 Case Study Selection Criteria

To ensure the representativeness of the selected case studies, the criteria were meticulously established based on their relevance to Nigeria's tropical wet and dry climate and their potential to serve as prototypes for deep-plan office environments. Key considerations included architectural design, orientation, and daylighting strategies. A focus was placed on buildings that demonstrated innovative approaches to optimising daylight utilisation, aligning with the research objectives.

3.3.1 Criteria for Case Study Selection

i. Geographical Relevance: The Centre of Excellence at Ahmadu Bello University and the Bank of Industry are situated in Nigeria, providing a contextualised examination of daylighting strategies in a tropical wet and dry climate.
ii. Architectural Diversity: The selected case studies offer a range of architectural styles and design approaches, allowing for a nuanced analysis of daylighting applications in different office settings.
iii. Occupant Diversity: Each case study's varied functions and user groups, including students, faculty, and administrative staff at the Centre of Excellence and banking professionals at the Bank of Industry, provide insights into diverse occupant needs and preferences.
iv. Daylighting Installations: Both case study locations feature deliberate daylighting installations, facilitating an in-depth investigation into the effectiveness of these strategies in real-world office environments.

3.3.2 Selection of Representative Buildings

i. Centre of Excellence at Ahmadu Bello University: This educational institution represents a dynamic and active environment with diverse occupancy patterns. The study aims to extrapolate findings from this case to broader educational contexts.
ii. Bank of Industry in Abuja: As a financial institution, the Bank of Industry operates in a high-demand, professional setting. Exploring the impact of daylighting in such a context contributes valuable insights for office designs that prioritise functionality and occupant well-being.

The primary function of the case studies is to assess existing daylighting strategies within deep-plan office buildings and to evaluate the potential improvement from implementing light pipes.

3.4 Data Collection and Analysis

i. Data Collection Procedures: Extensive data collection procedures were implemented to ensure the accuracy and reliability of the gathered information. Architectural and daylighting data for the selected case studies were obtained through on-site measurements, surveys, and detailed analysis of building plans. Special attention was given to capturing variations in daylight availability at different times and seasons to account for dynamic lighting conditions.
ii. Simulation Parameters: During the simulation phase, consistent input parameters were rigorously applied to ensure the reliability and validity of the software performance. These parameters included geographical location data, building orientation, window configurations, and internal reflective surfaces. By maintaining consistency in simulation parameters across different case studies, the research aimed to establish a robust basis for comparative analysis and draw meaningful conclusions regarding the effectiveness of various daylighting strategies.

3.5 Quantitative Metrics for Evaluation

i. Uniformity: The evaluation of uniformity employed quantitative metrics, comparing values such as the ratio of minimum illuminance (Emin) to average illuminance (Eavg) or maximum illuminance (Emax) to average illuminance (Eavg) on the work plane. This comprehensive analysis extended to assessing how daylight was evenly distributed across specified heights of the work plane within the deep-plan office spaces under investigation.
ii. Illuminance Levels: Besides uniformity, another critical aspect of the investigation involved assessing illuminance levels (lux) achieved in different areas of the deep-plan office buildings. This assessment allowed for a nuanced understanding of how well horizontal light pipes with depths of 5m, 10m, and 15m provided adequate lighting for various office spaces, addressing the specific challenges posed by the deep-plan configuration.
iii. Light Pipe Configurations: To systematically explore the impact of varying light pipe lengths (5m, 10m, and 15m), diffuser sizes, and orientations on daylight distribution and resultant visual comfort, a structured approach was devised. Each light pipe was meticulously simulated in four office models, with sizes systematically increasing by 2.5m in depth. These models were constructed to represent the following configurations:

- 5m light pipe (5m x 5m, 5m x 7.5m, 5m x 10m, 5m x 12.5m).
- 10m light pipe (10m x 10m, 10m x 12.5m, 10m x 15m, 10m x 17.5m).
- 15m light pipe (15m x 15m, 15m x 17.5m, 15m x 20m, 15m x 22.5m).

3.6 Office Models and Configurations

A core research component systematically explored the impact of varying light pipe lengths, diffuser sizes, and orientations on daylight distribution and resultant visual comfort. Multiple office models were designed and evaluated, each characterised by specific dimensions and light pipe configurations. Fig 1 shows the components of the light pipe from Solatube used in this study, including a light collector, light tubes (which are flexible and can be bent up to 30 degrees), and a diffuser. Fig 2 presents a visual representation of the 5m x 5m office model, showcasing sensor points and the placement of the 5m light pipe. Sensor points were situated at 2m intervals, forming nine sensor points. The southern orientation was selected for light pipe placement.

Fig. 1: Light pipe components.
(Source: Solatube)

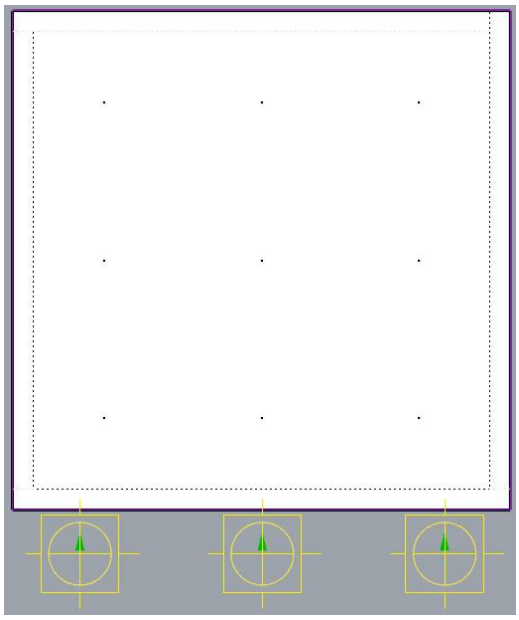

Fig. 2: Light pipe placement and sensors on a 5m x 5m model.
(Source: Climate Studio)

4.0 RESULTS

The findings of this research offer crucial perspectives on the influence of various horizontal light pipe configurations on the uniformity of light distribution and illuminance levels within deep-plan office buildings, with a particular focus on Nigeria's tropical wet and dry climate. Fig 3 shows the section view in Rhinoceros 3D, showing the light pipe placement of a model.

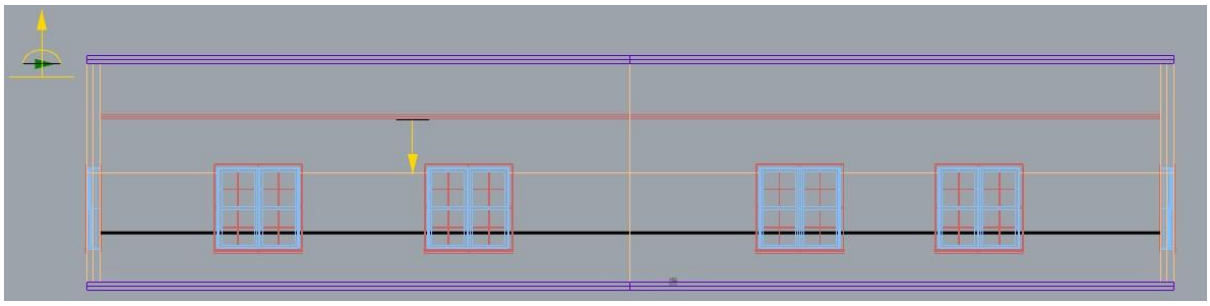

Fig. 3: Light pipe placement.
(Source: Climate Studio)

4.1 Impact of Light Pipe Configurations

The research explored the effects of light pipes with depths of 5m, 10m, and 15m on daylighting performance in office models of varying sizes. Fig 4 presents the simulation results for a 5m light pipe, serving as a benchmark for subsequent comparisons.

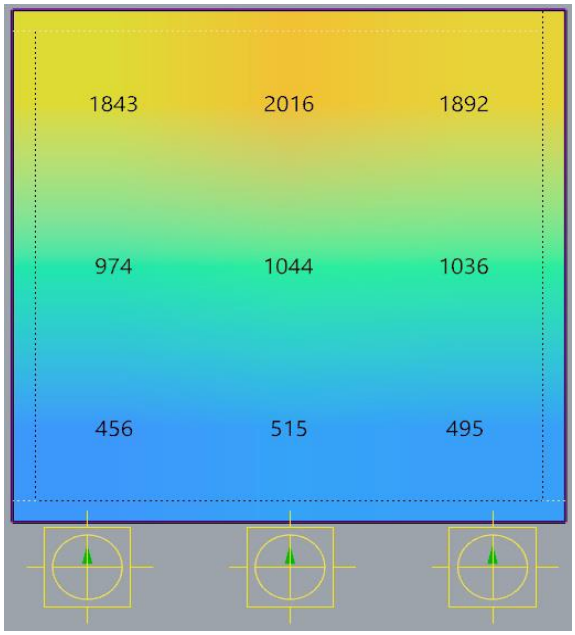

Fig. 4: Simulation result for light pipe with a length of 5 meters.
(Source: Climate Studio)

Moving to Fig 5, the outcomes of simulations involving a 10m light pipe were examined. Notably, this configuration significantly enhances illumination levels throughout the office space, particularly in areas previously characterised by insufficient lighting.

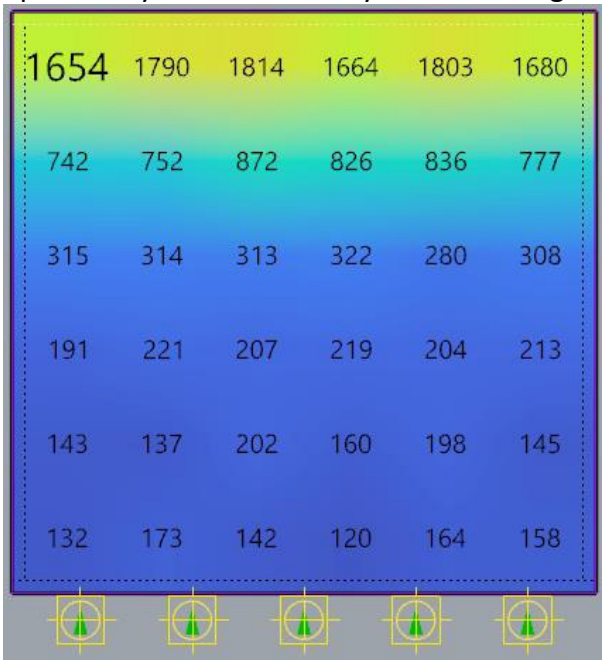

Fig. 5: Simulation result for light pipe with a length of 10 meters.
(Source: Climate Studio)

Fig 6 broadens the scope of the investigation to a 15m light pipe. While there is a noticeable enhancement in illumination, it is crucial to highlight that the performance of the 15m light pipe seems to be eclipsed by the 10m configuration when it comes to achieving a balanced and desirable lighting level.

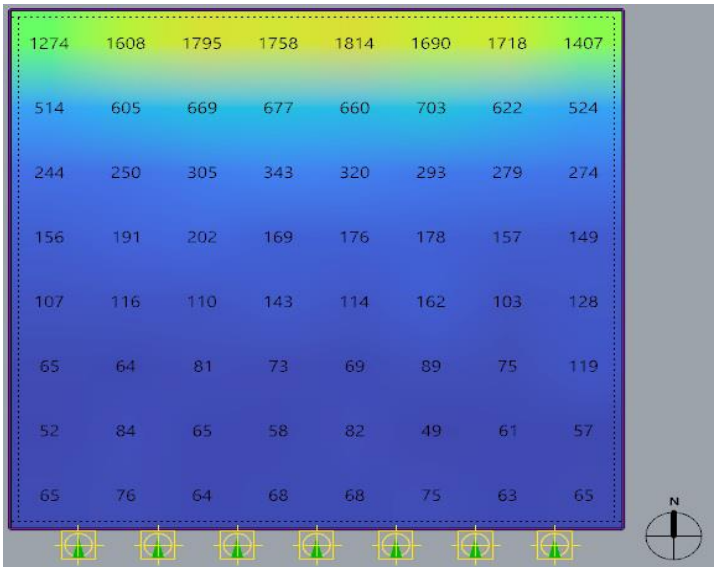

Fig. 6: Simulation result for light pipe with a length of 15 meters.
(Source: Climate Studio)

These visual representations provide an in-depth understanding of how different light pipe lengths affect light distribution and illuminance levels within deep-plan office spaces, specifically in Nigeria's unique climatic conditions.

4.2 Quantitative Metrics for Evaluation

Numerous quantitative metrics were evaluated to develop a more comprehensive understanding of the impact of different light pipe depths. These included minimum illuminance, average illuminance, mean illuminance, and uniformity ratio (UR) for different light pipe configurations (5m, 10m, and 15m) and office models of varying sizes. The results are presented in Table 1.

Table 1: Illuminance Levels and Uniformity Ratio for Different Light Pipe Configurations

Light Pipe Depth (m)	Office Model Size	Minimum Illuminance (Lux)	Average Illuminance (Lux)	Mean Illuminance (Lux)	Uniformity Ratio (UR)
5	5 x 5	456	1141	799	0.4
	5 x 7.5	345	817	581	0.4
	5 x 10	165	632	399	0.26
	5 x 12.5	79	508	294	0.15
10	10 x 10	120	561	341	0.21
	10 x 12.5	79	485	282	0.16
	10 x 15	58	407	233	0.14
	10 x 17.5	73	366	220	0.20
15	15 x 15	49	381	215	0.12
	15 x 17.5	27	346	187	0.07
	15 x 20	25	319	172	0.07
	15 x 22.5	24	279	152	0.08

4.3 ANOVA Test

An Analysis of Variance (ANOVA) test was conducted to ascertain whether significant differences exist among the means of different light pipe lengths for various performance indicators. The test was performed using Microsoft Excel; the results are summarised in Tables 2 and 3.

Table 2: Illuminance Levels and Uniformity Ratio for Different Light Pipe Configurations

SUMMARY						
Groups	Count	Sum	Average	Variance		
Light Pipe Depth (m)	12	120	10	18.18182		
Uniformity Ratio (UR)	12	2.26	0.188333	0.013124		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	577.6128	1	577.6128	63.49158	6.31E-08	4.30095
Within Groups	200.1444	22	9.097471			
Total	777.7572	23				

Table 3: ANOVA Test Results for Average Illuminance

SUMMARY						
Groups	Count	Sum	Average	Variance		
Light Pipe Depth (m)	12	120	10	18.18182		
Mean Illuminance (Lux)	12	3875	322.9167	36606.63		
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	587501	1	587501	32.08213	1.07E-05	4.30095
Within Groups	402872.9	22	18312.41			
Total	990374	23				

4.3.1 Interpretation of ANOVA Results for Uniformity Ratio (UR)

The ANOVA test results for uniformity ratio (UR) reveal significant differences among the means of different light pipe depths (5m, 10m, and 15m). The p-value ($p < 0.001$) indicates these differences are statistically significant. Moreover, the F-value (63.49) exceeds the critical F-critical value, leading to the rejection of the null hypothesis (Ho). Thus, it can be inferred that significant differences exist in uniformity between the 5m, 10m, and 15m light pipe depths.

4.3.2 Interpretation of ANOVA Results for Mean Illuminance

The ANOVA test results for mean illuminance also demonstrate significant differences among the means of different light pipe depths (5m, 10m, and 15m). The low p-value ($p < 0.001$) suggests these differences are statistically significant. In addition, the F-value (32.08) surpasses the critical F-critical value, leading to the rejection of the null hypothesis (Ho). As a result, it is concluded that there are significant differences in mean illuminance levels between the 5m, 10m, and 15m light pipe depths.

5.0 DISCUSSIONS

The investigation aimed to uncover the influence of varying light pipe depths on the uniformity of light distribution and mean illuminance levels within office spaces. The ANOVA test results for uniformity ratio (UR) indicated significant disparities among the 5m, 10m, and 15m light pipe configurations. The 10m light pipe configuration emerged as the most efficient in achieving uniform lighting distribution, outperforming the 5m and 15m configurations. This holds significant importance in office design, as uniform lighting contributes to reduced glare and shadows, ultimately enhancing visual comfort for occupants. While the 15m light pipe was considered, it did not exhibit statistically significant differences in uniformity compared to the 5m and 10m configurations. However, it may have advantages in specific contexts.

Furthermore, the results of the ANOVA tests revealed significant differences between light pipes at depths of 5m, 10m, and 15m. Consistently, the 10m light pipe configuration delivered higher mean illuminance levels across the office space when compared to the 5m and 15m configurations. The 10m light pipe excelled in uniformity and proved effective in providing sufficient lighting conditions within deep-plan office environments. Adequate mean illuminance levels are pivotal for cultivating productive and comfortable work environments, further highlighting the significance of the 10m configuration.

The study provides a comprehensive understanding of the impact of different light pipe configurations on the uniformity of light distribution and illuminance levels within deep-plan office buildings. The findings suggest that the 10m light pipe configuration is the most efficient in achieving uniform lighting distribution and delivering higher mean illuminance levels. These insights hold significant implications for office design, particularly in Nigeria's unique climatic context, and pave the way for future research. The study also emphasises the importance of considering local climate conditions when designing lighting systems for office buildings. Future studies could explore the impact of other factors, such as window size and orientation, shading devices, and light-reflecting materials, on daylighting performance.

This research contributes to the growing knowledge of daylighting in office buildings and provides valuable insights for architects, designers, and building professionals. It highlights the potential of light pipes as a sustainable solution for enhancing daylighting performance in deep-plan office buildings, particularly in tropical climates like Nigeria. The findings of this study could inform the design of more sustainable, energy-efficient, and comfortable office environments. Ultimately, this research underscores the importance of sustainable design practices in mitigating the impacts of climate change and promoting the well-being of building occupants.

5.1 Implications and Limitations

In light of the research findings, the implications for Nigeria's design and construction industry are substantial. The study underscores the importance of prioritising dynamic daylighting strategies in office buildings to enhance occupant well-being, visual comfort, and overall productivity. Architects and designers can leverage these insights to inform design decisions, emphasising the integration of adaptive lighting systems that respond to real-time environmental factors and user preferences. This approach aligns with global trends emphasising sustainable and human-centric design and caters to the specific climatic conditions of Nigeria's tropical wet and dry climate.

However, implementing these strategies may need to be improved within the Nigerian context. Limited awareness and understanding of the benefits of dynamic daylighting among stakeholders in the design and construction industry could pose a barrier to widespread adoption. Additionally, the upfront costs associated with integrating smart building technologies and adaptive lighting systems may be perceived as a financial hurdle.

6.0 CONCLUSION

The study investigated how light pipes could improve daylighting in deep-plan office buildings in Nigeria's tropical wet and dry climate. This study tested 5m, 10m or 15m light pipes using case studies and simulations to determine which configuration would provide the best visual comfort and lighting performance. The results demonstrated that the 10m light pipe configuration provided the most consistent and uniform lighting, reducing glare and shadow. It also consistently provided adequate illuminance, enhancing visual comfort, and supporting productivity in office spaces. The 10m configuration has been validated by statistical analysis and ANOVA as performing better than the 5m and 15m configurations. The 15 m light pipe offered flexibility for specific contexts but did not provide significant performance advantages.

The study concluded that the 10m configuration is the most effective choice for deep-plan office buildings in Nigeria. It offers a balanced approach to daylighting that supports occupant well-being and energy efficiency.

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JOURNAL OF ARCHITECTURE, PLANNING & CONSTRUCTION MANAGEMENT
Volume 14 Issue 1, 2024 E-ISSN: 2462-2222 ISSN: 2231-9514

EXAMINING THE INFLUENCE OF URBAN FORM ON THE THERMAL COMFORT OF STREET CANYONS IN TEHRAN: A CASE STUDY OF NARMAK NEIGHBOURHOOD

Received: 29th January 2024 | Accepted: 14th June 2024 | Available Online: 30th June 2024

DOI: 10.31436/japcm.v14i1.862

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ABSTRACT

As urbanization advances, the emphasis on outdoor spaces grows, highlighting poor thermal balance as a detrimental factor in achieving comfort within densely populated urban structures. Consequently, an urgent imperative exists to evaluate and optimize urban morphology to ensure sufficient outdoor thermal comfort. This study assesses the thermal efficiency of residential areas in Narmak, Tehran, Iran, with the primary goal of enhancing thermal comfort, specifically the PET, and discerning optimal urban layouts. Employing computational simulation techniques, this investigation meticulously examines urban design variables that influence outdoor thermal comfort, encompassing street direction, enclosure, building forms' typology, and tree planting. The research findings unveil that the orientation of street canyons exerts the most significant influence at 39.12%, closely followed by the aspect ratio at 36.78%. Remarkably, within the considered climatic components such as air temperature, wind speed, and humidity, tree planting emerges as the most influential factor impacting outdoor thermal comfort in this case study. These analytical outcomes furnish valuable insights into the contextual design of elements that influence the thermal comfort of outdoor open spaces.

Keywords: Outdoor Thermal Comfort, Urban Morphology, Street Canyons, Urban Heat Island, Urban Configuration

1.0 INTRODUCTION

The urban heat island (UHI) phenomenon is characterized by heightened temperatures in metropolitan areas compared to their surrounding regions, as documented by Yin et al. (2021). This predicament arises from the intricate interplay of urbanization processes and associated climate changes, as Salmanian and Ujang (2021) highlighted, contributing to increased energy consumption within urban locales due to heightened cooling demands, especially during heat waves. This, in turn, places additional stress on the power grid, as pointed out by Othman et al. (2021). The elevated ambient temperatures experienced in urban environments not only present health challenges, as identified by Shari and Dahlan (2023) but also underscore the growing importance of integrating comfort and health in

defining well-being within the built Environment. This realization has spurred a heightened interest in outdoor comfort research, as observed in the work of Liu et al. (2022). The acknowledgment of responsive open spaces as integral to an elevated quality of living is on the rise, with outdoor thermal comfort emerging as a critical factor influencing the quality of outdoor open areas and consequently impacting people's engagement in outdoor activities. This trend has led to a significant surge in attention towards considering outdoor thermal comfort in the sustainable design of cities, as evidenced by Othman et al. (2019). Cities with hot and humid climates featuring elevated temperatures, humidity, and low wind speeds may experience exacerbated UHI effects.

In contrast, periods of warm weather act as catalysts for outdoor and semi-outdoor activities, prompting individuals to gravitate towards open environments without air conditioning, as De and Mukherjee (2017) observed. The geometric attributes of city blocks and building materials emerge as pivotal factors influencing Urban Heat Island (UHI) effects, underscoring the significance of well-conceived outdoor spaces and environments prioritizing thermal comfort. Such considerations have a positive impact on public health, well-being, tourism, the effective utilization of open spaces, and levels of social interaction, as elucidated in studies by Nasir et al. (2018), Ge et al. (2017), and Zhang et al. (2023). Despite these benefits, research by Mokhtar and Reinhart (2023) indicates a decline in outdoor activities with rising summer temperatures (Ta), leading to urban outdoor areas often needing more microclimate considerations in their design and needing to be more utilized. This issue is further exacerbated by the need for more practical and applicable urban planning design guides, as Kyprianou et al. (2023) emphasized.

Delving into the intricacies of thermal dynamics in outdoor environments within the Mediterranean region, this investigation hones in on the scorching summer climate prevalent in Tehran's Narmak Neighbourhood, Iran. The primary focus of this study revolves around the development of precise guidelines for urban design, with a specific emphasis on enhancing outdoor thermal comfort through the application of advanced computational optimization processes. This intricate process involves the utilization of parametric design methodologies and simulation techniques to fine-tune the thermal efficiency of Street Canyons. The overarching aim is to thoroughly and systematically evaluate the existing thermal conditions within the selected case study. Concurrently, the study seeks to strategically optimize urban design parameters to align seamlessly with the microclimate intricacies prevalent in the designated zones.

2.0 LITERATURE REVIEW

2.1 Thermal Condition In Outdoor Open Spaces

The nuanced comprehension of outdoor temperature perception is a multifaceted concern subject to local climate characteristics' influence, as Ravichandran and Gopalakrishnan (2023) illustrated. In high-density urban environments, scholarly inquiries discern three pivotal determinants influencing this perception, as illustrated by Liu et al. (2022): meteorological conditions, encapsulating solar radiation, humidity, and wind speed; individual health considerations; and psychological parameters. Amidst these environmental determinants, air temperature is paramount as the key microclimate element significantly shaping the perception of heat, as noted by Lee et al. (2023). Furthermore, the attainment of thermal comfort hinges on air temperature and additional climatic factors, including radiant

temperature and wind speed, as elucidated by Ouyang et al. (2023). Of particular note, air movement surpassing velocities of 1.5 m/s exerts a substantial influence on the heat perception experienced by individuals in outdoor spaces, according to findings by Zhang et al. (2023). The Urban Heat Island (UHI) phenomenon, influenced by solar radiation patterns and various design factors, presents an opportunity for mitigation through alterations in building layouts, especially in temperate climates. This proposition is supported by the works of Salmanian and Bayat (2023) and Kaoutar, Ouali et al. (2018).

Moreover, a suitable urban configuration layout can aid in alleviating the adverse impacts of urban climate conditions. Despite extensive efforts to construct urban building configurations focused on enhancing thermal and climate comfort through scientific methodologies, it remains essential to regulate design aspects to ensure optimal influencing factors and establish standards. Additionally, in numerous cities, urban planners and designers overlook considerations of thermal comfort and environmental attributes when developing new urban areas, especially in hot climates where there is a greater need for thermal comfort, shaded areas, and improved airflow (Abd Elraouf et al., 2022).

A plethora of research endeavors have delved into an array of strategies designed to optimize outdoor thermal comfort, casting a spotlight on ventilation dynamics (Tang et al., 2023), material properties (Oquendo-Di Cosola et al., 2023), vegetative elements (Dong & He, 2023), and the presence of water bodies (Deng et al., 2023). Regarding high-density urban environments, scholarly inquiries discern three pivotal determinants influencing this perception, as illustrated by Liu et al. (2022): meteorological conditions, encapsulating solar radiation, humidity, and wind speed; individual health considerations; and psychological parameters. Notably, street canyons' aspect ratio and orientation emerge as pivotal considerations in urban planning, constituting critical factors that demand meticulous attention to optimize outdoor thermal comfort, as underscored by Deng et al. (2023). The following subsections offer a comprehensive overview of these influential factors, elucidating their roles in conjunction with the impact of urban surface conditions on the overarching domain of outdoor thermal comfort.

2.2 Enclosure

The enclosure (measured using aspect ratio), expounding on the correlation between the height of buildings and the width of streets, emerges as a pivotal parameter in urban planning, specifically in thermal comfort considerations (Zhang et al., 2023). Elevated aspect ratios and deeper street canyons wield the effect of diminishing sun exposure and temperatures, resulting in outdoor environments that register an approximate cooling of 3.5e6 oC (Zhang et al., 2023; Deng et al., 2023). Classifying canyons into shallow and deep forms, with aspect ratios less than 0.5 and equal to 2, respectively, an optimal aspect ratio of 1 is identified to create streamlined canyons (Bedra et al., 2023). Rodrı'guez-Algeciras et al. undertook an investigation, presenting suggested thresholds for the design parameter height to width as 1 and 1.5, aiming to attain satisfactory outdoor thermal comfort in both summer and winter seasons (Algeciras et al., 2016). Compact canyon shapes, characterized by lower aspect ratios, contribute to an elevated level of outdoor comfort, primarily attributed to the shading effect of neighboring buildings (Yahia et al., 2017). This heightened comfort level is particularly noteworthy in the summer, where shaded areas become preferred for outdoor activities, while sunlit spaces gain favorability in the winter (Yahia et al., 2017). The association between

higher aspect ratios and reduced wind speed, coupled with wider streets leading to increased wind speed, reveals that alterations in wind speed within deep street canyons can induce temperature fluctuations of up to 5°C (Hao et al., 2023). In urban environments marked by high population density and towering structures, there is an elevation in mean radiant temperature (Tmrt) and outdoor wind speed. This starkly contrasts low-rise buildings, which typically induce a heightened perception of discomfort in urban outdoor settings.

2.3 Street Canyon Orientation

Numerous research investigations have underscored the critical role of street canyons' orientation and aspect ratio in shaping outdoor thermal comfort (Li et al., 2023). Findings from these investigations indicate that canyons aligned in a north-south direction provide the utmost comfort for individuals in outdoor settings, whereas those oriented east-west offer less favorable conditions, as Zhang et al. (2022) posited. Notably, east-west-oriented streets are particularly susceptible to intense solar radiation, resulting in elevated mean radiant temperature (Tmrt) values (Miao et al., 2023). Additionally, a consensus in multiple studies identifies the northeast-southwest orientation as the optimal layout for street canyons in urban planning (Yilmaz et al., 2022), with the north-south orientation deemed most conducive to favorable thermal comfort for outdoor residents. Nevertheless, this urban arrangement has inherent drawbacks, notably an increase in energy consumption required for building cooling, attributed to heat dissipation from outer walls and diminished exposure to sunlight, as elucidated by El-Darwish and Gomaa (2017).

The impact of street orientation on airflow coefficients at the pedestrian level constitutes a significant aspect of urban environmental dynamics (Chatzidimitriou & Axarli, 2017). Streets parallel to the prevailing wind flow exhibit elevated wind speeds, further intensified by reducing the aspect ratio within street canyons (Emmanuel et al., 2016). Perturbations in building height and the introduction of asymmetric aspect ratios can induce turbulence, consequently influencing ventilation patterns around tall structures (Song et al., 2023).

2.4 Surface Conditions In Urban Areas

Within urban spaces, the elevated temperatures of anthropogenic structures result in the outward dissipation of sensible heat, thereby elevating the air temperature (Ta) (Geletič et al., 2023). The surface temperature in urban open spaces plays a pivotal role in influencing the thermal conditions of outdoor open spaces. Consequently, design principles often advocate implementing east-west-oriented streets to optimize sunlight exposure (Ma et al., 2023). Incorporating high-albedo surfaces holds promise in mitigating temperatures within urban open spaces (Yakubu et al., 2023). A study conducted in 2017 demonstrated that a synergistic approach involving cool roofs, walkways, and augmentation of vegetative cover holds the potential to ameliorate the comfort index and mitigate correlated health hazards substantially, yielding a potential reduction of up to 60% (Kumar et al., 2023). During summer, vegetation is crucial in urban settings as it absorbs surface energy via photosynthesis and transpiration. Its ability to shade effectively also blocks solar radiation.

Moreover, the canopy of vegetation can slow down airflow, causing obstruction and decreasing wind speed (Chen et al., 2023). In urban areas, using vegetation as a heat-mitigation approach is preferred over employing high albedo materials on the ground to enhance pedestrians' thermal comfort. Greenery alters outdoor thermal conditions through

various mechanisms, including evapotranspiration, sun reflection, shading, and airflow modification. Specifically, vegetation cools the Environment through transpiration, where absorbed solar energy leads to water evaporation from plant surfaces, thus reducing temperatures. These effects are typically quantified using a measure of cooling power per unit volume of vegetation based on leaf area density. Additionally, vegetation increases the overall reflectivity of short-wave radiation in the city, resulting in less heat absorption than building materials. Furthermore, tree canopies help prevent the escalation of air and surface temperatures by intercepting solar radiation (Gatto et al., 2020).

The introduction of green plants has been correlated with mitigating the effects of the Urban Heat Island (UHI) (Ramakrishnan et al., 2020). Through the deliberate manipulation of pivotal meteorological variables, namely temperature, wind speed, and relative humidity, the systematic deployment of trees at intervals of 4 meters has been empirically shown to engender a reduction in the mean radiant temperature by as much as 23°C in comparison to an arboreal-lacking urban milieu (Srivanit & Jareemit, 2020).

3.0 METHODOLOGY

The primary objective of this study is to systematically investigate and analyze the optimal urban design considerations for residential development in Narmak, Tehran, Iran. The research scrutinizes various influential design factors such as street canyon orientation, aspect ratio, building morphology, and the spatial arrangement of tree planting in outdoor spaces. The methodology employed in this research is visually represented in Figure 1, depicting the systematic workflow. Within this workflow, the ENVI-met tool and the Physiologically Equivalent Temperature (PET) index are integral components as analytical instruments to evaluate the existing street configurations and the envisioned scenarios designed for the study.

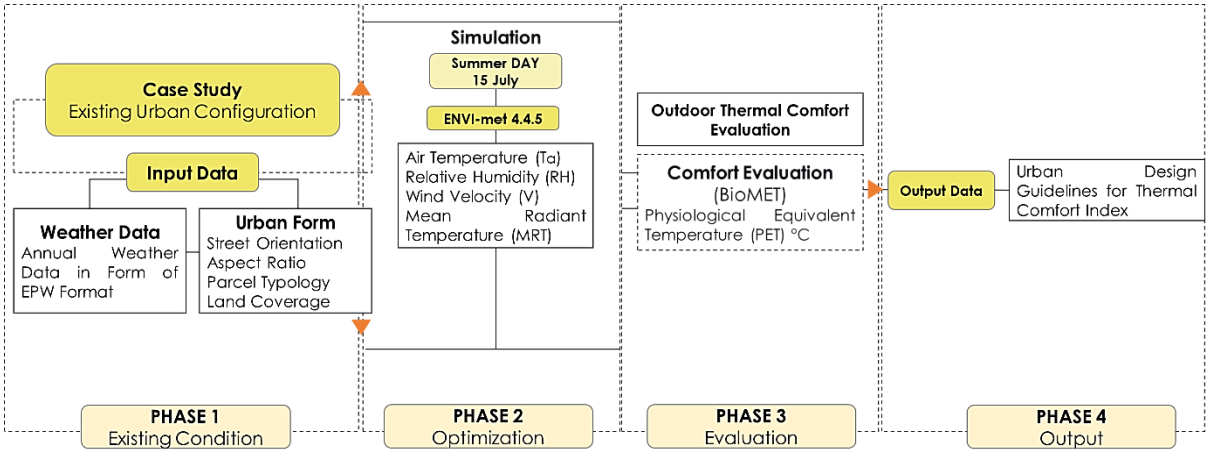

Fig. 1: Flowchart demonstrating the research procedure

3.1 Case Study

Narmak, situated in the eastern part of Tehran, is a crucial residential expansion area. The anticipated growth in housing units poses the potential for significant alterations in the microclimate conditions of Narmak's streets, leading to unfavorable outdoor thermal environments. Narmak encompasses three distinct road widths and two intersecting alignments. The residential zones within Narmak are characterized by either local 2-lane

roads (7m in width) or secondary 4-lane roads (10m in width), with a limited number of primary 6-lane roads (15m or more). For this study, a 6-lane road, segregated and located away from residential areas, was not included in the evaluation. The study adopts a width of 8m for a two-lane road, where the primary thoroughfare features conventional black asphalt and a 1.5m wide concrete pavement (refer to Figure 2).

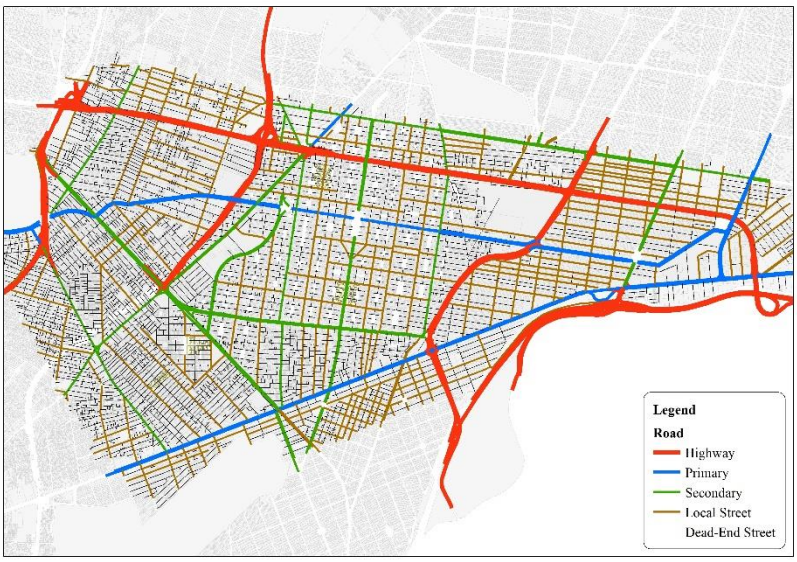

Fig. 2: Street Morphology, width, and orientation in the study area

Three orientations, namely North-South, East-West, and Northwest-Southeast, exhibit nine variations, encompassing the majority of the neighborhood blocks (refer to Fig. 3). The residential structures comprise attached houses ranging from 1 to 5 stories, featuring brick as the predominant facade material. An average height of 12 meters has been established to adhere to regional roofing standards. Typically, dwellings are positioned adjacent to the main street canyon, characterized by extensive tree coverage. This placement influences the microclimate of the surrounding streets by augmenting greenery and concurrently mitigating the urban heat island effect.

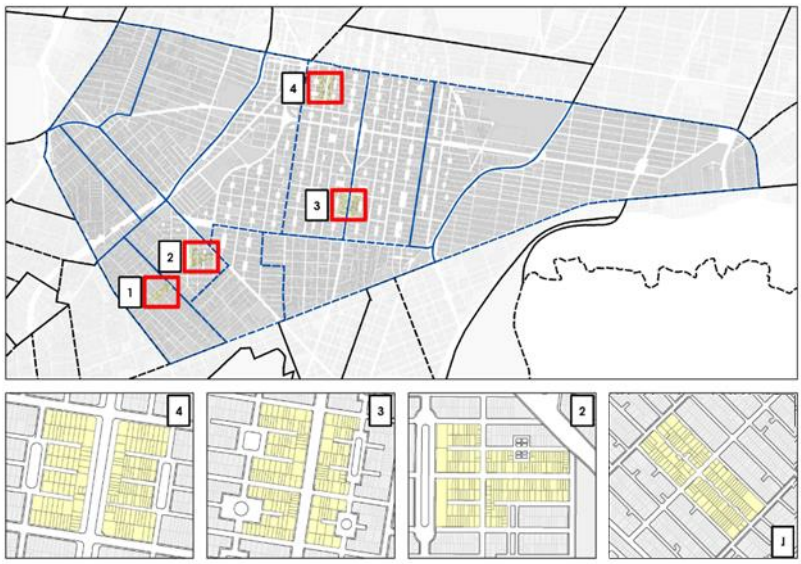

Fig. 3: Defining the study area location and urban morphology

3.2 Research Design

This research employs a comprehensive simulation approach to investigate the optimal layout for urban design parameters such as street orientation (north-south, east-west, northeast-southwest, southeast-northwest), building classification (linear and singular), enclosure (ratio of 0.5, 1, 1.5, 2), and tree planting patterns (based on the thermal Environment) at 5m and 10m intervals. The simulation incorporates a 2m-wide swath of greenery, representing the minimum width dictated by the modeling mesh. Diverse spatial intervals, specifically 5 and 10 meters, are being examined to assess the influence of green spaces on al fresco thermal comfort. This investigation explores two distinct planting configurations: one with denser foliage and the other exhibiting sparser vegetation. This study adopts an iterative and phased approach in the independent analysis of each design element to derive urban planning guidelines focused on enhancing thermal comfort. Each element undergoes isolated simulation, and the most effective option is iteratively advanced to subsequent phases. The collective evaluation of variables occurs only in the succeeding stage. The influence of tree planting on outdoor thermal comfort is assessed, and the least effective option (0.5 aspect ratio) is chosen as the input for the next phase. This selection is rooted in the premise that roads in optimal configurations (aspect ratio of 2) already offer satisfactory thermal comfort levels, obviating the need for further enhancements like introducing water bodies and additional green areas.

Consequently, the effort shifts towards achieving optimal thermal conditions by implementing the identified tree planting pattern on a road with an aspect ratio of 0.5. The building component of the study considers the prevalent facade material in Narmak, which is brick, streamlining computational processes. The characteristics of highway and sidewalk surfacing remain consistent with existing conditions. Table 1 and Figure 4 provide a detailed overview of various urban design scenarios, outlining the proposed dynamic tuning parameters.

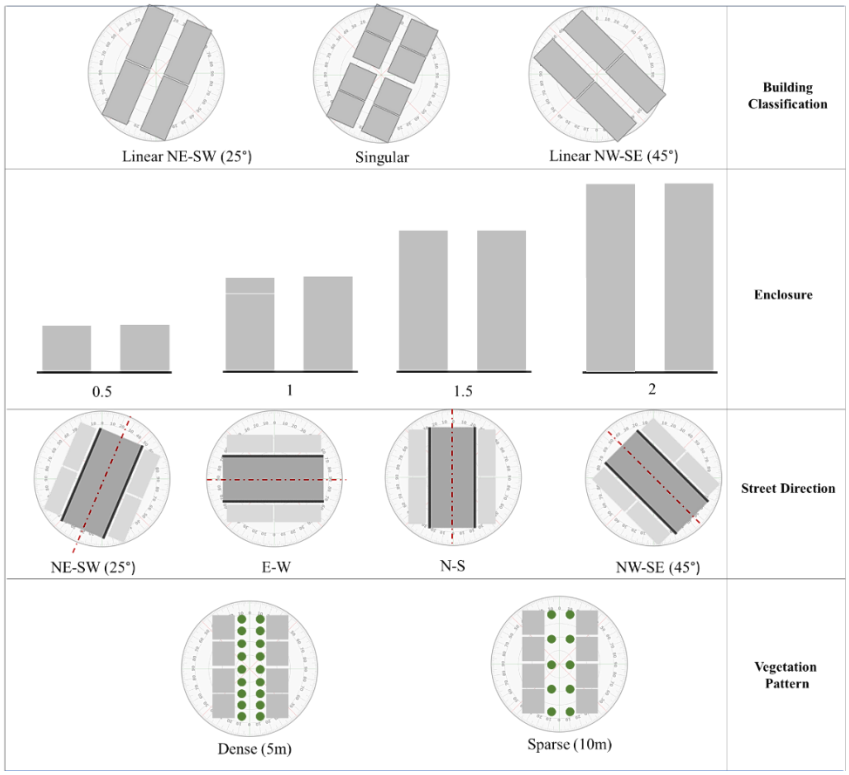

Fig. 4: Research Design Variables

Table 1: Proposed scenarios for the design process

Building Classification	Linear NE-SW	Singular	Linear NW-SE
Enclosure	0.5	1	1.5	2
Street Direction		NE-SW	E-W	NW-SE
Vegetation Pattern	Dense (5m)		Sparse (10m)	

3.3 Computer-Aided Simulation

Given the intricate nature of urban climate studies, numerical simulation emerges as a highly effective methodology for research at the point of sale, with a preference for computational approaches due to the extensive array of morphological variables (Gangwisch et al., 2023). Although various studies have utilized computer simulations (Zhang et al., 2022; Li et al., 2023; Huang et al., 2023), the current investigation utilizes computational simulations of microclimate conditions to scrutinize 14 distinct design scenarios employing the 3D modeling tool ENVI-met. ENVI-met, introduced by Bruse in 2004 (Wang et al., 2021), is a microclimate-centric tool that yields precise values for critical parameters, including air temperature, MRT, relative humidity, wind speed, and solar radiation. The reliability of ENVI-met in providing accurate data closely mirroring real-time meteorological conditions, particularly in summer calculations, has been firmly established. BioMET (V2.0) is also employed for PET calculations in this investigation. The urban microclimate dynamics are simulated by ENVI-met, employing atmospheric physics and heat transfer principles. The 3D wind flow is computed using the incompressible, non-hydrostatic Navier-Stokes equations with the Boussinesq approximation. Simulations in ENVI-met typically span 24-48 hours, with the optimal start time being at night or sunrise to align with atmospheric processes. Input parameters defining the 3D geometry of the target area, including buildings, vegetation, soils, and receptors, are necessary for ENVI-met simulations. Key input data comprise weather conditions, urban geometry, material properties, and vegetation characteristics. However, it is worth noting that ENVI-met has limitations in simulating the entire city's microclimate due to the restricted number of grid cells (Bochenek & Klemm, 2021).

In the course of this inquiry, an analytical mesh characterized by a cell size of 2*2 m^2 is employed, and its validation ensures the production of reliable data with an elevated level of precision, concurrently reducing computation time when juxtaposed with high-resolution models featuring smaller cells, as demonstrated by Salata et al. (2015). Within the confines of the 3D model, the specified spatial domain comprises a 100m street canyon, equivalent to 50 cells along the length of the grid. The outcomes are extracted at a height of 1.4m above the ground, representative of the standing height of an individual, thereby facilitating the evaluation of user comfort levels in outdoor environments.

3.4 Evaluation And Verification Of The Thermal Comfort

PET is prominent in hot and humid climates, as evidenced by a comprehensive literature review on outdoor thermal comfort in 2020 (Binarti et al., 2020). The definition of PET revolves around "the air temperature at which the core and skin temperatures are equal under the conditions studied, and the thermal equilibrium of the human body is maintained." The index in question is predicated upon a streamlined human energy balance model, specifically employing the Munich Individual Energy Balance Model, which was initially introduced under the German guideline VC13787 (VDI, 2008; Su et al., 2023).

Numerous investigations (Christine & Matzarakis, 2016; Briegel et al., 2023) have asserted the significance of Physiologically Equivalent Temperature (PET) as a pivotal metric for assessing outdoor comfort. PET involves the computation of Mean Radiant Temperature (Tmrt), utilizing a composite of global temperature, air temperature, and wind speed to gauge outdoor thermal comfort (Yahia et al., 2017). The BioMET PET calculations integrate user-specific factors, such as clothing condition and metabolic rate index, with meteorological parameters. In this context, the anthropometric profile adopts a model representing a 30-year-old male weighing 85 kg, height of 1.70 m, clothing insulation, and metabolic rate of 0.8 W/m² and 85.11 W/m², respectively. The derived Physiologically Equivalent Temperature values elucidate the temporal extent within the comfort range from 6:00 to 18:00 on a standard summer day. Table 2 provides default parameters for diverse thermal sensations and the associated thermal loads, each corresponding to specific PET regions.

Table 2: Physiological Equivalent Temperature thermal sensation/thermal stress estimate of outdoor open space

Thermal sensation/stress	PET (°C)
Extreme cold stress	-
Very strong cold stress	-
strong cold stress	<4
Moderate cold stress	4-8
Slight cold stress	8-18
Comfortable	18-23
Moderate heat stress	23-25
Strong heat stress	35-41
Very strong heat stress	>41

(Source: Matzarakis & Helmut,1996)

The assessment of simulation accuracy hinges on using Root Mean Square Error (RMSE) as a pivotal metric. The Honeybee plug-in is employed in this study, a well-established tool acknowledged in prior research for evaluating comfort conditions in urban outdoor environments (Geletič et al., 2023). Hourly temperature data generated by two distinct simulation engines, namely Compare Energyplus and ENVI-met, undergo a comparative analysis based on identical city configurations to gauge the precision of the models. The results reveal a strong correlation coefficient of 0.87 between temperature parameters assessed by the Honeybee and ENVI-met tools, affirming the model's high precision and the notably elevated R^2 value. Additionally, the Mean Square Error mathematical approach quantifies the deviation between simulated values obtained from the Honeybee plug-in and the ENVI-met software. The resulting minimal Root Mean Square Error (RMSE) values, specifically equating to 1.37, underscore the selected framework's reliability and validate the accuracy of microclimate condition simulations within the specific case studies.

3.5 Weather Data

The period characterized as the hot season in Tehran spans approximately 3.6 months, extending from May 29 until September 18. During this phase, the typical daily maximum temperature exceeds 87°F. Among these months, July is the hottest, with an average high temperature of 97°F and a corresponding low of 77°F. Conversely, the cool season spans around 3.5 months, commencing on November 24 and concluding on March 8, during which

the average daily high temperature remains below 57°F. The chilliest month in Tehran is January, registering an average low of 35°F and a high of 47°F (Figure 4).
To explore the influence of diverse urban layouts on the perception of heat among outdoor inhabitants, the date of July 15, notable for its high summertime temperatures, was selected. Within the scope of this study, a 24-hour simulation duration was adopted to capture the daily fluctuations in temperature.

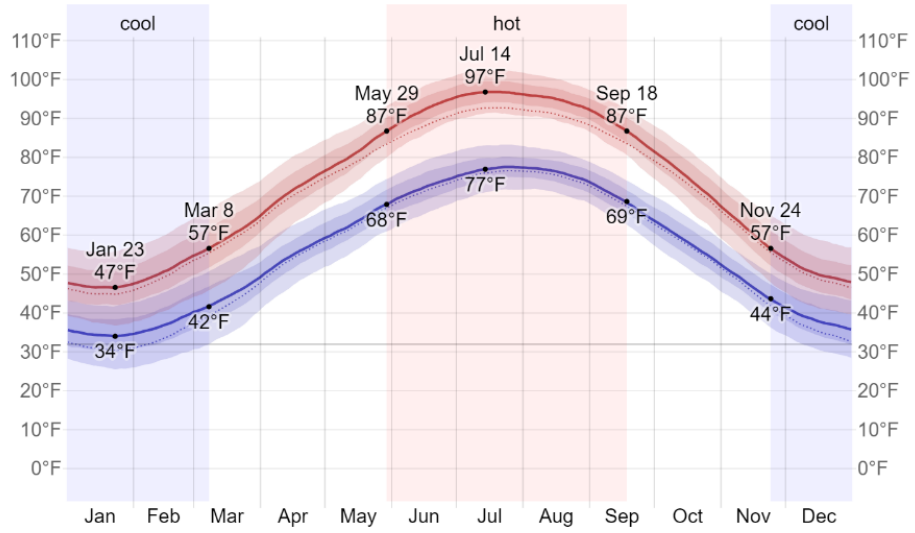

Fig. 5: The mean high temperature (depicted by the red line) and mean low temperature (illustrated by the blue line) for each day are presented, accompanied by the ranges spanning from the 25th to 75th percentiles and from the 10th to 90th percentiles. The faint dashed lines represent the average perceived temperatures that correspond to the data above points
(Source: https://weatherspark.com/y/105125/Average-Weather-in-Tehran-Iran-Year-Round#Figures-Temperature)

Tehran displays a moderate fluctuation in its average hourly wind speed over a year. The period marked by elevated wind activity spans approximately 7.1 months, extending from February 11 through September 14, during which the average wind velocities exceed 5.4 miles per hour. Notably, the zenith of windiness transpires in June, manifesting an average hourly wind speed of 6.5 miles per hour. Conversely, a phase of relative tranquillity prevails for around 4.9 months, encompassing the interval between September 14 and February 11. Within this interval, December emerges as the most placid month in Tehran, featuring an average hourly wind speed of 4.3 miles per hour (Figure 5).

Humidity assessment is predicated upon the comfort criterion of the dew point, a parameter instrumental in discerning the potential for perspiration to undergo evaporation from the skin, thus effectuating bodily cooling. Diminished dew points indicate diminished moisture content, yielding a sensation of dryness, whereas elevated dew points evoke an augmented sense of humidity. Unlike temperature, characterized by conspicuous diurnal fluctuations, the dew point exhibits a propensity for more gradual transformations. Consequently, although temperature fluctuations manifest prominently from day to night, a day typified by muggy conditions tends to be succeeded by night similarly imbued with mugginess. The perceived magnitude of humidity within Tehran, quantified through the proportion of time wherein the comfort threshold for humidity is gauged as muggy, oppressive, or distressing, evinces nominal seasonal variance, maintaining an almost unchanging 0% threshold throughout the year (Figure 6).

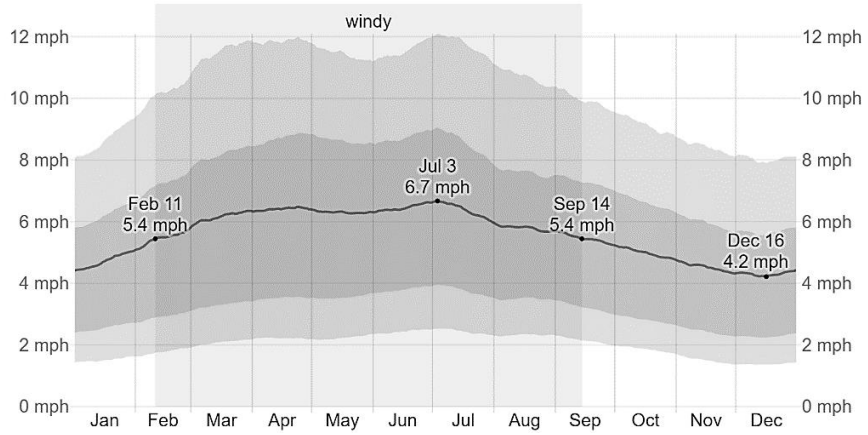

Fig. 6: The mean of hourly wind speeds (represented by the dark grey line), along with the interquartile range (25th to 75th percentiles) and the decile range (10th to 90th percentiles), is depicted

(Source: https://weatherspark.com/y/105125/Average-Weather-in-Tehran-Iran-Year-Round#Figures-WindSpeed)

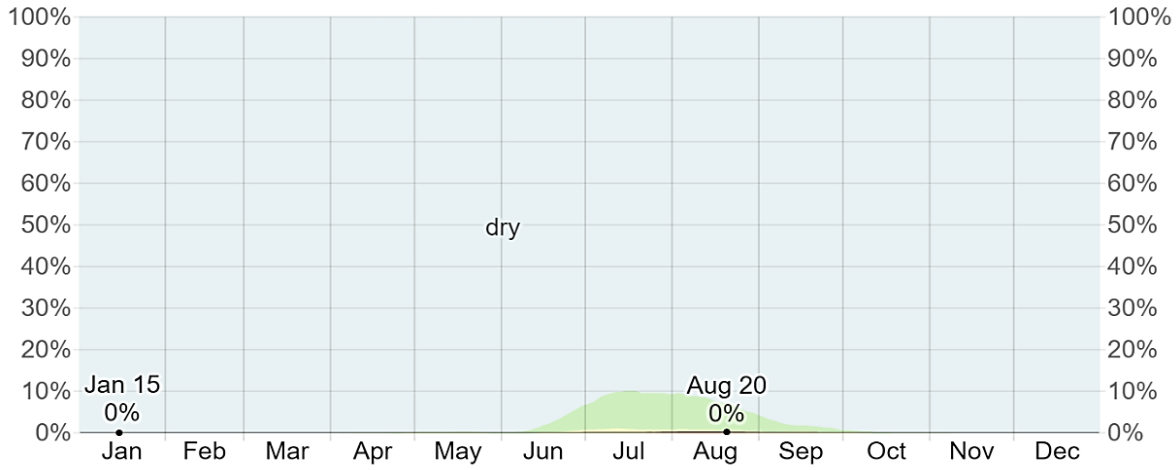

Fig. 7: The proportion of time allocated to different humidity comfort categories, classified based on dew point levels

(Source https://weatherspark.com/y/105125/Average-Weather-in-Tehran-Iran-Year-Round#Figures-Humidity)

4.0 RESULTS

The case study analysis yields insights into the thermal conditions of residential streets in Narmak. Notably, roads aligned along the east-west axis exhibit superior thermal comfort levels compared to their north-south counterparts, evidenced by daytime Physiologically Equivalent Temperature (PET) values within the comfort range of 14.35% throughout the day (6:00-18:00). The design parameters associated with road width, however, do not precipitate significant alterations in thermal conditions. The limited discernible influence can be ascribed to the slight difference in their measurements (2m) and the comparatively modest height of neighboring structures. Figure 8 visually illustrates the detailed hourly frequencies of PET across various case studies.

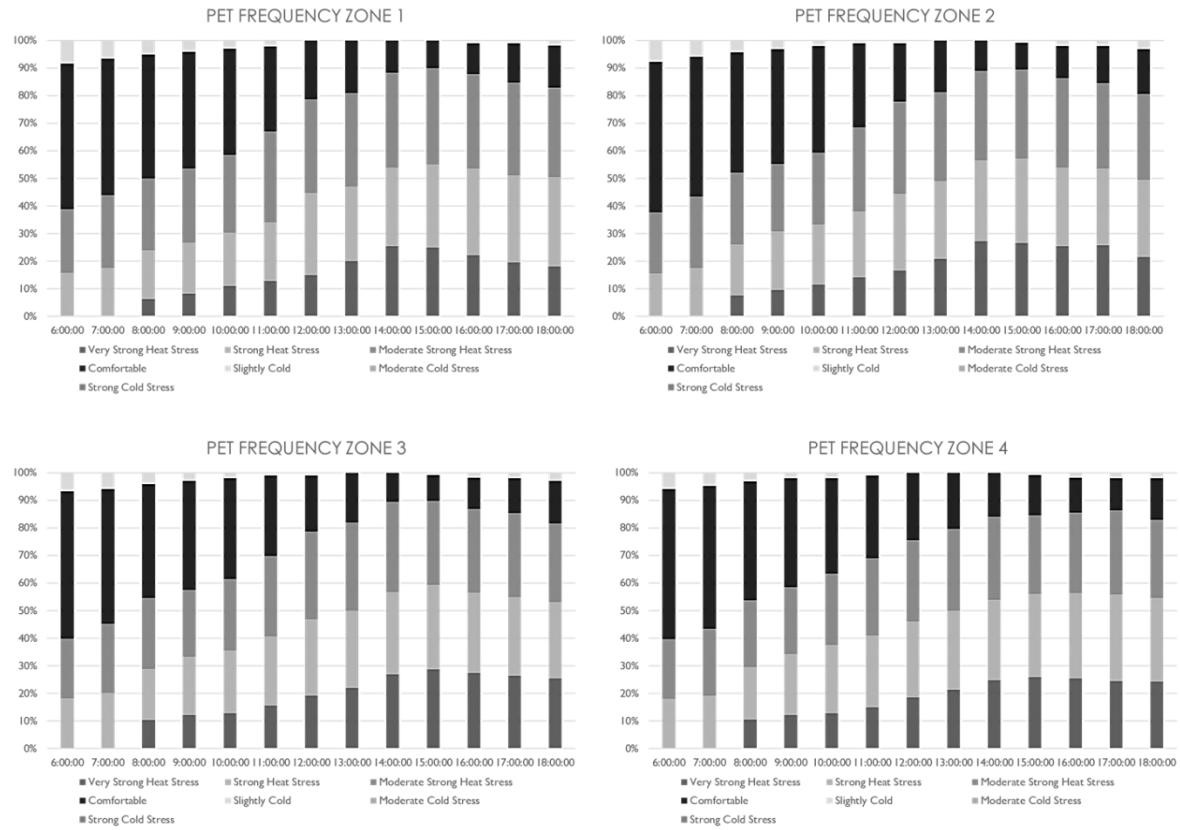

Fig. 8: Frequency of Physiological Equivalent Temperature (PET) from 6:00:00 a.m. to 6:00:00 p.m. in Zones 1-4 within Narmak Neighbourhood.

Streets aligned in the north-south direction significantly influence both humidity and wind speed, showing an average rise of 5.08% and 14.03%, respectively, as illustrated in Figure 9. A comparison between these north-south-oriented streets and their east-west counterparts reveals a notable difference of 3.98 m/s in airflow during the peak hour (3:00 pm) and a deviation of 9 degrees from the central axis. In the residential region of Narmak, a road with a half-width exhibits elevated wind speeds when contrasted with a narrower street. Precisely, a 10-meter-wide road leads to an average daytime wind speed elevation of 3.21% compared to an 8-meter-wide road. The air temperature values remain constant across the four chosen case studies, whereas the mean radiant temperature parameter shows less than five °C variances.

Fig. 9: a- Comparative assessment of Potential Air Temperature (°C) status in zones 1-4. b- Comparative Wind Speed (m/s) status analysis in zones 1-4. c- Comparative evaluation of Relative Humidity (%) status in zones 1-4. d- Comparative examination of Mean Radiant Temperature (°C) status in zones 1-4.

4.1 Street Direction

This study's primary focus of investigation centers around street orientation, recognized as a paramount design element in urban planning geared towards enhancing outdoor thermal comfort. Illustrated in Figure 10-a, the findings reveal that the NE-SW axis-oriented road surpasses alternative roads in the other three directions by an average of 34.73%, establishing this urban configuration as providing the highest level of thermal comfort. This layout creates a thermally comfortable environment for outdoor users, particularly during the hottest months, from 10 am to 4 pm. At different periods throughout the day, the felt warmth remains "mildly cool," deemed satisfactory and favorable. This perceptual result is largely shaped by meteorological elements, with a key emphasis on the impact of wind speed in the context of elevated air temperatures (Ta) characteristic of a typical summer day. When combined with shaded areas, wind speed becomes a vital factor influencing thermal comfort. Therefore, it can be affirmed that the orientation of streets, a fundamental aspect of urban planning, notably affects Physiologically Equivalent Temperature (PET) values, particularly wind speed and direction.

The North-South orientation of the street canyon (as illustrated in Figure 10-b) emerges as the second most pivotal priority in the realm of outdoor thermal comfort-based urban design, providing thermal comfort for outdoor spaces approximately 32.17% of the time throughout the day. In contrast, the northwest-southeast direction is deemed the least favorable road option for outdoor thermal comfort in an urban setting (refer to Figure 10-d). With a rise in the duration of

sunlight, an increase in Mean Radiant Temperature (Tmrt), and a decline in wind speeds, individuals in open areas encounter discomfort in thermal conditions. These two elements, namely solar radiation and wind speed, are the primary climatic factors that significantly impact the comfort level of outdoor environments. Roads oriented in the northwest-southeast direction encounter "moderate heat stress" approximately 30.23% of the time. The second least favorable street canyon orientation is E-W, which enhances early morning thermal comfort and increases daytime heat stress. Strategies to improve comfort in these orientations may involve increasing shade effects, optimizing skyscraper design (higher aspect ratio), and implementing strategic tree planting. In all potential orientations of street canyons, a uniform perception of 'slightly cooler' temperatures is noted during the early morning (before 8 am) and late afternoon (after 5 pm).

Moreover, the perception of heat is significantly influenced by climatic parameters, particularly those associated with street canyon orientation. In this context, east-west-oriented roads exhibit the highest average mean radiant temperature at 33 °C, resulting in a moderate heat load persisting throughout the day. This parameter experiences a notable reduction to 8.24% for northeast-southwest-oriented roads, signifying an optimal urban design for thermal comfort. The average wind speed for the most favorable option (Northeast-Southwest Road) is 59.09% higher than that of the Northwest-Southeast Road (Figure 10-d). Meanwhile, meteorological factors like humidity and temperature remain relatively stable compared to alternative orientation choices. As a result, the most favorable configuration of road layouts leads to achieving optimal wind speeds.

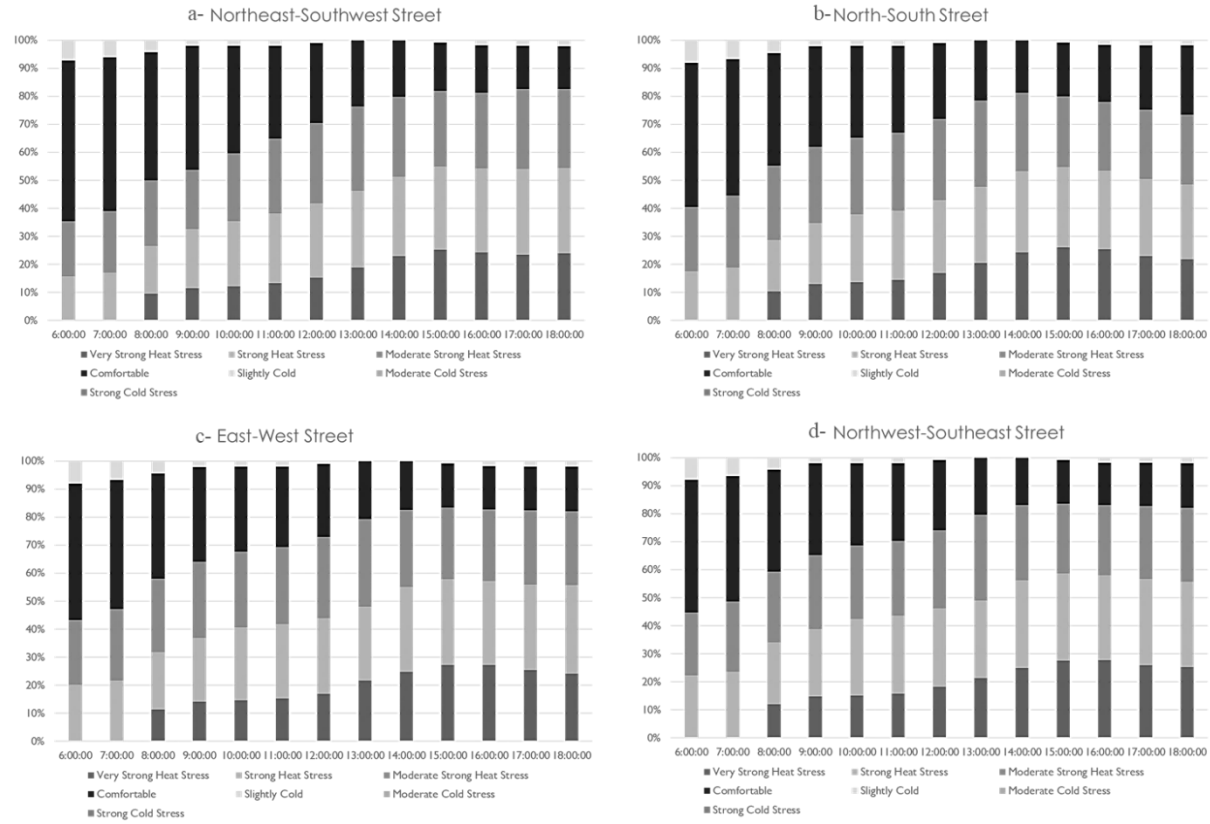

Fig. 10: a- The impact of streets situated in the northeast-southwest orientation on the frequency of PET. b- The influence of streets oriented in the north-south direction on the frequency of PET. c- The consequence of streets oriented in the east-west direction on the frequency of PET. d- The impact of streets oriented in the northwest-southeast direction on the frequency of PET.

The comparison between the orientations of street canyons highlights significant differences in their impact on outdoor thermal comfort. The NE-SW axis-oriented road stands out as the most favorable option, providing the highest level of thermal comfort, with an average improvement of 34.73% compared to alternative orientations. This layout ensures a thermally comfortable environment, particularly during the hottest months, maintaining a perception of "mildly cool" temperatures throughout the day. In contrast, the northwest-southeast direction is identified as the least favorable option, experiencing moderate heat stress for a considerable portion of the day. Similarly, while offering early morning comfort, E-W orientation increases daytime heat stress. Strategies to address these challenges involve increasing shade effects and optimizing building design. Moreover, the perception of heat is significantly influenced by climatic parameters, particularly mean radiant temperature, which is notably lower in NE-SW-oriented roads than in E-W orientations. Additionally, wind speed plays a crucial role, with the most favorable orientation (NE-SW) experiencing significantly higher average wind speeds, contributing to enhanced thermal comfort.

4.2 Building Classification

In the context of this investigation, it has been determined that the influence of building typology on outdoor thermal comfort is comparatively minor when contrasted with other factors that make up urban morphology. The research outcomes reveal that the linear arrangement of buildings along the northwest-southeast axis (depicted in Figure 11-c) is identified as the more comfortable option among the two alternatives—singular and extended linear northeast-southwest typologies—signifying a thermal environment of superior quality. However, despite the observed comfort, this specific design element does not instigate noteworthy alterations in Physiologically Equivalent Temperature (PET) values, relegating its significance to a less critical role in outdoor thermal comfort-based urban planning. The inter-building spacing on northeast-southwest-oriented streets, typically associated with the linear typology, notably fails to enhance thermal conditions. Hence, avoiding incorporating this arrangement in urban planning solutions is recommended. Even though the linear typology intersects the street direction, the orientation and aspect ratio of the design elements remain consistent among these three building typology alternatives, leading to minimal disparities in comfort conditions based on the current favorable thermal performance findings.

The investigation reveals that the maximum wind speeds are observed in a linear building configuration extending in the northeast-southwest direction. Notably, there is a reduction in wind speed by 4.57% to 2.29% in the northwest-southeast alignment for both extended and singular building typologies (refer to Figure 11-c). Importantly, these three building typologies display no significant changes in other climatic parameters, with variations in relative humidity and mean radiant temperature ranging from 1% to up to 2 °C.

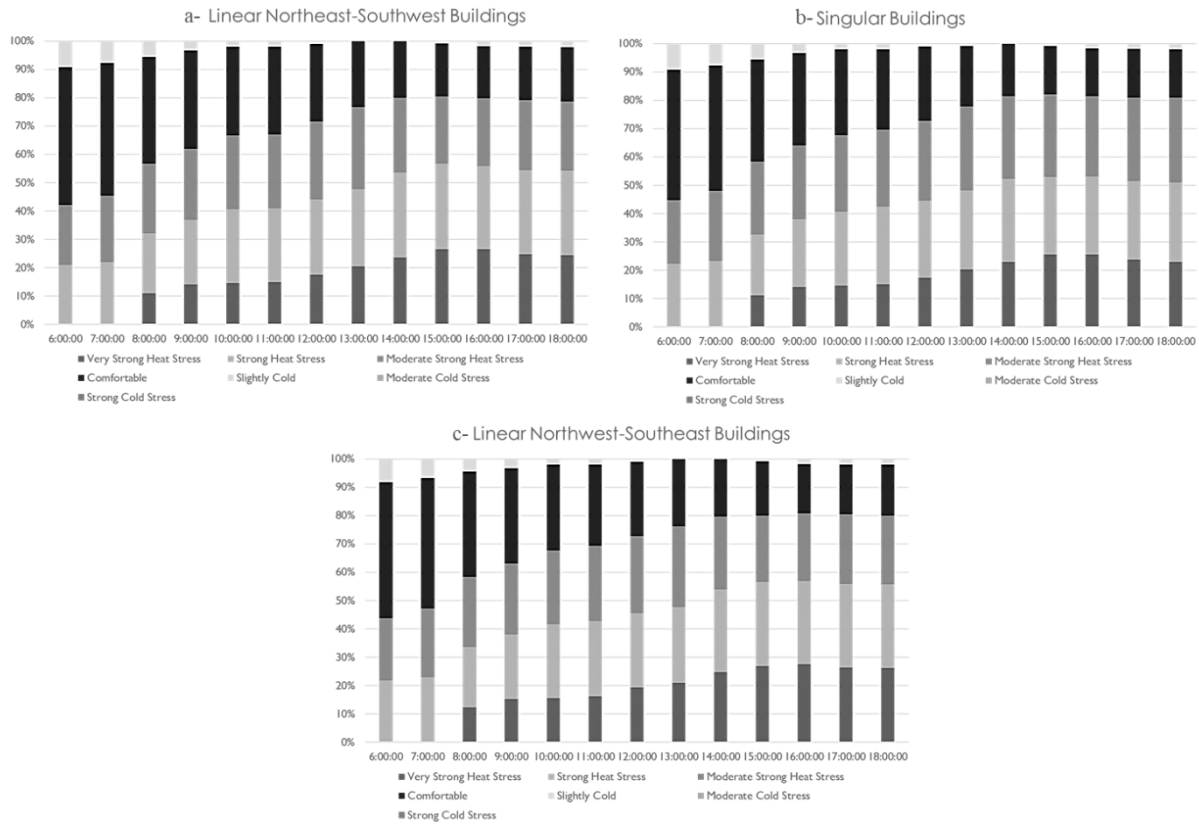

Fig. 11: a- The impact of buildings arranged in a linear northeast-southwest direction on the frequency of PET. b- The influence of individual buildings on the frequency of PET. c- The consequence of buildings arranged in a linear northwest-southeast direction on the frequency of PET.

The primary similarity among these classifications is their minimal impact on Physiologically Equivalent Temperature (PET) values, indicating that building typology has a comparatively minor influence on thermal comfort compared to other urban morphology factors. Despite providing a more comfortable thermal environment, the linear northwest-southeast axis arrangement does not significantly alter PET values, suggesting its limited significance in outdoor thermal comfort-based urban planning. However, a notable difference lies in the wind speed observations, where maximum wind speeds are observed in the linear configuration extending in the northeast-southwest direction. This reduces wind speed in the northwest-southeast alignment for both extended and singular building typologies. Additionally, these three typologies exhibit consistent orientations and aspect ratios, minimizing disparities in comfort conditions based on thermal performance findings. Furthermore, there are no significant changes in other climatic parameters, such as relative humidity and mean radiant temperature, among the different building typologies

4.3 Enclosure

The enclosure (aspect ratio), identified as the second most critical urban design element contributing to the delineation of a thermally comfortable urban environment, underwent meticulous adjustments through northeast-south orientation and the elongation of buildings along a straight northwest-southeast axis—an arrangement explored within the framework of street composition. Increasing the aspect ratio by 0.5 yielded an average reduction of

2.90°C in the maximum mean radiant temperature during the early morning and evening, resulting in decreased Physiological Equivalent Temperature (PET) values. The transition from a design parameter value of 0.5 to 1 extended the duration of comfort by 30.59%. Nevertheless, it is cautioned not to increase the aspect ratio beyond one in this area with elevated wind speeds, as it shifts the comfort range and results in moderately cooler road conditions for most of the day, particularly at 6:06 pm. An increase of 0.5 in the aspect ratio resulted in an average reduction in thermal comfort of 2.22%. As a result, maintaining the aspect ratio at one is recommended for buildings oriented along the northeast-to-southwest axis.

In contrast, case studies with a ratio of 0.5 accentuated the average heat load from 10 am to 3 pm. Achieving satisfactory comfort levels necessitates elevating the aspect ratio value, thereby increasing the proportion of horizontal surface shading. As the aspect ratio undergoes augmentation, there is a corresponding decline in the average radiant temperature. Specifically, the Mean Radiant Temperature Index (MRI) parameter registers a decrease of 3.31°C (13.23%) for every 0.5 increase in the ratio value. Notably, no significant alterations were observed in wind speed or humidity levels during these adjustments.

4.4 Vegetation Pattern

Implementing vegetation and tree planting represents an additional effective parameter that merits consideration for enhancing thermal conditions within urban streets, particularly for roadways characterized by suboptimal orientation and low-rise buildings, as exemplified by an optimized city layout with low buildings having an H/W ratio of 0.5.

By employing densely planted trees at a spacing of 5 meters, the Physiological Equivalent Temperature (PET) value can be reduced by as much as 12.07% (as illustrated in Figure 12-b). However, when adopting a sparser planting pattern, this reduction may decrease to 7.83% (as depicted in Figure 12-c). These findings offer valuable insights for mitigating PET levels in urban locales where creating comfortable thermal environments is challenging.

The introduction of greenery and planting of trees contribute to an increase in relative humidity of a maximum of 1.1%, thereby enhancing the thermal comfort of the streets. Furthermore, the consolidation and strategic removal of plantations reduce the average mean radiant temperature from 1.23 °C to 1.12 °C.

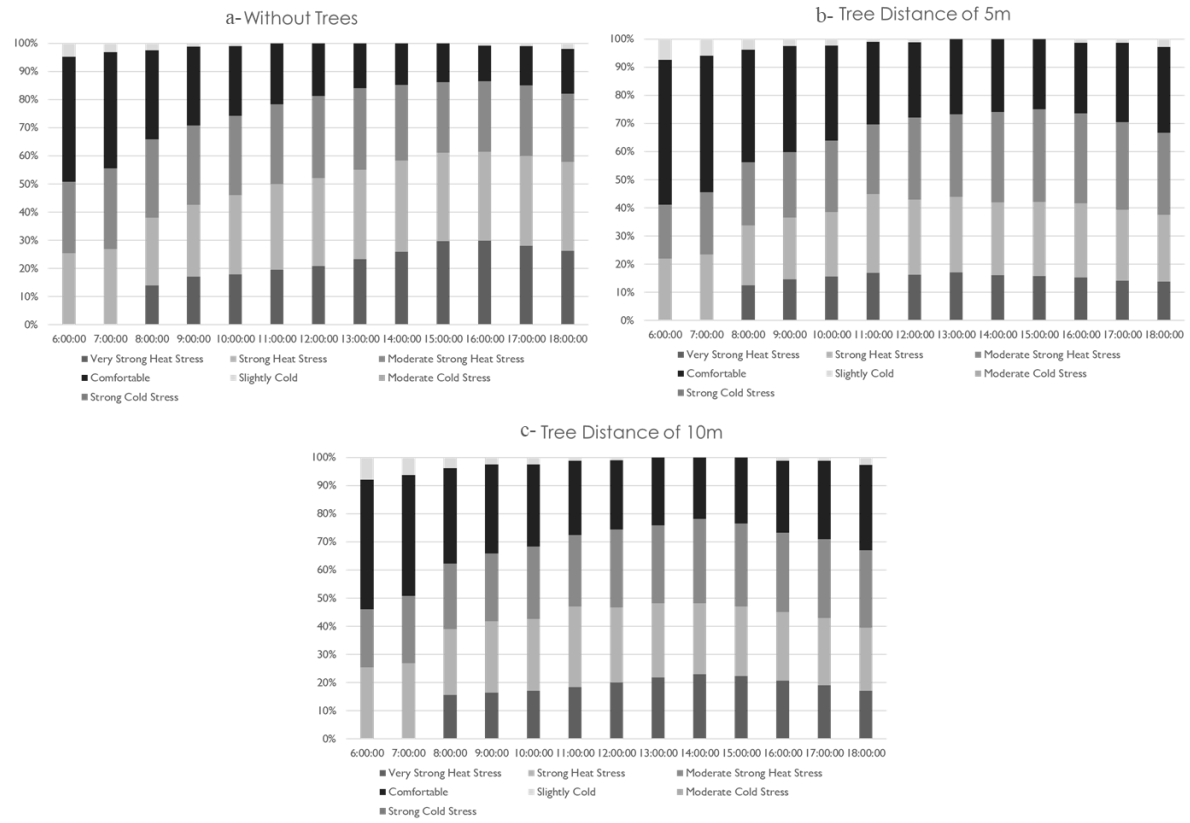

Fig. 12: a- The impact of the absence of trees on the frequency of PET. b- The influence of tree planting at a distance of 5 meters on the frequency of PET. c- The consequence of tree planting at a distance of 10 meters on the frequency of PET.

5.0 DISCUSSIONS

The predominant residential neighborhoods in Narmak must establish an urban environment that aligns with thermal comfort standards. Manifestations of heat stress are conspicuously evident on north-south roads, lingering for several hours each day yet imparting a perceptibly satisfactory sense of warmth. This perceptual outcome is primarily ascribed to the constrained utilization of the "aspect ratio" parameter, diminishing shadow effects and elevating the average radiant temperature in the street canyons. The distribution of time spent daily in a comfortable thermal environment across various case studies is depicted in Figure 13. Comparing the trends of potential air temperature between honeybees and ENVI-met data reveals a consistent pattern of temperature variation throughout the day. Both datasets show an increase in temperature from the early morning hours to midday, followed by a gradual decrease towards the evening. This pattern aligns with the expected diurnal variation in temperature in outdoor environments. However, there are slight discrepancies in the recorded temperatures between the two datasets at each time interval. Overall, Honeybee tends to report slightly higher temperatures compared to ENVI-met data across most of the recorded hours. Despite these differences, both datasets depict a similar trend of temperature fluctuation over the day, indicating a general agreement in capturing the overall temperature dynamics within the studied area.

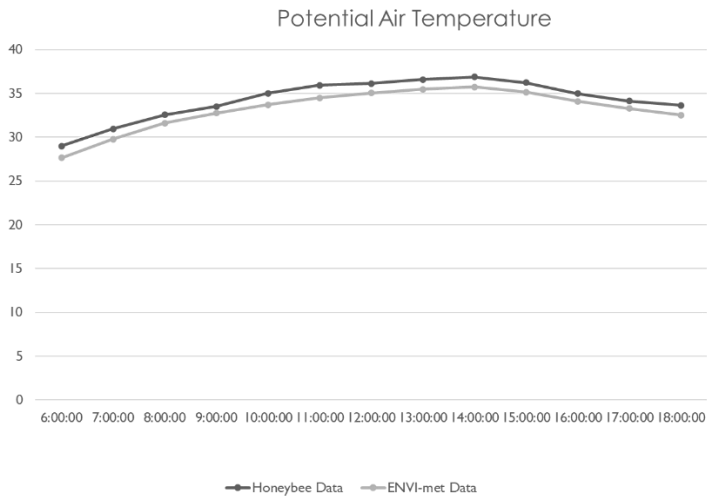

Fig. 13: Potential Air Temperature status from Honeybee and ENVI-met tool

The main objective of this investigation is to improve the thermal conditions of outdoor areas, thereby enabling their potential integration into future urban development and planning initiatives. Among the aspects studied in urban planning, street orientation was the most impactful at 39.12%, followed closely by aspect ratio at 36.78%, area ratio (connected to greenery), and building type. As depicted in Figure 14, embracing the optimal urban layout proposed in this study leads to an extension in the duration of thermal comfort. Consequently, upon scrutinizing all alternatives, it becomes apparent that roads aligned along the northeast-southwest axis, flanked by medium-sized buildings (with a H/W ratio of 1) extending in the northwest-southeast direction, present the most favorable thermal conditions.

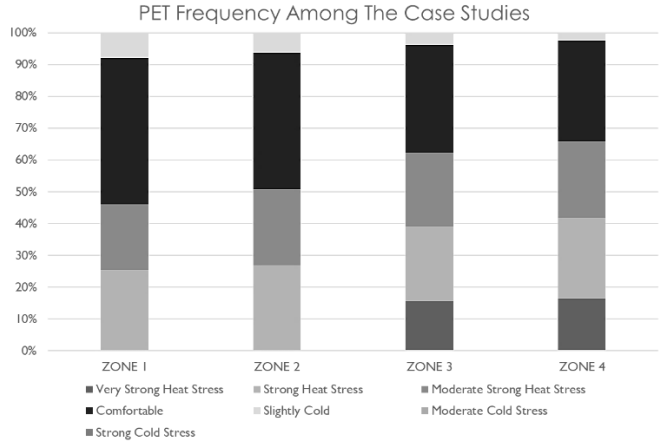

Fig. 14: PET frequency in selected zones

The research reveals that wind speed stands out as the primary factor affecting outdoor thermal comfort in this particular coastal area with humid subtropical climatic conditions. Following closely as the second most significant factor is the mean radiant temperature (H), representing exposure to solar radiation. Therefore, the considerable influence of road orientation and aspect ratio variables on Physiological Equivalent Temperature (PET) values is anticipated. Analyzing the PET data across different zones reveals varying thermal comfort and stress levels. Zones 1 and 2 exhibit similar patterns, with a significant proportion experiencing moderate to strong heat stress, indicating potentially uncomfortable conditions.

In contrast, Zones 3 and 4 demonstrate a more balanced distribution, with a notable presence of comfortable conditions alongside moderate heat stress. Interestingly, Zone 3 displays a higher prevalence of slightly cold conditions than the other zones, suggesting a more diverse thermal experience. These findings underscore the importance of considering localized variations in thermal comfort when designing urban environments, highlighting the need for targeted interventions to mitigate heat stress and promote comfort across different zones.

Table 3 outlines the relationship between urban design elements and the four crucial weather parameters in effective percentages. This measure quantifies the difference between the optimal and least favorable options for each street orientation, building typology, aspect ratio, and planting pattern design aspect. Notably, temperature and relative humidity are identified as the least impactful, suggesting that their values show limited variability depending on the city's structure.

Table 3. Impact Percentage of Design Factors on Climatic Components

Research Parameters	**Effective Percentage**				
	T_a	Wind Speed	T_{mrt}	Relative Humidity	PET
Street Direction	0.27	13.65	24.39	2.56	39.12
Building Typology	0.19	8.12	22.46	2.47	4.17
Enclosure	0.54	0.76	41.12	0.57	36.78
Tree Planting	0.39	48.17	15.37	3.12	17.69

The proposed physical characteristics of the urban area are defined by its thoughtful design elements aimed at enhancing thermal comfort and livability. Firstly, the predominant NE-SW axis-oriented road layout ensures the highest level of thermal comfort compared to alternative orientations, with a substantial improvement of 34.73%. Secondly, the linear arrangement of buildings along the northwest-southeast axis is preferred, offering a superior thermal environment compared to alternative building typologies. This configuration promotes a comfortable urban atmosphere. Thirdly, maintaining an aspect ratio of 1.5 for buildings oriented along the northeast-to-southwest axis on roadways is recommended, optimizing the balance between architectural design and thermal performance. Lastly, the strategic deployment of densely planted trees at a 5-meter spacing further contributes to thermal comfort, significantly reducing the Physiological Equivalent Temperature (PET) by up to 12.07%. These combined features create an urban environment with exceptional thermal comfort and sustainability, fostering a pleasant and inviting atmosphere for residents and visitors alike.

6.0 CONCLUSION

This study delves into the thermal performance of streets within the Narmak Neighbourhood in Tehran, specifically focusing on the prevalent urban configurations found in residential areas of Tehran's region 4. Employing a parametric approach, a comprehensive series of thermal comfort investigations were conducted to systematically evaluate the effect of various urban design factors on outdoor space thermal conditions. The results are presented in the context of key climatic factors, including air temperature, mean radiant temperature, wind speed (V), and Relative Humidity. Utilizing the Physiological Equivalent Temperature (PET) Comfort Index as the benchmark for comfort levels, the study meticulously examines

the microclimate conditions within Narmak's urban canyon. The research aims to contribute to a comprehensive thermal comfort guide for urban development, emphasizing the significant influence of relevant design parameters. The findings underscore that optimizing design parameters has the potential to markedly enhance thermal comfort, ultimately contributing to creating a more pleasant outdoor environment. By incorporating these urban design guidelines, planners and designers can create more comfortable and livable urban environments that prioritize outdoor thermal comfort and mitigate the adverse effects of heat stress. Here are the urban design guidelines provided from the research output:

1- Urban Street Direction

1-a) Prioritising NE-SW Street Orientation: Given its superior performance in providing thermal comfort, urban design should prioritize the orientation of streets along the NE-SW axis. This orientation creates a thermally comfortable environment for outdoor users, particularly during peak heat hours. Designing streets in this direction can significantly improve outdoor comfort levels and reduce the risk of heat stress.

1-b Considering North-South Orientation: While less favorable than NE-SW orientation, North-South street orientation emerges as the second most pivotal priority for enhancing outdoor thermal comfort. Designers should consider incorporating this orientation where feasible to provide thermal comfort for outdoor spaces throughout the day.

1-c) Mitigate Heat Stress in Less Favorable Orientations: For orientations such as northwest-southeast and east-west, where moderate to increased heat stress is experienced, urban design interventions are essential to mitigate thermal discomfort. Strategies include increasing shade effects, optimizing building design to provide shade and ventilation, and implementing green infrastructure such as strategic tree planting.

1-d) Optimise Wind Flow: Wind speed plays a vital role in outdoor thermal comfort. Designing streets and urban spaces to facilitate optimal wind flow, particularly in favorable orientations like NE-SW, can enhance thermal comfort. Strategies include incorporating open spaces, creating wind corridors, and minimizing obstructions to wind flow.

1-e) Consider Microclimatic Factors: Understanding microclimatic factors such as mean radiant temperature and wind speed variations across different orientations is crucial in urban design. Designers should consider these factors in site planning, building placement, and landscape design to create microclimates that optimize outdoor thermal comfort.

2- Building Classification

2-a) Preference for Northwest-Southeast Building Arrangement: The linear arrangement of buildings along the northwest-southeast axis is identified as the more comfortable option for outdoor thermal comfort. Urban planning solutions should prioritize this orientation to create a thermal environment of superior quality.

2-b) Avoidance of Northeast-Southwest Building Arrangement: The finding suggests avoiding the incorporation of a linear building typology extending in the northeast-southwest direction. This arrangement fails to enhance thermal conditions notably and may lead to less comfortable outdoor environments.

2-c) Consistency in Building Typology Design: Despite variations in building typologies, such as singular and extended linear configurations, the orientation and aspect ratio of the design elements remain consistent. Urban planners should maintain this consistency to ensure minimal disparities in comfort conditions based on current favorable

thermal performance findings.

2-d) Consideration of Wind Speeds: Urban design should consider the impact of building configurations on wind speeds. The investigation highlights that maximum wind speeds are observed in a linear building configuration extending in the northeast-southwest direction. Designers should leverage this insight to optimize wind flow and enhance outdoor comfort.

2-e) Monitoring Climatic Parameters: While the investigation did not reveal significant changes in other climatic parameters, such as relative humidity and mean radiant temperature, ongoing monitoring of these factors is crucial in urban planning. Designers should remain vigilant to variations and adapt design strategies to maintain optimal outdoor thermal comfort.

3- Enclosure

3-a) Optimal Aspect Ratio for Thermal Comfort: Adjustments to the enclosure aspect ratio significantly delineate a thermally comfortable urban environment. Increasing the aspect ratio by 0.5, within certain limits, reduces maximum mean radiant temperature and Physiological Equivalent Temperature (PET) values, thus enhancing comfort. However, caution should be exercised not to exceed an aspect ratio of one in coastal areas with elevated wind speeds, as this can shift the comfort range and result in moderately cooler road conditions, particularly in the late afternoon.

3-b) Aspect Ratio and Shading: Increasing the aspect ratio contributes to a higher proportion of horizontal surface shading, which is crucial for achieving satisfactory comfort levels, especially during peak heat hours from 10 am to 3 pm. Designers should consider augmenting the aspect ratio to enhance shading and mitigate heat load, improving thermal comfort in urban environments.

3-c) Effect on Mean Radiant Temperature: Augmenting the aspect ratio correlates with a decline in the average radiant temperature, as indicated by the Mean Radiant Temperature Index (MRI) parameter. For every 0.5 increase in the ratio value, there is a corresponding decrease in the MRI parameter, highlighting the effectiveness of this strategy in reducing thermal discomfort.

3-d) Maintaining Wind Speed and Humidity Levels: No significant alterations were observed in wind speed or humidity levels during adjustments to the aspect ratio. Urban designers can thus optimize the aspect ratio to enhance thermal comfort without compromising other climatic factors.

4- Vegetation Pattern

4-a) Implementation of Vegetation and Tree Planting: Introducing vegetation and planting trees along urban streets is an effective strategy for improving thermal comfort, especially in areas with suboptimal orientation and low-rise buildings. This approach, particularly with densely planted trees spaced at 5 meters, can significantly reduce Physiological Equivalent Temperature (PET) values by up to 12.07%. However, even with a sparser planting pattern, a notable reduction in PET levels, up to 7.83%, can still be achieved.

4-b) Optimal Planting Patterns: Urban planners should carefully consider the planting pattern of trees to maximise the reduction in PET values. Dense planting patterns are more effective in mitigating thermal discomfort than sparse arrangements. Thus, prioritising densely planted trees, especially in areas with challenging thermal environments, can yield greater benefits for improving outdoor comfort.

4-c) Impact on Relative Humidity: The introduction of greenery and trees contributes to an increase in relative humidity by a maximum of 1.1%. This increase in humidity enhances thermal comfort in urban streets, especially during hot and dry conditions, by creating a more pleasant microclimate.

4-d) Management of Plantations: Consolidating and strategically removing plantations can optimise thermal conditions. This management approach can lead to a reduction in the average mean radiant temperature, thereby enhancing overall comfort levels for pedestrians and outdoor users.

ACKNOWLEDGMENTS

This paper is part of a PhD thesis under the supervision of Dr. Norsidah Binti Ujang at the Faculty of Design and Architecture (FRSB), Universiti Putra Malaysia (UPM).

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JOURNAL OF ARCHITECTURE, PLANNING & CONSTRUCTION MANAGEMENT
Volume 14 Issue 1, 2024 E-ISSN: 2462-2222 ISSN: 2231-9514

EVALUATION OF MAQASID SHARIAH PRINCIPLES IN INSTITUTIONAL WORK ENVIRONMENT

Received: 29th February 2024 | Accepted: 28th May 2024 | Available Online: 30th June 2024

DOI: 10.31436/japcm.v14i1.870

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ABSTRACT

This research aims to explore the link between a safe work environment and its Impact on employees' well-being, focusing on the principles of Maqasid Shariah. Utilizing insights from previous literature, the research objectives are to identify the current criteria of the work environment and assess how the criteria contribute to ensuring the safety and well-being of employees, to analyse how Maqasid Shariah principles are applied in work environment to enhance employees' privacy and well-being, considering factors such as Visual Comfort and Acoustic Sensory and to provide recommendations for creating a conducive work environment aligned with Maqasid Shariah's principles. This research evaluates employee perceptions of their current work environments and their impact on performance and well-being, aiming to improve work environments to encourage productivity while maintaining Islamic values of safety and privacy. The findings collected successfully provided input on the influence of Visual Comfort and Acoustic Sensory factors towards the overall experience of office space, particularly in addressing privacy concerns. Recommendations derived from the findings aim to create a conducive work environment aligned with Maqasid Shariah's principles.

Keywords: Maqasid Shariah, work environment, workspace, safety, privacy, wellbeing, protection of life

1.0 INTRODUCTION

Institutions are work environments where employees spend a significant portion of their day working. It is essential to create a conducive working environment that considers both functional and psychological factors to enhance employees' performance and well-being (Dandona, 2013; Cavanaugh, 2019; Ahmed, 2022). Among various factors influencing employees' performance and well-being, safety and security aspects of the work environment are particularly significant. Designing appropriate safe working environments has a significant impact on employees' mental and physical well-being (Colenberg, Jylhä, and Arkesteijn, 2021; Yadav et al., 2022). The challenge lies in creating work environments that balance collaborative interactions with individual privacy and security concerns. The lack of privacy especially in open-plan layout offices may not be conducive for departments handling confidential information (Oktra, 2020).

Maqasid Shariah, the higher objectives or goals of Islamic law, provides principles that cover many aspects of life, aiming to protect and enhance human interests like religion, life, intellect, progeny, and wealth (Mochamad Sandisi, 2020). These principles guide Muslims in

pursuing personal and societal well-being while staying true to Islam's core values. Therefore, Maqasid Shariah's principles of Protection of Life hold significant implications for designing and managing work environments that prioritize the well-being and productivity of employees as part of duties as Khalifah (Sarkawi, Md Dali, Abdullah and Mohd Khazani 2017; Mohamad, 2017). It encompasses the preservation and enhancement of human life, with the primary objective is emphasizing the protection and promotion of physical, mental, and spiritual welfare. Protection of Life, a principle of Maqasid Shariah, emphasizes the safety and well-being of employees in the work environment (Arsad et al., 2015; Mohamad, 2017). Ensuring adequate visual comfort and acoustic sensory factors align with this principle, promoting employees' security and efficiency (Kim & de Dear, 2013; Asadi and Hussein, 2014; Güler and Demirkan, 2021).

In studying the principles of Maqasid Shariah toward a secure and conducive work environment, the following research questions and research objectives are assessed: -

Table 1: Research Questions and Research Objectives

Research Question	Research Objectives
What are the characteristics of Maqasid Shariah's Protection of Life in providing safety and well-being of office building occupants?	To examine the key characteristics of Maqasid Shariah's Protection of Life within office building design and how they contribute to ensuring the safety and well-being of occupants.
How do Maqasid Shariah principles address in the office design for human comfort?	To analyse how Maqasid Shariah principles are applied in office design to enhance human comfort, considering factors such as spatial arrangement, lighting, and ergonomic considerations.
What are the recommendations for the good design of office buildings according to Maqasid Shariah's Protection of Life?	To determine effective design of office buildings in alignment with Maqasid Shariah's Protection of Life, encompassing strategies to optimize safety, well-being, and user comfort within the built environment.

Figure 1 below provides an overview of the conceptual framework established through synthesizing information from the literature review to explore how the work environment affects employee safety and productivity, with a special focus on privacy issues in open-plan offices. The review of existing studies points out several important factors contributing to privacy issues, such as Visual Comfort and Acoustic Sensory. Visual Comfort, including variables such as visual privacy and lighting, helps alleviate privacy concerns. Similarly, Acoustic Sensory, which includes variables like noise level and soundproof partitions, plays a vital role in addressing challenges related to privacy.

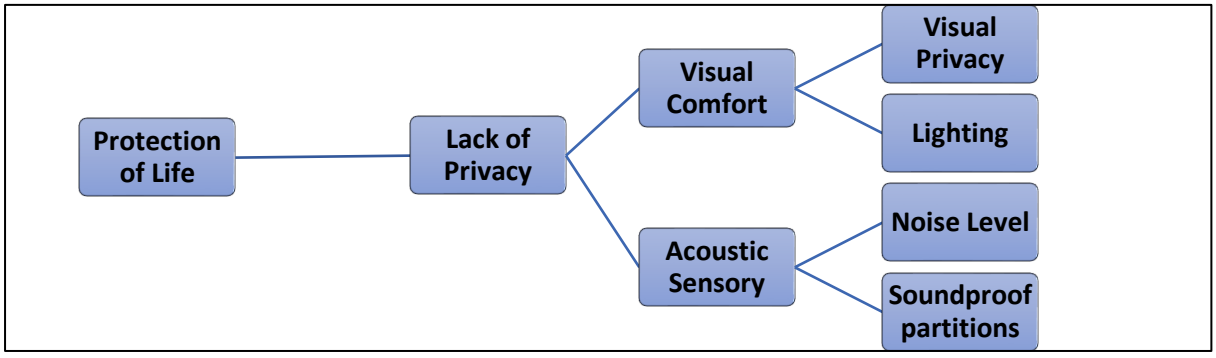

Fig. 1: Conceptual Framework

2.0 LITERATURE REVIEW

This section discusses the analysis of existing research and scholarly articles relevant to Maqasid Shariah and its principles, specifically the Protection of Life. Elements related to addressing the Lack of Privacy in the work environment are discussed to establish a linkage between the Protection of Life and factors that mitigate the lack of privacy, including Visual Comfort and Acoustic Sensory.

2.1 The Principles of Maqasid Shariah

Maqasid Shariah provides a comprehensive framework that encompasses various aspects of human life, including work environment. These principles are derived from the primary sources of Islamic law and aim to preserve and promote fundamental human interests. This includes the preservation of religion, life, intellect, descendants, and wealth (Md Dali, Abdullah, Sarkawi, 2016; Tarmizi, 2019). Often discussed interchangeably with maslahah, Maqasid Shariah in daily life has already been adopted by all people with its application covers various fields and industries, which includes construction, banking and finance, education, politics, medicine, and so on (Tarmizi, 2019). There are verses in the Al-Quran that cover certain provisions, aiming at accomplishing certain objectives (maqasid) made by Allah SWT for a purpose and value, and also to give a reminder to the men on the earth who is a vicegerent (Khalifah) to Allah SWT (Arsad, Ahmad, Mohamed Fisol, Said, Othman, 2015). It is understood that Maqasid Shariah requires human beings to be compliant with rules, policies, and guidelines to achieve specific goals. Principally, Maqasid Shariah functions as nurturing the quality of life which needs to be integrated with worldly concerns including built environment such as town planning, quantity surveying, and architecture. This is intended so that it can benefit the ummah and the entire human beings of the universe.

2.1.2. Maqasid Shariah Objectives and Their Application to the Built Environment

From the context of construction and building, Maqasid Shariah principles guide making a building space functional (primary) while at the same time making it appealing and aesthetic (secondary) and then differentiate between necessity and luxury in the function of the space based on darūrāt (necessity), followed by hājīyāt (needs) and the taḥsīnīyāt (luxury) (Sulayman, 2014; Sarkawi, et. al. 2017). The five objectives in Maqasid Shariah, namely, protection of life, protection of wealth, protection of progeny, and protection of religion provide in-depth knowledge and a comprehensive framework for developing a well conducive space and environment (Vejzagic, and Smolo, 2011; Md Dali, Abdullah and Ahmad Sarkawi, 2016; Julia, Kassim, and Engku Ali, 2018; Tarmizi, 2019).

2.1.3 Protection of Life (hifz an-nafs)

Hifz an-nafs focuses on preserving the safety and well-being of individuals, ensuring a dignified life and a return to Allah SWT in a state similar to our birth condition. In designing work environments that uphold the principle of hifz an-nafs, it is crucial to prioritize factors such as accessibility and sustainable design. This includes using sustainable materials, implementing indoor air quality management measures, and integrating safety features to promote a healthy lifestyle (Zein, 2018; Avion Tech, 2021). Employing safety for privacy while doing work such as room partitions and noise controlling mechanisms are paramount

considerations during the design and construction phases. Furthermore, using safe organic building materials like straw bale walls with added silica content and structural concrete insulated panels (SCIP) offers exceptional fire resistance and resilience against natural disasters such as earthquakes and strong winds (Heath, Farrell, and Mashal, 2014). Therefore, the principle of Protection of Life becomes the central idea of this research taking into the aspect of Visual Comfort and Acoustic Sensory as its elements. This principle and its elements aim to mitigate issues related to the lack of privacy and promote a secure and private work environment that aligns with Islamic values.

2.2 Protection of Life: Lack of Privacy And Safety

Open office layouts are increasingly adopted by organizations to foster collaboration and productivity. Furthermore, office layouts are often determined by organizational hierarchy, with lower-grade employees in shared or open floor layouts and middle/top managers in cubicles or private rooms (Hassain, 2020). The lack of privacy in such settings can negatively affect employees' well-being and job satisfaction, with open-plan layouts presenting challenges in creating a conducive work environment. Study shows that open-plan office layouts may pose several health problems such as airborne diseases in fostering conducive work environment (U.S. Environmental Protection Agency, 1991; Nawi, Baharum, Ibrahim, and Riazi 2017). Furthermore, it lacks physical barriers, and compromises privacy, resulting in increased stress levels, reduced focus, and decreased productivity compared to enclosed office layouts (Muzaffar, Noor, and Mahmud, 2020). Employees need to have a designated working space that they perceive as safe and does not distract them from performing their work efficiently (Wütschert, Pereira, and Eggli, 2022).

To address the lack of privacy in office space, two key factors are identified that significantly impact the quality of privacy in the office, which are Visual Comfort and Acoustic Sensory. Visual Comfort encompasses the aesthetic and ergonomic aspects of the physical environment that enhance well-being, while acoustic sensory relates to the sound environment that affects concentration, effective communication, and privacy maintenance.

2.2.1 Visual Comfort

Visual Comfort refers to optimal visual conditions that reduce eye strain and promote overall well-being (Asadi and Hussein, 2014; Xue et al., 2022). It includes factors like lighting, glare reduction, colour, and contrast. The research underscores the importance of visual comfort in office environments. De Giuli and Valeria (2008) found that adequate lighting and colour temperature positively impact visual comfort and productivity. Boyce, Hunter, and Howlett (2003) highlighted the importance of glare reduction strategies such as shading devices and screen positioning to mitigate discomfort caused by excessive brightness or contrast.

Visual Privacy involves controlling the visibility of personal or confidential information within office spaces. It plays a vital role in maintaining confidentiality, reducing distractions, and fostering a sense of security among occupants. Various aspects contribute to visual privacy, including office layout, furniture arrangement, and the use of visual barriers. Strategically positioning workstations, partitions, or screens can enhance privacy levels (Yildirim, Akalın, and Celebi, 2007). Moreover, the influence of visual privacy on occupants' satisfaction and productivity, highlights the need for appropriate visual barriers and individual control over privacy settings (Güler and Demirkan, 2021).

Lighting is essential for achieving visual comfort and enhancing the visual environment, covering natural and artificial sources, color temperature, and controls. Proper lighting design can improve mood, concentration, and visual performance. Mayhoub and Rabboh (2022) found that customers prefer daylighting in shopping malls, while other research highlights the importance of lighting conditions for employee well-being and productivity (Boyce et al., 2003). Asadi and Hussein (2014) note that optimal daylighting positively impacts productivity and reduces energy consumption.

2.2.2 Acoustic Sensory

Acoustic Sensory factors play a crucial role in addressing the lack of privacy concerns by considering variables such as noise level and sound absorption. The sound environment of an office space significantly impacts the ability to concentrate, communicate effectively, and maintain privacy.

Noise Level and Sound Absorption. High noise levels in office environments can negatively impact privacy, as distracting background noise hinders effective communication and increases the risk of unintentional disclosure of sensitive information (Asadi and Hussein, 2014; CareerBuilder, 2015; Güler and Demirkan, 2021). Incorporating sound-absorbing materials and treatments in office design, such as acoustic panels and ceiling baffles, can minimize sound reflections and prevent the spread of private conversations (Reinten, Braat-Eggen, Hornikx, Kort and Kohlrausch, 2017; Macchie, Secchi and Cellai, 2018). Therefore, noise level control and sound absorption are crucial elements to consider for indoor environment design to enhance privacy, concentration, and communication (Cucharero et al., 2019).

3.0 METHODOLOGY

This section elaborates on the process of obtaining the data for the research which includes research design, sampling technique, questionnaire design, and collection of the data. The research design is generated to help in determining questions to be asked to respondents to achieve the research objectives. UNITEN and IIUM are selected for this research to assess the extent to which the Maqasid Shariah principle of protection of Life is incorporated in the selected buildings of each institution. It will offer valuable insights into how these institutions prioritize the well-being and safety of their occupants. The respondents selected are employees who are occupants of the office building whereby their opinion is based on the research questions given. This research uses a probability sampling technique, where employees from each university were identified based on their divisions and then selected through a simple random format. They were contacted via email or approached in person at their offices to confirm their availability to answer the provided questionnaire.

The organizational structure of both universities was examined, and questionnaires were distributed to the following divisions: -

Table 2: Division Selected for the survey

Universities	**Division Selected**
UNITEN	Administration Office
	Research & Innovation/ Research Department
	Chancellery Offices
	Finance Department
	Marketing
	Other
IIUM	Kulliyyah of Architecture and Environmental Design
	Administrative Office
	Academic Office
	International Office
	Postgraduate Office
	Finance Department
	Marketing
	Other

To address the research questions at hand, questionnaires were divided into four parts as follows:-

Table 3: Questionnaire Design

Part		**Description**	**Format**
A.	Respondent's Background	To provide demographic understanding, targeted and comparative analysis, gaining contextual insights, tailoring recommendations, avoiding bias, and ensuring the validity of this research.	• Multiple questions • Open questions
B.	Office Space Environment	To provide an overview perception of office worker relating to his/her current workspace. This serves as warm up to allow respondents understand the purpose of the research.	• Multiple questions • Likert scale questions • Ranking questions • Open questions
C.	Opinion Concerning Protection of Life	To provide opinion of office worker relating to his/her current workspace specifically on visual comfort	• Multiple questions • Likert scale questions • Open questions
		To provide opinion of office worker relating to his/her current workspace specifically on acoustic sensory.	
D.	Office Design Improvement	To provide recommendation to improve the office space relating to Protection of Life	• Open questions

The data collection process involved distributing physical and online questionnaires to employees in selected divisions of their institutions. Physical distribution was done by visiting offices and providing questionnaires directly, while online distribution involved sharing questionnaire links. Approximately 100 questionnaires were distributed to each institution, resulting in a 30% collection rate. Respondents had one week to complete the questionnaires,

spanning two months across both institutions. Data were reviewed, assessed, and recorded in Statistical Package for the Social Sciences (SPSS) after cleaning for spelling, grammar, and language consistency. Questions were systematically coded for organization and integration into SPSS for analysis. Frequency distribution analysis was used to examine demographic variables, such as age group, gender, and job role, while mean rating and standard deviation calculations provided insights into consensus and variability of responses on Likert scale questions. Regression analysis was conducted to explore relationships between variables, particularly examining the influence of Visual Comfort and Acoustic Sensory experiences on overall perceptions of the work environment.

4.0 RESULTS

4.1 Respondents' Overall Perception of Office Space

This section discusses the findings about how employees view their workplace environment. It focuses on the importance of visual comfort and its impact on employees' well-being. The results show that all respondents from UNITEN and IIUM are satisfied with their current office environment.

4.1.1 Priority Ranking for Office Space

The following Table 4 shows the mean rank values provided by respondents from both universities to assess the overall importance rating of various aspects of office space according to the universities.

Table 4: Respondents' Priority for Office Space by Universities

Universities	Aspects	Mean Rank	Rank
UNITEN	Good ventilation	2.87	1
	Well Equipped	3.03	2
	Good thermal condition	3.63	3
	Ample Space	5.00	5
	Pleasant view	5.27	6
	Good Lighting/Daylighting	4.23	4
	No excessive noise	6.73	7
	Pleasant smell	6.80	8
	Other	7.43	9
IIUM	Good ventilation	3.07	2
	Well Equipped	2.48	1
	Good thermal condition	5.34	5
	Ample Space	4.68	4
	Pleasant view	5.43	6
	Good Lighting/Daylighting	4.14	3
	No excessive noise	6.32	8
	Pleasant smell	6.18	7
	Other	7.36	9

Based on the overall responses regarding factors to consider and prioritize in an office space from both universities, both universities highly prioritize good ventilation and having their workplace being well-equipped, indicating their crucial role in office space considerations. Other than the top two choices highlighted, UNITEN respondents consistently prioritize good thermal conditions whereas IIUM respondents prioritize more on having good lighting/daylighting in their workplace. Additionally, while both groups consider aspects like ample space and no excessive noise as important, there are variations in the rankings, with respondents from IIUM showing more emphasis on ample space compared to UNITEN respondents. However, pleasant views and pleasant smells does not emerge as top priorities for either group, with both universities rated second choice as their highest. Although the Other aspect is not prioritized highly by respondents from either university, most respondents perceive it as safety and security, emphasizing the need for an overall secure working environment to foster conduciveness.

4.1.2 Overall Opinion of Office Space

Based on the findings for the overall perception of office space, it is suggested that both UNITEN and IIUM employees generally perceive a positive atmosphere in their office spaces. It demonstrates several aspects that can be related to the Maqasid Shariah principle of Protection of Life. This includes having to perceive a positive level of satisfaction with Visual Comfort and Acoustic Sensory through Visual Privacy, Lighting, Noise, and Sound. In terms of Visual Comfort, both respondent groups perceive the elements of Visual Privacy and Lighting positively in their work environments. Regarding Visual Privacy, respondents from both universities generally feel a sense of safety and security in their office space designs, although there are some inconsistencies in their responses. Additionally, both groups agree that office space design contributes to work productivity to some extent, with IIUM respondents rating it slightly higher. While both universities somewhat acknowledge the privacy of the workplace, some inconsistencies in responses were identified. Concerning Lighting, both groups agree that the lighting conditions in their respective offices meet employees' expectations. In terms of Acoustic Sensory, the findings suggest that both UNITEN and IIUM respondents generally perceive the noise control mechanisms in their office workspaces as effective, although there is more variability in opinions among UNITEN respondents. Additionally, both universities find that their audio-sensory features effectively promote comfort and well-being in their work environments, with UNITEN showing a slightly stronger perception of effectiveness. However, there are consistent but differing opinions among respondents regarding the effectiveness of these features. Both responses also show satisfaction with good ventilation and cleanliness in their workspace, which contribute to the physical and mental health of employees and emphasize the holistic approach to the Protection of Life principle.

4.2 Respondents' Opinion Concerning Protection Of Life

4.2.1 Visual Comfort

In essence, Visual Comfort can generally be seen in both universities, particularly focusing on Lighting and Visual Privacy. In terms of Lighting, both UNITEN and IIUM respondents highly appreciate the effectiveness of lighting conditions, including both daylight and artificial sources, in creating a comfortable and inviting atmosphere for work. This indicates a shared perception among employees from both universities that lighting plays a crucial role in

enhancing visual comfort in the workplace, with minimal variability in opinions within each institution. Concerning the presence of glare in office workspaces, both universities' respondents perceived a similar level of glare, with a neutral perception leaning slightly towards agreement. However, there was a considerable difference in the variability of responses among UNITEN and IIUM respondents, suggesting a more diverse range of opinions regarding the impact of glare on visual comfort. Therefore, there is a need to improve issues relating to glare in office space. Among approaches to consider which include implementing glare reduction mechanisms such as applying anti-glare coatings or films on windows and glass cover on the light, installing adjustable lighting, or opt for lighting fixtures that have diffusers or covers to reduce direct glare. Additionally, regarding visual privacy features in office spaces, both universities reported positive perceptions, with UNITEN respondents expressing slightly stronger agreement.

Similarly, when considering the quality of outdoor views from workstations, both universities' respondents generally rated the quality as neutral to satisfied, with IIUM respondents showing a slightly higher average rating compared to UNITEN respondents. This difference is attributed to IIUM having more outdoor views compared to UNITEN. These findings underscore the importance of considering various factors, including lighting and visual privacy features, to create visually comfortable and conducive work environments that cater to the needs and preferences of employees in different university settings. Therefore, one aspect that needs to be considered is addressing the diverse responses given by both groups regarding statements relating to privacy screens or cubicle features, glaring issues, and the adequacy of office daylight. Enhancing these areas both physically and visually, would improve the overall quality of visual comfort for both universities. This, in turn, would align with the Maqasid Shariah principle of Protection of Life by fostering spaces that enhance the physical and mental health of individuals in the workplace.

4.2.2. Acoustic Sensory

The findings reveal variations in responses regarding factors contributing to Acoustic Sensory comfort in work environments, particularly concerning Noise and Sound. There is a disparity in perceptions between UNITEN and IIUM respondents regarding noise levels in the office. UNITEN employees agree that noise can be distracting during communication, while IIUM employees disagree with the statement. Additionally, while the presence of soundproof partitions and privacy screens is positively perceived by both universities which contributes to audio and visual comfort, IIUM respondents show a slightly lower level of agreement compared to UNITEN. Furthermore, UNITEN respondents express stronger agreement towards the availability of designated meeting rooms for confidential discussions compared to IIUM. Therefore, addressing audio-sensory concerns is crucial. This includes implementing noise reduction mechanisms, enhancing privacy features like soundproof partitions, and improving soft, ambient background music or outdoor natural sounds to help mask distracting noises. These improvements should be tailored according to each university's preferences. With IIUM showing less agreement towards the effectiveness of audio-sensory aspects compared to UNITEN, it is important to reassess and enhance auditory perception elements in IIUM offices. This will help employees feel a greater sense of privacy and comfort when performing their tasks. Some mitigation actions to consider include implementing noise reduction mechanisms, improving the effectiveness of privacy features, providing more soundproof rooms for discussions, enforcing stricter office policies and etiquette guidelines

to promote respectful and quiet behavior, and enhancing the ambient environment for a more comfortable and private acoustic experience for employees while they are at work.

4.3 Relationship Between Overall Office Design in Addressing Lack of Privacy

Based on the overall findings, UNITEN generally received positive feedback from respondents on the overall perception of the office and its Visual Comfort and Acoustic Sensory features. Therefore, there is a moderate positive correlation between Visual Comfort and Acoustic Sensory factors towards the overall experience of the office space, suggesting that good visual comfort and acoustic sensory features in the office positively influence the overall office experience, effectively addressing employees' privacy concerns while performing their work. Contrastingly, the relationship between overall office experience and the perception of Visual Comfort and Acoustic Sensory at IIUM painted a different picture. The weaker positive relationship between Visual Comfort and Acoustic Sensory factors, as indicated by the regression analysis, suggests that IIUM's office design may not fully optimize these aspects to enhance the overall experience. This outcome suggests that, in the context of UNITEN, maintaining good visual comfort and acoustic elements or enhancing it further can effectively bring impact to improve privacy in a work environment for employees. However, for IIUM, the university should focus on improving acoustic elements and also consider other aspects not explored in this analysis which could be crucial in addressing the issue of privacy in their office spaces.

5.0 DISCUSSIONS

5.1 Protection of Life Addresses Research Question And Research Objectives

The research question and research objectives outlined are assessed to see the relationship between the Maqasid Shariah principle, Protection of Life, and Lack of Privacy in providing a conducive work environment through Visual Comfort and Acoustic Sensory. Each research objective is examined to determine if it has been addressed based on the findings provided above.

5.1.1 To examine the key characteristics of Maqasid Shariah's Protection of Life within office building design and how they contribute to ensuring the safety and well-being of occupants.

Visual Comfort: Visual Privacy and Lighting. Visual privacy features, such as partitions, and frosted screens contribute to creating a sense of safety and security within the work environment. By providing designated areas for work and meetings, visual privacy measures reduce the risk of unauthorized access to sensitive information and ensure confidentiality. Employees feel more secure knowing that their workspace is protected from prying eyes, promoting a conducive environment for focused work and collaboration. In addition, adequate lighting plays a crucial role in office design to enhance safety and well-being. Based on the responses provided, issues relating to glare need to be addressed thoroughly by implementing proper lighting levels to improve visibility, reduce eye strain, and create a comfortable visual environment for employees. Well-illuminated spaces contribute to a sense of security by ensuring that all areas are well-lit and free from dark corners or shadows where potential hazards may emerge. Furthermore, good lighting design supports productivity and alertness among employees, fostering a positive work environment that promotes well-being.

Acoustic Sensory: Noise and Sound. Effective noise and sound control mechanisms are essential for creating a peaceful and productive work environment. Excessive noise levels can be distracting and disruptive, leading to decreased concentration and increased stress among occupants. By implementing soundproof partitions, acoustic treatments, and sound-absorbing materials, office spaces can minimize noise disturbances and create a quieter atmosphere conducive to focused work and communication. This not only enhances productivity but also contributes to the overall well-being of employees by reducing stress levels and promoting a sense of calm and tranquillity.

5.1.2 To analyse how Maqasid Shariah principles are applied in office design to enhance human comfort, considering factors such as spatial arrangement, lighting, and ergonomic considerations.

Spatial Arrangement entails organizing the layout in a way that facilitates smooth movement and interaction among employees while also ensuring privacy for confidential tasks. The need for a well-designed office layout, as discussed in the findings, relates to better exits, easy access to workstations, and the availability of more private areas. This will involve creating designated areas for collaboration, quiet zones for focused work, and private spaces for meetings or personal tasks.

Lighting. Good lighting design is further emphasized in this section, focusing on providing sufficient illumination throughout the workspace while avoiding harsh glare or uneven lighting, which can cause eye strain and discomfort. This includes utilizing natural light where possible and incorporating adjustable artificial lighting to accommodate different tasks and preferences.

Ergonomic Features. Ergonomic considerations in office design involve selecting furniture and equipment that promote physical comfort and health. This includes ergonomic chairs that support proper posture, adjustable desks to accommodate different heights and preferences, and ergonomic accessories like keyboard trays and monitor stands to reduce strain on the body. By prioritizing ergonomic design, offices can create environments that reduce the risk of musculoskeletal disorders and promote overall well-being among employees.

5.1.3 To determine the effective design of office buildings in alignment with Maqasid Shariah's Protection of Life, encompassing strategies to optimize safety, well-being, and user comfort within the built environment.

Safety Measures. Implementing robust safety measures such as automated lock door systems, surveillance cameras, and access control measures to ensure the physical security of occupants and their belongings. Additionally, ensure proper lighting in parking areas and walkways to prevent accidents and enhance personal safety.

Well-being Enhancements. Creating a conducive environment for physical and mental well-being by providing ergonomic furniture, adequate natural lighting, and proper ventilation. Ergonomic chairs, adjustable desks, and comfortable breakout zones promote physical comfort, while access to natural light and fresh air improves mood and productivity.

Privacy Considerations. Addressing the need for privacy within the office space through the thoughtful layout and design of workstations, meeting rooms, and common areas. Incorporating soundproof partitions, privacy screens, and designated quiet zones can help minimize distractions and foster a sense of confidentiality.

Accessibility Features. Ensuring accessibility for all occupants, including individuals with disabilities, through the design of accessible pathways, ramps, and restrooms. This promotes inclusivity and ensures that all employees can navigate the workspace safely and comfortably.

Biophilic Design. Integrating elements of nature into the built environment, such as indoor plants, green walls, and access to outdoor views, to enhance well-being and connection with the natural world. Biophilic design principles have been shown to reduce stress, improve cognitive function, and enhance overall satisfaction in the workplace.

5.2 Limitation to The Research

During the entire process of research from sampling data, collecting data, data processing, and assessment before analyzing them, some limitations necessitated careful considerations. In the context of studying office space experience and respondent profiling, some constraints may influence the validity and generalizability of the findings. Firstly, one of the primary limitations is the possibility of sampling bias. The research was conducted on selected units/functions, focusing on one campus for each institution, resulting in sampling bias. This approach does not accurately represent the entire population of interest and may limit the generalizability of the findings to the entire workforce. Secondly, resource and time constraints also impacted the accuracy of the data. One week was given for respondents to complete the questionnaires. However, achieving a 100% collection rate within this timeframe was not possible, leading to additional efforts to locate respondents and resulting in a 30% collection rate. This prolonged the data collection process for two months. Furthermore, the small number of responses collected also affects the robustness and generalizability of the findings. Additionally, the research only relies on literature to develop hypotheses and distributes questionnaires for data collection to support these hypotheses. Interviews, focus groups, case studies, and site visit analysis were not considered in this research, which may have missed out on valuable insights that could have been gained from this research. Finally, response bias poses another significant challenge to this research. Respondents may provide inaccurate or biased responses, consciously or unconsciously, leading to inaccuracies in the data collected. This could undermine the reliability of the findings, as the data collected may not authentically reflect the true sentiments and experiences of employees in general.

6.0 CONCLUSION

The research emphasized the importance of creating conducive work environments, particularly in educational institutions to improve employee well-being and performance. By prioritizing safety and security in office space design, organizations could significantly impact employee productivity and well-being. Based on the literature discussed the principles of Maqasid Shariah Protection of Life provided a comprehensive framework for designing work environments that prioritized employee well-being and productivity. It guided the creation of workspaces aligned with Islamic values while enhancing employee well-being and

productivity. Elements like Visual Comfort and Acoustic Sensory factors are integral in improving workplace efficiency and safety, reflecting Islamic principles of societal welfare. Through analysis of the opinions of respondents from Universiti Tenaga Nasional (UNITEN) and International Islamic University Malaysia (IIUM), the study highlighted variations in preferences and priorities regarding their current office space design. Findings revealed that both universities prioritized elements like good ventilation and being well-equipped, with UNITEN emphasizing good thermal condition and IIUM prioritizing ample space and good lighting/daylighting. Safety and security concerns were notably expressed by respondents from both universities, indicating a holistic approach to evaluating office space beyond physical comfort aspects.

6.1 Further Research

6.1.1 Diverse Sampling Strategies

Future research could employ more diverse sampling strategies to mitigate sampling bias. The sampling size should also look into faculties, other departments, and branch campuses so that the data recorded for analysis are more thorough. Instead of focusing solely on selected departments or units within institutions, a stratified sampling approach could be utilized to ensure representation from various segments of the workforce. This would provide a more comprehensive understanding of office space experiences across different departments and roles.

6.1.2 Mixed-Methods Approach

Incorporating a mixed-methods approach by supplementing physical and online questionnaires with qualitative methods such as interviews or focus groups can offer a more holistic understanding of office space experiences. Qualitative methods can capture nuanced insights, perceptions, and experiences that may not be fully captured through quantitative surveys alone, thereby enriching the depth of understanding of the issues being investigated.

6.1.3 Mitigating Response Bias

To address response bias, future research could implement measures to mitigate potential inaccuracies in data collection. This may include ensuring confidentiality and anonymity of responses, providing clear instructions and explanations to respondents, and employing techniques such as randomized response techniques to encourage more honest and authentic responses. Additionally, conducting pre-tests or pilot studies can help identify and address any potential biases or ambiguities in survey questions.

6.1.4 Explore Maqasid Shariah Principles In Depth

While this research focuses specifically on the Protection of Life principle, other principles are also worth exploring. Although Protection of Religion, Lineage, Wealth, and Intellect were briefly discussed in Chapter 2, this research should further investigate how a conducive work environment can be improved through these principles. Exploring these principles within the context of a conducive work environment or spatial development would provide a more comprehensive understanding of how Islamic principles can inform and guide workplace practices and policies beyond just the protection of life.

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JOURNAL OF ARCHITECTURE, PLANNING & CONSTRUCTION MANAGEMENT
Volume 14 Issue 1, 2024 E-ISSN: 2462-2222 ISSN: 2231-9514

CATEGORISATION OF ISLAMIC WALL DECORATIONS IN FOUR BUILDINGS: VISUAL ANALYSIS AND COMPARATIVE STUDY FOR STYLISTIC AND HISTORICAL CONTEXTS

Received: 17th April 2024 | Accepted: 10th June 2024 | Available Online: 30th June 2024

DOI: 10.31436/japcm.v14i1.872

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ABSTRACT
Islamic decoration on buildings boasts a rich cultural tradition often characterised by intricate finesse and stunning artistry. This paper delves into categorising Islamic wall decorations, including Muqarnas, tile work, glass work, and other crafts, prevalent within the architectural spaces of four historically significant mosques. The study uses a visual analysis methodology to centre on The Dome of the Rock, Umayyad Mosque, Alhambra Palace, and Sheikh Lotfollah Mosque. The primary objective is to comprehensively analyse these Islamic wall decorations using visual data such as photographs and artistic representations. While Islamic art has been extensively studied, there is a need for rigorous documentation of wall decorations at prominent buildings as it will contribute to a more nuanced understanding of the field. Executing a search strategy across various databases and sources gathers an extensive collection of visual materials. Each mosque receives meticulous scrutiny, unveiling its historical context, architectural intricacies, and the presence of diverse artistic embellishments inherent in Islamic traditions. Through comparative analysis, it is evident that the four majestic buildings exhibit a variety of designs, each showcasing unique intricacies and stylistic variations. While some structures feature muqarnas and tilework predominantly in their dome interiors, others incorporate them extensively along the walls and columns, indicating diverse approaches to architectural embellishment across Islamic heritage sites.

Keywords: Islamic wall decorations, Islamic crafts, Islamic art, visual analysis, Islamic historical mosques.

1.0 INTRODUCTION

The decorations adorning walls hold immense cultural and artistic significance within Islamic architecture (Shafiq, 2014). These intricate designs and skilled craftsmanship reflect the rich heritage of Islamic artistry, offering a deeper understanding of the intersection between art, culture, and architectural traditions in the Islamic world (Mohammad et al., 2023). Investigating Islamic wall decorations is essential for their visual appeal and the cultural and religious identities they embody within mosque architecture (Zahra & Shahir, 2022). This study delves into the detailed designs of Islamic wall decorations in four historically significant mosques: the Dome of the Rock, Umayyad Mosque, Alhambra Palace, and Sheikh Lotfollah Mosque. Each of these mosques represents a unique era, cultural context, and architectural significance, providing a comprehensive platform to examine the diverse manifestations of Islamic wall decorations. These selected buildings are architectural marvels and cultural heritage sites that invite scholarly exploration into the intricate details of Islamic decorative traditions.

The Dome of the Rock, blending Byzantine and early Islamic influences, is an early example of

Islamic decorative artistry. The Umayyad Mosque stands as a testament to the artistic and cultural synthesis of the Umayyad dynasty. The Alhambra Palace, a pinnacle of Nasrid craftsmanship, showcases the zenith of Islamic decorative arts in medieval Spain. The Sheikh Lotfollah Mosque epitomises Safavid architectural innovation and the rich tradition of Persian Islamic art. Together, these buildings encapsulate a broad spectrum of historical periods, architectural styles, and cultural blends within the Islamic world.

The chosen mosques represent various historical periods, architectural styles, and cultural blends within the Islamic world. Their architectural grandeur and ornate decorations serve as both design marvels and cultural heritage preservers. This study aims to explore Islamic wall decorations, emphasising their artistic and architectural significance within the context of these selected mosques. While Islamic wall decorations have been studied extensively, this paper's novelty lies in its focused visual analysis and comparative study of these four historic buildings, providing unique insights into their stylistic and historical contexts.

While Islamic wall decorations have been studied extensively, this paper's novelty lies in its focused visual analysis and comparative study of these four historical buildings, providing unique insights into their stylistic and historical contexts. By examining these decorations in detail, the study aims to contribute to a deeper understanding of Islamic architecture's artistic traditions and cultural significance, ultimately enriching the broader discourse on Islamic art and heritage.

2.0 ISLAMIC ART AND CRAFT

Islamic decorative crafts encompass a wide range, ranging from loose adornments like textiles, carpets, pottery, and embroidery to structured wall decorations comprising ceramic, metalwork, glasswork, and the distinctive muqarnas incorporating calligraphic, floral, and geometrical motifs (Blair & Bloom, 2003). Integrating decorative elements in Islamic buildings shows a symbiotic interaction between artisanal craftsmanship and the architectural domain. Fine handicrafts artistry, including tiling, woodcarving, painting, and other art forms, is essential in enhancing Islamic architectural structures' aesthetic appeal and cultural quality. Typically, such architectural decors exist in four areas: exterior adornments, embellishments within entrance spaces, interior ornamentations, and decorative elements meant to bridge the inner and outer realms of a building. The primary aim of this research is to meticulously categorise Islamic wall decorations that exist both as the interior and exterior architectural designs of the four selected mosques. This categorisation is based on a thorough visual analysis, aiming to discern, classify, and categorise the diverse decorative elements in these sacred spaces.

This research aims to compare the wall decorations of the selected mosques, evaluating similarities and differences in terms of materials, techniques, and design styles.

2.1 Four prominent Islamic buildings

Islamic decorative crafts encompass a wide range, ranging from loose adornments like textiles, carpets, pottery, and embroidery to structured wall decorations comprising ceramic, metalwork, glasswork, and the distinctive muqarnas incorporating calligraphic, floral, and geometrical motifs (Blair & Bloom, 2003; Malik Omaid, 2015). Integrating decorative elements in Islamic buildings shows a symbiotic interaction between artisanal craftsmanship

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This study meticulously encompasses four prominent buildings: the Dome of the Rock, the Umayyad Mosque, the Alhambra Palace, and the Sheikh Lotfollah Mosque.

As shown in Figure 1, The construction of the Dome of the Rock in 691 CE during the Umayyad caliphate marks its significance as one of the oldest Islamic monuments. Its architectural style, blending Byzantine and early Islamic influences, features intricate mosaic artworks, with calligraphy as its most prominent Islamic wall decoration, conveying spiritual inscriptions (Abo-Diyyeh, 2017).

Fig. 1: The Dome of the Rock, Jerusalem, Palestine
(Source: García, 2018)

Secondly, the Umayyad Mosque in Damascus, Syria is chosen for this study. In 705 CE, substantial parts of the Damascus Christian temple were converted into the Great Mosque of Damascus, which currently represents an architectural blend of diverse cultural influences (Abdullahi & Embi, 2013; Flood, 2021). Characterised by its grand courtyard and stunning mosaics, its most prevalent Islamic wall decorations encompass elaborate floral and geometric patterns, reflecting the Umayyad dynasty's artistic ability and cultural amalgamation, as shown in Figure 2.

Fig 2: Umayyad masjid in Damascus, Syria
Source: (r/islam, 2021)

As shown in Figure 3, the fourth studied building is Alhambra Palace. Constructed during the

Nasrid dynasty in the 13th and 14th centuries in Granada, Spain, it represents the peak of Nasrid artistry (Bush, 2009; Eggleton, 2012). Its elaborate muqarnas, showcasing three-dimensional designs, intricate tile work, and arabesques, denote its architectural magnificence and cultural significance in preserving Islamic art.

Fig. 3: Alhambra Palace
Source: (Mirmobiny, 2015)

Fourth, the Sheikh Lotfollah Mosque in Isfahan, Iran, built during the Safavid dynasty in the early 17th century, stands as a masterpiece of Safavid architecture, as shown in Figure 4. Adorned with mesmerising tile work and inscriptions in calligraphy, the mosque symbolises the epitome of Persian Islamic heritage and architectural excellence.

Fig. 4: The Sheikh Lotfollah Mosque in Isfahan, Iran
Source: (Aprochi, 2024)

3.0 METHODOLOGY

The methodology employed for this study involves a structured approach to gather, analyse, and categorise visual data concerning Islamic wall decorations within the selected mosques. To achieve the objectives of this paper, the study adopts a robust visual analysis methodology, emphasising the scrutiny of visual data encompassing photographs, artistic representations, and visual documentation of the chosen mosques. This entails leveraging various databases and sources and employing specific search terms tailored to procure a comprehensive collection of visual materials (Gast & Spriggs, 2014; Oliveira et al., 2001). The visual analysis method conducted the research on the wall decorations in the four selected buildings. The data was collected through library documents, a literature review of direct observation, and photography of predetermined cases (Mohammadi & Azamzadeh, 2021). The visual analysis method is useful in architecture and design for analysing visual material, including art, design, and architecture (Barbour, 2014; Gast & Spriggs, 2014). It can help increase understanding of how visual material communicates and functions, whether generating meaning, eliciting emotion, or creating a mood. Visual analysis can be applied to any visual material, including photographs, films, videos, paintings, drawings, collages, and graphics (Salour et al., 2021).

Multiple databases, including scholarly repositories and digital archives, have been accessed to accumulate a diverse array of visual data. This includes academic journals and renowned architectural databases offering a wealth of visual resources. The methodology emphasises identifying, documenting, and categorising the intricate motifs, designs, and craftsmanship evident in the wall decorations adorning these mosques' interior and exterior spaces.

Each building has been specifically selected in this study for two criteria: architectural significance through different Islamic eras and historical significance and prominence within Islamic heritage. Selection and analysis criteria have been tailored to explore Islamic wall decorations comprehensively. These criteria prioritise a meticulous examination of interior and exterior designs, emphasising geometric patterns, calligraphy, arabesques, Muqarnas, tile work, glass work, and other ornamental motifs.

4.0 RESULTS

The meticulous Islamic wall decorations across the Dome of the Rock, the Umayyad Mosque, the Alhambra Palace, and the Sheikh Lotfollah Mosque portray an array of exquisite adornments intrinsic to Islamic architectural heritage. The Dome of the Rock is adorned with a striking array of Faience tile work, incorporating intricate patterns and colours that radiate cultural richness (Abo-Diyyeh, 2017; Muhammad, 2004; Qurain, 2021). The decoration of the Dome of the Rock embodies a rich semantic and symbolic feature that reflects profound spiritual significance within Islamic tradition. Central to its design are elements such as qur'anic verses and vegetal and geometric decoration meticulously chosen to evoke the divine presence and illustrate the magnificence of Allah's creation (Elizabeth Macaulay, 2015; Muhammad, 2004). Figure 5 shows Arabic calligraphy in the Thuluth script adorns the surface, lending an air of elegance and sophistication to the overall composition. Horizontal consecutive floral designs and repeated geometrical patterns featuring six-pointed hexagons and stars enhance the aesthetic appeal of the exterior of the Masjid.

Fig. 5: Faience tilework at the exterior of the dome of the rock in Palestine
Source: (Erik, 2020)

At the heart of the dome's symbolism is the sacred word of Allah, proclaiming the oneness of God and His supremacy. This inscription, along with intricate floral motifs, including depictions of flowers and fruit trees such as palms, olives, pomegranates, figs, and almonds, serves to evoke the imagery of paradise, symbolising the eternal bliss promised to the faithful

in the afterlife (García, 2018; Muhammad, 2004). The choice of golden, green, and blue hues further reinforces this celestial motif, evoking the splendour of heaven itself, as shown in Figure 6.

Fig. 6: Ajami art at the dome of the rock interior
Source: (Erik, 2020)

Inscribed upon the ceiling is also the throne verse from the Quran, a passage of profound significance within Islamic scripture. This verse is a potent reminder of divine sovereignty and instils reverence and awe in those who behold it (Khoury, 1993; Mazidi et al., 2023). The technique employed in crafting the ceiling reflects the artistic prowess of the Umayyad dynasty, utilising intricate Ajami art and Ablaq art, alternating rows of black and white stone to create a visually stunning masterpiece, as shown in Figure 7.

Fig 7: Ablaq artwork at columns
Source: (Erik, 2020)

The choice of materials, including wood, pastiglia (raised gesso), natural marble stones, golden glass, and stone, speaks to the skilled craftsmanship of the artisans involved in its creation. Mosaic work adds a layer of intricacy and detail, with floral patterns meticulously rendered in vibrant hues. This hue magnifies this ancient monument's visual appeal and spiritual resonance, as shown in Figure 8.

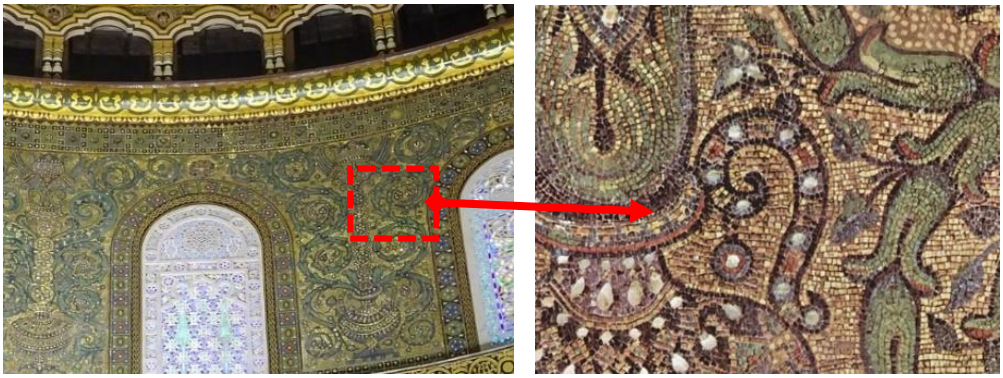


Fig. 8: The interior space of the Dome of the Rock
(Source: Elizabeth Macaulay, 2015)

Secondly, the Umayyad Mosque in the capital of Syria, Damascus, exhibits a blend of decoration crafts such as mosaic, stained glass windows, muqarnas, carved stucco, Ablaq, Ajami art, and Fresco painting (Flood, 2021). This amalgamation portrays diverse artistic techniques and cultural influences; it is dominated by Greek, Roman, Byzantine, and some Persian and Assyrian influences, while in some decorations are inspired by local flowers and gardens and peacock feathers enriching the mosque's visual narrative. Figure 9 shows the rich golden colour and floral decoration representing the rich history of the golden age and the Umayyad time; the dome of Bayt Al-Mal is the place where Muslims collect the zakat, that was one of the main rituals practised by rich Muslims to help the poor (Enab, 2020; Schibille et al., 2022).

Fig 9: Mosaic art in the courtyard of Umayyad Masjid
(Source: Badat, 2022)

The architectural elements and decorative features of the Umayyad Mosque in Syria exemplify a profound integration of geometric patterns inspired by natural forms, reflecting a concept deeply rooted in Islamic symbolism and spirituality where the flowers and gardens in the decorations are the representation of the heaven or the local nature of Damascus. Beyond its utilitarian function, Geometry assumes a symbolic significance within the context of the mosque's design, embodying supernatural concepts and allusions. The intricate vegetal motifs, such as the acanthus leaves symbolising eternal life and the afterlife in Islamic belief, are meticulously incorporated into various elements like woodwork, stained glass windows, and fresco paintings. These motifs, reminiscent of paradisiacal gardens, echo the celestial imagery evoked in Islamic scripture, as shown in Figure 10.

Fig. 10: Fresco painting on the dome interior at Umayyad Mosque in Damascus, Syria
(Source: Yagh, 2024)

Moreover, the geometric arabesque designs adorning woodwork and inlaid patterns, alongside the calligraphic inscriptions and floral ornamentation, imbue the space with a sense of divine order and harmony. The diverse mediums utilised, including stone, wood, glass, and marble, further enrich the architectural vocabulary, each material meticulously crafted to manifest geometric complexity and aesthetic beauty, as shown in Figure 11.

Fig 11: woodwork and decorated Ablaq and marblework
(Source: Yagh, 2024)

Through decoration crafts like Ajami art, muqarnas, stucco carving, and mosaic tilework, geometric and floral patterns are meticulously rendered, celebrating the divine unity and perfection inherent in natural forms, as shown in Figure 12.

Fig. 12: A close of the mihrab in the Umayyad Mosque of Damascus
(Source: Ali, 2022)

Also, the stained-glass windows containing floral and calligraphy of sacred names and Zikir create a colourful light penetration over the interior ambience. Thus, the Umayyad Mosque stands not only as a testament to architectural ingenuity but also as a sacred space where the interplay of geometry and natural symbolism elevates the spiritual experience of worshippers, as shown in Figures 13 and 14.

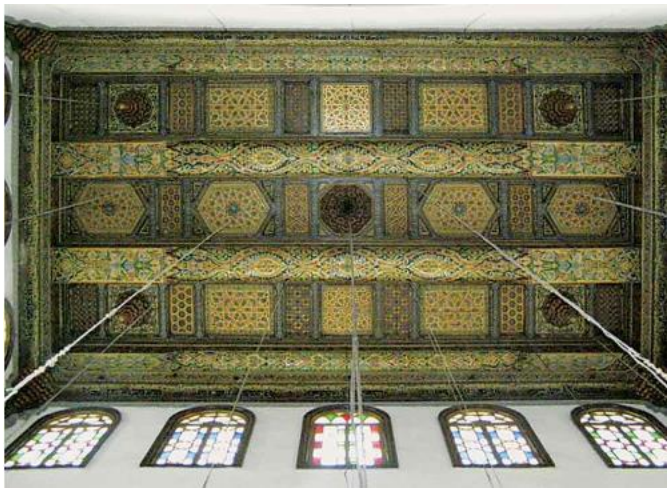


Fig 13: Ajami Art on the ceiling of the prayer hall, Umayyad Mosque
(Source: Heiske, 2004)

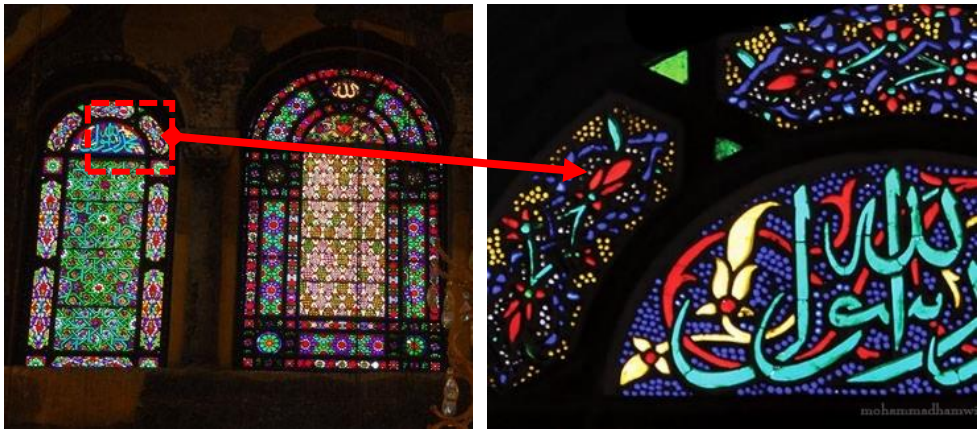


Fig. 14: Stained glass window in the Umayyad Mosque
(Source: Brian et al., 2007)

The Alhambra Palace in Spain is a distinctive example of Islamic architecture, characterised by its intricate decorative elements, profound symbolic significance, and historical context. Symbolism plays a central role in the palace's design, emphasising symmetry as a manifestation of unity (Kamarudin et al., 2020; Salour et al., 2021). This emphasis on balance and harmony reflects the Islamic concept of tawhid, or Allah's oneness, underscoring the architectural endeavour's spiritual underpinnings (Irwin, 2004; Willmert, 2011). Furthermore, the geometric decorations adorning the walls and ceilings of the Alhambra Palace evoke a sense of grandeur and beauty, inviting viewers to contemplate the divine order inherent in the universe. These geometric patterns, such as the muqarnas, meticulously crafted with precision and attention to detail, serve as ornamental embellishments and visual representations of cosmic principles and metaphysical realities, as shown in Figure 15.

Fig. 15: Muqarnas art at Alhambra Palace
(Source: Mirmobiny, 2015)

Historically, the Alhambra Palace holds significance as a testament to Islamic civilisation's cultural and artistic flourishing during the Nasrid dynasty in Spain. Built amidst a backdrop of political and cultural upheaval, the palace emerged as a supreme of cultural synthesis and artistic innovation (Bombalova, 2021; Bush, 2009; Irwin, 2004). Figure 16 shows the richness and beauty of the decoration crafts used in Alhambra Palace, such as the carved stucco of the Arabic calligraphy of no victorious but Allah and the Faience tilework in geometrical and tessellation patterns.

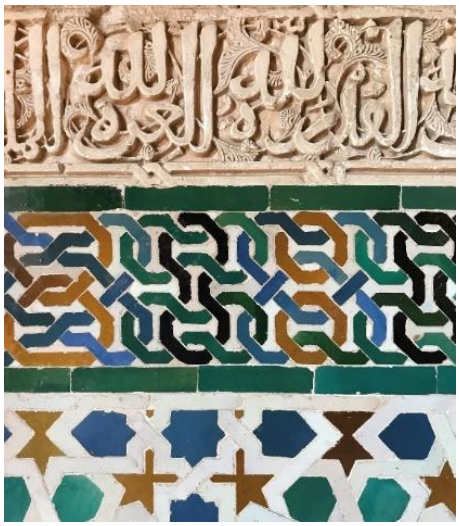


Fig.16: Stucco carving and ceramic tessellation tiles at Alhambra Palace
(Source: Mirmobiny, 2015)

The architectural marvels of the Alhambra Palace, such as the Hall of Ambassadors, embody the cosmological aspirations of its creators. The celestial symbolism embedded within the palace's design, particularly evident in the representation of the seven heavens and stars of paradise on the ceiling of the Hall of Ambassadors, speaks to a worldview rooted in spiritual transcendence and metaphysical contemplation, as shown in Figure 17.

Fig. 17: Intricated wooden ceiling at the hall of the throne in Alhambra palace
(Source: lea, 2016)

As shown in Figure 18, the decorative techniques employed in constructing the Alhambra Palace showcase the mastery of Islamic craftsmanship and artistic ingenuity. From lattice wooden screens and plaster windows to tessellated ceramic tilework and muqarnas vaulting, each element is executed with meticulous precision and attention to detail, reflecting the rich cultural heritage and architectural sophistication of Islamic Spain (Bush, 2009; Eggleton, 2012).

Fig. 18: Wooden lattice window at Alhambra palace
(Source: Bombalova, 2021)

Stucco carving, with its intricate calligraphy and floral design motifs, adds a layer of elegance and sophistication to the palace's interior spaces, while the Artesonado woodwork, characterized by its assembly of small wooden panels to fabricate ceilings, contributes to the palace's distinctive aesthetic charm.

The Sheikh Lotfollah Mosque in Iran is a captivating testament to the Safavid era's architectural prowess, replete with semantic depth, symbolic richness, and historical context. Its decorative elements serve as a canvas for conveying spiritual messages and cultural identity, interwoven with intricate patterns and symbolism (Mohammadi & Azamzadeh, 2021; Vaziri et al., 2021; Vogel, 2019). The Sheikh Lotfollah Mosque in Iran stands adorned with Haft Rangi, Mosaic tiles, Ceramic tiles, Muqarnas, and Lattice Windows. The unique Haft Rangi tilework in Muqarnas, walls, domes and archways showcases the finesse of Persian Islamic decorative traditions. As shown in Figure 19, the Haft Rangi covers all the masjid parts from inside and outside, representing the powerful decoration craft of Iran (Ghazarian & Ousterhout, 2001; Mousavi, 2021).

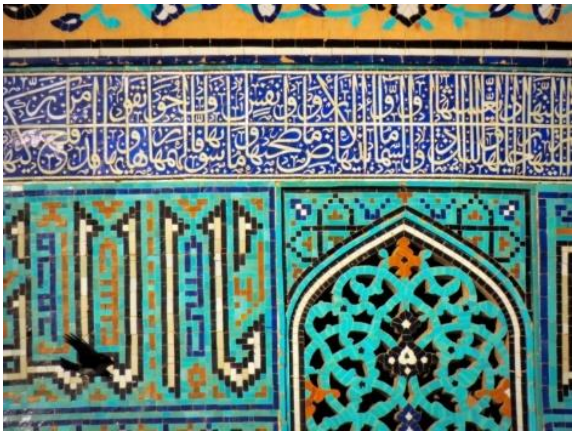


Fig. 19: Calligraphy and perforated windows in Haft Rangi Mosaic tile work
(Source: Vogel, 2019)

Upon entering the prayer chamber, visitors are greeted by walls adorned with a mesmerising array of blue, yellow, turquoise, and white tiles, meticulously arranged in elaborate arabesque patterns (Mazidi et al., 2023; Mohammadi & Azamzadeh, 2021). These tiles not only captivate the eye but also serve as a visual representation of the divine beauty and harmony celebrated within Islamic art and architecture.

Fig. 20: Haft Rangi art at the interior of the dome of blue mosque in Iran
(Source: Iran Paradise, 2019)

As shown in Figures 20, one of the mosque's most unique features is the peacock motif adorning the centre of the interior dome's side. This intricate design, featuring the peacock's tail extending towards the entrance gate, cleverly incorporates the natural light filtering

through the hole in the ceiling, creating the illusion of sunrays and imparting a sense of celestial radiance to the space (Mazidi et al., 2023; Mohammadi & Azamzadeh, 2021). Moreover, the peacock motif symbolises beauty, resurrection, and immortality, adding layers of symbolic significance to the architectural composition.

Fig. 21: The interwoven patterns of lights and shadows of lattice windows and tile works
(Source: Persia advisor travel, 2017)

The Safavid artisans employed various techniques and mediums to embellish the mosque's interior. Haft Rangi mosaic tilework, characterised by its vibrant colours and intricate patterns, adorns the walls with Nasakh calligraphy and tiny floral designs, exemplifying Safavid art's meticulous craftsmanship and attention to detail.

The muqarnas, multi-layered and heavily adorned with floral motifs in Haft Rangi, contribute to the mosque's aesthetic grandeur while showcasing the Safavid era's architectural innovation (Mazidi et al., 2023; Mohammadi & Azamzadeh, 2021). Similarly, the lattice windows, crafted from gypsum and featuring perforated geometric designs, serve both functional and decorative purposes, allowing natural light to filter into the prayer hall while adding a touch of elegance to the architectural ensemble, as shown in Figure 22.

Fig. 22: Muqarnas tilework
(Source: Persia advisor travel, 2017)

5.0 DISCUSSIONS

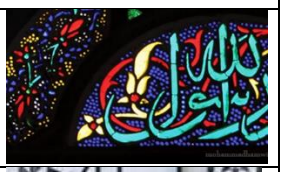
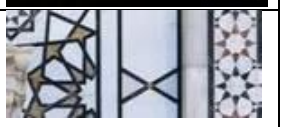
The decoration of the Dome of the Rock stands as a testament to the ingenuity of Islamic artistry and the profound spiritual significance imbued within its design. Through a harmonious blend of symbolic motifs, intricate craftsmanship, and meticulous attention to detail, it serves as a visual expression of the divine majesty and eternal truths enshrined within Islamic tradition. Table 2 shows the various decoration crafts listed and found by observing the rock interior and exterior dome.

Table 1: Analytical table of the Dome of the Rock

Semantic and symbolic features	Decoration Craft	Medium	Decoration type	Illustration
Sacred word of Allah referring to the oneness of Allah Golden, green and blue colors representing the heaven fruit trees, such as palms, olives, pomegranates, figs, and almonds, in addition to various vegetable trees and their types, such as acanthus leaves that represent enduring life or the hereafter in Muslim beliefs.	Faience tilework	a glazed ceramic material that is made from crushed quartz or sand, lime, and either natron or plant ash	Arabic Calligraphy in Thuluth script	
			Horizontal Consecutive Floral Design	
			Repeated Geometrical six-pointed hexagon and stars Design	
	Ajami Art	Wood and pastiglia (Raised gesso)	Repeated floral pattern	
			Thuluth calligraphy	
	Mosaic	natural marble stones and golden glass	Floral pattern	
	Ablaq	Stone	Alternating rows of black and white stone.	

The Umayyad Mosque in Damascus, Syria, showcases a remarkable fusion of decorative crafts, including mosaic, stained glass, muqarnas, stucco carving, Ablaq, Ajami art, and Fresco painting. These elements, influenced by Greek, Roman, Byzantine, Persian, and Assyrian styles, alongside local motifs like flowers and peacock feathers, create a visually captivating narrative. The architectural features, such as geometric patterns inspired by nature, reflect Islamic symbolism, with motifs symbolising eternal life and paradisiacal gardens. Calligraphic inscriptions, arabesque designs, and diverse materials like stone, wood, and marble further enhance the mosque's aesthetic and spiritual significance. Through meticulous craftsmanship, the Umayyad Mosque becomes not just a marvel of architecture but also a sacred space where the interplay of geometry and natural symbolism enriches the spiritual journey of worshippers. Table 3 shows the various decoration crafts listed and found in the observation of the Umayyad Mosque in Syria.

Table 2: Analytical table for the Umayyad Mosque, Syria

Semantic and symbolic features	Decoration Craft	Medium	Decoration type	Illustration
Geometry has a symbolic meaning and refers to supernatural concepts and subjects vegetable trees of acanthus leaves that represent enduring life or the hereafter in Muslim beliefs the fruits and floral plants refer to heaven and gardens similar to the pattens used in the dome of the rock	Arabesque Woodwork (inlaid)	Wood and shells	Geometric arabesque design	
	Stained Glass Window	powdered glass, iron oxide, and ground copper	Calligraphy and floral ornamentation	
	Ablaq	Stone	Geometrical designs in different patterns and sizes	
	Ajami Art	Wood and pastiglia (Raised gesso)	Floral and geometrical patterns	
	Stucco carving	A mixture of marble powder and plaster	Calligraphy painted with golden colour	
	Fresco Painting	water-based paint directly onto wet plaster	Thuluth Calligraphy in geometrical shapes and floral ornamentation	
	Muqarnas	White marble	Simple double layer design	
	Lattice Windows (plaster)	A mixture of marble powder and plaster	Geometrical perforated design	
	mosaic tilework	natural marble stones and golden glass	Floral design of acanthus leaves	

The Alhambra Palace is a testament to the enduring legacy of Islamic art and architecture, embodying medieval Spain's cultural richness, spiritual depth, and artistic brilliance. Through its symbolic motifs, historical context, and masterful execution, the palace invites visitors to explore the intersection of art, spirituality, and culture, offering insights into the complexities of Islamic civilisation and its enduring contributions to global heritage. Table 5 shows the rich decoration crafts used in the Alhambra Palace to make it a living masterpiece.

Table 3: Analytical table of Alhambra Palace

Semantic and symbolic features	Decoration Craft	Medium	Decoration type	Illustration
symmetry can be considered a manifestation of unity geometrical decorations induce a sense of grandeur and beauty in the viewer. this method was used in order to craft the cosmological significance of the Hall of Ambassadors. The ceiling was originally meant to represent the seven heavens of the Islamic faith, depict the stars of paradise, and symbolize the "four trees of life" with its diagonal structures The Muqarnas, in particular, stand out with their intricate honeycomb-like vaulting, epitomizing the palace's architectural magnificence and ornamental craftsmanship.	Lattice wooden window	Wood	geometrical patterns	
	Lattice plaster windows	Plaster	geometrical patterns	
	Faience tilework	Ceramic	Tessellation and geometrical patterns	
	Muqarnas	Plaster	intricate honeycomb-like vaulting	
	Artesonado Woodwork	Wood	Geometric arabesque design	
	Arabesque Wooden doors	Wood	Geometric arabesque design	
	Stucco carving	A mixture of marble powder and plaster,	Calligraphy and floral design	

The Sheikh Lotfollah Mosque is a masterpiece of Safavid architecture, rich in symbolic meaning, historical significance, and artistic splendour. Through its intricate decorative elements and thematic resonance, the mosque invites visitors to explore the intersection of spirituality, culture, and architectural innovation, offering insights into the rich crafts of Iran's cultural heritage. Table 6 shows the summary of the decoration crafts found in the Sheikh Lotfollah Mosque.

Table 4: Analytical table of masjid Lotfollah decorations craft

Semantic and symbolic features	Decoration Craft	Medium	Decoration type	Illustration
The suras emphasize the rightness of a pure soul and the fate in hell of those who reject God's way, most likely referring to the Ottoman Turks. Entering the prayer chamber, one is confronted with walls covered with blue, yellow, turquoise, and white tiles with intricate arabesque patterns. One unique feature of the mosque is a peacock in the centre of the interior dome's side.	Haft Rangi mosaic tilework	Persian polychrome mosaics of overglaze polychrome ceramics	Nasakh calligraphy and tiny intricate floral design	
	Muqarnas	Ceramic	Heavy floral pattern over multi-layered muqarnas	
	Lattice Windows	Gypsum	Perforated geometrics	

The identification of sixteen distinct decoration crafts within four iconic architectural landmarks, namely the Dome of the Rock, the Umayyad Mosque, the Alhambra Palace, the and the Sheikh Lotfollah Mosque, sparks a compelling discussion on the rich tapestry of artistic techniques and cultural influences embedded within Islamic architecture. Firstly, the diversity of decoration crafts observed across these landmarks underscores the intricate craftsmanship and artistic sophistication prevalent within Islamic architectural traditions. From the intricate Faience tilework adorning the Dome of the Rock to the vibrant Stained-Glass windows of the Umayyad Mosque, each decoration craft represents a distinct artistic tradition contributing to these structures' overall visual splendour.

Moreover, decoration crafts such as Ajami Art, Muqarnas, and Mosaic highlight the cross-cultural influences and exchanges that have shaped Islamic architecture over centuries. Ajami Art, for instance, reflects the fusion of Persian decorative motifs with Islamic Umayyad architectural forms. At the same time, Muqarnas showcases the integration of complex geometric designs inspired by Islamic mathematics and aesthetics. Similarly, mosaics came into different forms throughout history and regions; mosaics in Iran came into the form of Haft Rangi tilework to represent the pure Safavid Iranian talent. Also, mosaics came into the Faience tilework in the Dome of the Rock and Alhambra Palace in various tessellation patterns.

Furthermore, the symbolic significance of these decoration crafts must be considered. Floral motifs, for example, symbolise themes of growth, regeneration, and paradise in Islamic culture, while the alternating light and dark patterns of Ablaq evoke notions of harmony and balance. Such symbolic associations imbue these architectural elements with deeper layers of meaning, enriching visitors' and worshippers' spiritual and cultural experiences.

Overall, the most predominant decoration craft found in the four chosen buildings is Mosaic Tilework in the usual form of mosaic made of golden coloured stones and in the form of Haft Rangi mosaic tilework (Persian) and Faience tilework (Mesopotamian); also, Muqarnas and Ablaq are mostly found in all the four buildings in different colours and materials and finishing. Other decoration crafts are Stucco carving, Lattice Windows (plaster, wood), Ajami Art, Arabesque Woodwork (inlaid), Stained Glass Window, Fresco Painting, and Artesonado woodwork, which were found in some of the buildings chosen for the study. Identifying and exploring these ten decoration crafts within the studied landmarks offer valuable insights into the complexity, diversity, and significance of Islamic architectural ornamentation. They underscore the enduring legacy of Islamic artistic traditions and the profound impact of cultural exchange and innovation on the built environment. As such, they invite further inquiry and appreciation of these iconic structures' rich heritage and architectural ingenuity.

Table 8 presents a detailed breakdown of the decoration crafts within the four prominent architectural landmarks, including the Dome of the Rock, the Umayyad Mosque, the Alhambra Palace, and the Sheikh Lotfollah Mosque. Each decoration craft is accompanied by its count and the specific buildings where it is prevalent.

Table 5: Summary of Decoration Crafts in Studied Buildings

No	Decoration Craft	Buildings	Count
1.	Mosaic Tilework: Haft Rangi mosaic tilework (Persian) Iznik mosaic tilework (Ottoman) Faience tilework (Mesopotamian)	Dome of the Rock, Umayyad Mosque, the Sheikh Lotfollah Mosque, Alhambra palace	4
2.	Muqarnas	Umayyad Mosque, Alhambra Palace, Sheikh Lotfollah Mosque	3
3.	Lattice Windows (plaster, wood)	Umayyad Mosque, Alhambra Palace, Masjid Lotfollah	3
4.	Ablaq	Dome of the Rock, Umayyad Mosque	2
5.	Stucco carving	Umayyad Mosque, Alhambra Palace,	2
6.	Ajami Art	Dome of the Rock, Umayyad Mosque	2
7.	Arabesque Woodwork (inlaid)	Umayyad Mosque, Alhambra Palace	2
8.	Stained Glass Window	Umayyad Mosque	1
9.	Fresco Painting	Umayyad Mosque	1
10.	Artesonado woodwork	Alhambra Palace	1

This classification accentuates the complex nature of Islamic wall decorations within the selected buildings, emphasising the convergence and diversity of artistic crafts. Such a thoughtful presentation underscores the individual significance of each decorative form, collectively contributing to the overarching visual brilliance and cultural significance of these architectural masterpieces. The direct visual analysis revealed a spectrum of Islamic wall decorations, encompassing mosaic art and intricate tilework among the predominant forms using calligraphic inscriptions, geometric patterns, and floral patterns as main elements.

6.0 CONCLUSION

Through visual analysis, the thorough examination of Islamic wall decorations across four historically significant buildings, the Dome of the Rock, Umayyad Mosque, Alhambra Palace, and Sheikh Lotfollah Mosque, offers profound insights into the diversity and cultural significance of these adornments. This study has unveiled a mosaic of intricate decorative arts illuminating Islamic heritage's architectural grandeur and cultural depth. The analysis

highlighted prevalent artistic forms such as mosaic tilework, muqarnas, black, stucco carving, lattice windows, Ajami art, arabesque woodwork, stained glass windows, fresco painting, and Artesonado woodwork.

The intricate mosaic patterns depicted religious symbols and geometric designs, while elaborate tilework featured ornate floral motifs, reflecting influences from various cultures. Muqarnas demonstrated stylistic and regional variations, and Ablaq decorations enriched walls with vibrant colours. This detailed categorisation underscores the multifaceted nature of Islamic wall decorations and their collective contribution to these architectural masterpieces' visual brilliance and cultural significance. This research enhances the understanding of Islamic art and architecture by providing a detailed categorisation and analysis of decorative elements in mosques, highlighting their stylistic and historical significance. The comparative study emphasised unique features and shared artistic themes in Islamic wall decorations. However, it also acknowledges the limitations of relying solely on photo analysis and suggests that future on-site examinations would complement and enrich these findings. This research lays the groundwork for further exploration and preservation efforts, fostering a deeper understanding of Islamic decorative traditions within mosque architecture. By highlighting their enduring importance, this study contributes significantly to the broader discourse on Islamic art and architectural history, advocating for preserving these cultural treasures for future generations.

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GLOSSARY

Muqarnas: A form of ornamental vaulting in Islamic architecture, often resembling a honeycomb structure, used to decorate domes, entrances, and half-domes.
Tile Work: Decorative ceramic tiles used in Islamic architecture, often featuring intricate patterns and calligraphy.
Mosaic: Art consisting of a design made by cementing small pieces of coloured stone, glass, or other materials in patterns or images.
Stucco Carving: The process of carving into stucco, a type of plaster, to create intricate decorative designs on walls and ceilings.
Lattice Windows: Windows featuring an interlaced, often geometric, design made from wood or metal, used to allow light while providing privacy and decoration.
Ajami Art: A decorative art style involving painted wood, often incorporating intricate patterns and calligraphic elements.
Arabesque Woodwork: A form of decorative art using intricate patterns of interlacing foliage, tendrils, and geometric designs, often found in Islamic woodwork.
Stained Glass Window: Windows made of colored glass pieces arranged to form patterns or images, used for decorative and narrative purposes.
Fresco Painting: A technique of mural painting on freshly laid lime plaster, allowing the paint to become an integral part of the wall surface as it dries.
Artesonado Woodwork: A form of ceiling decoration using interlocking wooden panels or beams, often richly carved and painted, commonly found in Islamic and Mudéjar architecture.
Calligraphy: Artistic, stylised, or elegant handwriting or lettering, particularly in the context of Arabic script used extensively in Islamic art.
Arabesque: A type of ornamental design featuring intertwined flowing lines, often used in Islamic art to symbolise the infinite nature of creation.
Geometric Patterns: Repetitive, abstract shapes and designs that are a hallmark of Islamic art, used to create complex and intricate decorative schemes.
Ablaq: An architectural technique involving alternating or layered stones of contrasting colours, typically used in Islamic masonry

JOURNAL OF ARCHITECTURE, PLANNING & CONSTRUCTION MANAGEMENT
Volume 14 Issue 1, 2024 E-ISSN: 2462-2222 ISSN: 2231-9514

MONTESSORI PRESCHOOL CURRICULUM ON LEARNING THROUGH PLAY (LTP) APPROACH THROUGH QUALITY LEARNING SPACES DESIGN

Received: 9th April 2024 | Accepted: 28th May 2024 | Available Online: 30th June 2024

DOI: 10.31436/japcm.v14i1.876

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ABSTRACT

Learning through play (LTP) has emerged as an integral part of the early childhood education system and has profound impacts on children's learning and holistic skills development. Throughout Montessori history, play has been applied as a learning approach in the Montessori classroom. Quality spatial design is beneficial to support LTP in preschool. However, LTP isn't integrated effectively into formal preschool in Malaysia as the spatial design of preschool does not support children's play. Furthermore, there is a dearth of evidence on how LTP can be employed effectively in quality spatial learning environments where the workforce's training and curriculum development are mainly concerned. The focus of this paper is to evaluate how spatial learning environments in Montessori preschools support LTP as curricula that may emerge across preschools in Malaysian contexts. This paper adopts interpretivism to frame the overall research and implements case studies through explanation building supported by data collection from document analysis and observation on spatial design of two case studies of Montessori preschools which are based upon prominent and established Montessori preschools in a global context. The findings are analyzed with a comparative analysis method based on the determinants of the spatial design features: - articulated space and form; outdoor learning space; social spaces; personalized environment; and anthropometric design, which are supported by Gibson's Theory of Affordance. Findings indicate that the quality learning space design to support LTP, and open-plan design space is important because of having flexible partitions for creating different areas and integrating with the dynamic external learning environment. Besides, the furniture and facilities all are child-size. Therefore, children are freely moving around and actively involved in either group or individual work. This study is beneficial to designers, educators, and policymakers as it highlights the role of LTP pedagogy in spatial design for developing children's play behavior patterns in preschool for Malaysia's future education.

Keywords: LTP (learning through play), preschool, Montessori, quality spatial design.

1.0 INTRODUCTION

Learning through play (LTP) is a playful experience that creates learning opportunities for children. Renowned psychologist Jean Piaget says that "Play is the work of childhood". Without controversy, play is the foundation and beneficial to children's development (Pyle et al., 2015; Smith & Pellegrini, 2023; Wallerstedt & Praming, 2011; Myck-Wayne 2010). Playtime is the greatest moment for children to learn as the play experience helps them to engage in deeper learning, applying knowledge, concepts, and skills to different environments

(Zosh et. al., 2017) and stimulating the development progress. Montessori pedagogy shares the ideology of play learning and it has been shown to have a positive outcome in enhancing children's positive attitude toward learning, self-developing in their pace where they are in joy and able to be independent, and confident.

The quality-built environment of preschool is one of the important sector's challenges with the advent of the 2030 Agenda for Sustainable Development Goals (SDG) set by the United Nations on SDG Goal 4: Quality Education. Numerous studies have shown that the quality-built environment of preschool should be equally prioritized as part of the evaluation of the overall quality of preschool. The space design of preschool plays a dominant role in the successful delivery of LTP. Montessori believes that a well-designed environment has been deemed essential to the educational process and will enhance the children's learning and development (Yalçin, 2018). Indeed, Montessori is putting effort and careful in preparing the space design.

Presently no design guidance governs the planning framework for the spatial design for early childhood education (ECE) in Malaysia (Rahmatullah, et. al., 2021; Lim & Bahauddin, 2019; Mohd Shahli & Akasah, 2019). The only guideline stated for private preschools in Garis Panduan Perancangan Dan Penubuhan Tadika dan Taska (2017) is to have a minimum 15ft^2 (1.4m^2) required space per child and the design shall follow the universal design. National Standard Preschool Curriculum (NSPC) also only short outline on space management for certain teaching and learning activities that could be conducted in the spaces. The built environment in the current preschools in Malaysia has been concluded would be unsuitable as a learning environment for the children and it isn't able to contribute towards a positive valued outcome which is to enhance children's development and wellbeing. Furthermore, preschools in Malaysia have often been under-emphasized in the discourse on spatial quality (Shaari et. al. 2020). The preschools are under the purview of the Ministry of Education (MOE), which is the policy maker, mainly concentrated on the social environment, such as workforce and staff training and curriculum and program development.

Thus, the spatial learning environment in the preschools that apply Montessori education is evaluated in this paper for the benefit Malaysian context. To understand in detail the above, this study is divided into four important sections as follows. First, the significance of LTP for children's development will be described. Secondly, will describe the implementation of LTP in Montessori Education; then followed by the role of Gibson's Theory of Affordance in quality learning space for LTP; and finally, the quality learning spaces for LTP implication in preschool will be elucidated in the following literature.

2.0 LITERATURE REVIEW

2.1 Significance of LTP for Children's Development

From the philosophers Plato to Kant, from pedagogue Froebel to psychologist Piaget, there is a long history of the study of play. In this century, researchers have concluded that play is not frivolous. Play is often known as child-directed with context and children's play is based on their personal interests, knowledge, and skills (Yahya & Wood, 2017). Therefore, play is a normative behavior of a child (Fehr, et. al., 2020) and has been recognized and identified as an important instrument in the ontogeny, especially in a child's development (Smaldino et. al., 2019; Smith, 2010; Hirsh-Pasek & Golinkoff, 2008). Undeniably, engagement in play can

enhance the children's development where through play, the children can explore and experience (UNICEF, 2018; Yogman et. al., 2018; Zamani, 2014; Vygotsky, 1967; Piaget, 1962).

Generally, most children play. Children spend 3% - 20% time and energy playing (Smith & Pellegrini, 2013). Besides, children are ready to learn through play from born (Zosh et. al., 2017). Indeed, play and learning are inextricably linked. The scaffolding concept happens during playtime when the child can explore new skills from time to time (Yogman et. al., 2018). Moreover, a child's development is inseparable from play behavior. Kathy Hirsh-Pasek and Roberta Golinkoff, contemporary American psychologists, state that, "Play is the primary way children were designed to learn." Furthermore, children learn across the development domains during playing – physical social, cognitive, and emotional (Loebach & Cox, 2020) then grow to form their personality. This was agreed by the American Academy of Pediatrics (AAP) in 2007, they stated that the "critical importance of play in facilitating parent engagement; promoting safe, stable and nurturing relationships; encouraging the development of numerous competencies, including executive function skills; and improving life course trajectories" (Loebach & Cox, 2020, pg1). Withal, neuroscience has provided strong evidence that plays will stimulate the brain and this development is very important during the childhood period (Yogman et. al., 2018; Zosh et. al., 2017). Therefore, play is not just for passing time for fun but it is vital activities that play a central role for children in learning and preparing them for adulthood (UNICEF, 2018; Zosh et. al., 2017).

Undeniably, LTP has been integrated as part of the ECE system to enhance children's learning and development (Gestwicki & Bertrand, 2011). Children need to prepare themselves with certain skills and mindsets to embrace the ever-changing world in the future, therefore play serves as a powerful mechanism that will create opportunities for children to learn through life happily and healthily (Zosh et. al., 2017). Zosh et. al. (2017) have established that LTP can be identified if the children are having fun and excitement with the play activities (joyful). Besides, the children will know what they are learning while playing (meaningful). The play activities enable the children to be hands-on and minds-on concurrently (actively engaging). Moreover, children can think critically and creatively with the play activities (interactive). Lastly, the play activities involve social interaction.

In Malaysia, preschools or Tadika is a formal ECE center that enrolls children aged four to six based on National Preschool Standard Curriculum (NPSC) as a teaching and learning curriculum under the subsection 22(1) National Education Act 1996 (Act 550) (Masnan, et. al., 2021). The NPSC incorporates six learning strands namely: Communication, Spirituality, Attitudes and Values, Humanity, Personal Competence, Physical Development and Aesthetics, and Science and Technology (NPSC, 2017). Even though LTP has been adopted in NPCS as part of the preschool essential teaching and learning approach providing opportunities for the children to learn in a free, safe, enjoyable, and meaningful environment supports the children's learning and development (Lim et al., 2015), unfortunately, most of the Malaysia preschools are still implementing teacher-centered teaching and learning approach (Abdullah, et. al., 2017) and focusing on academic development due to the non-supportive design physical environment in preschool context. Moreover, there are some other challenges encountered by Malaysian preschools in implementing a child-centered approach, such as teacher training, curriculum adaptation, extracurricular offerings, and policy support (Rusli, 2024; Vettiveloo, 2008). Therefore, it is worthwhile to refer to

Montessori education in this paper to further understand how LTP is well implemented. In this sense, the next section will elaborate on Montessori education in detail to serve as a basic framework for developing the indicators for the methodology section.

2.2 The Implementation of LTP in Montessori Education

Montessori education is an educational philosophy and approach that was developed by Italian physician and educator Dr. Maria Montessori in the 1900s. Dr. Maria mentioned, "Education must begin at birth" (Montessori, 1946). In the early twentieth century, the Montessori method has been widespread all over the world for more than a hundred years and it has become one of the most visible models applied in most of the ECE systems in the world to support the learning and development of children (Kiran, et. al., 2021).

Montessori observed that children develop through spontaneous sensory activity, which occurs without unnecessary interference from adults. She also believed that the child is the architect who has an inbuilt capacity and tendency to seek out learning by himself (Bahmaee, et. al., 2016). Therefore, the Montessori approach embraces child-led learning and self-discovery where the "one-size-fits-all" education helps children develop independence, self-discipline, and a sense of responsibility for their learning (Lillard, 2013). It likely recognizes that each child is unique and teachers tailor the curriculum to meet the individual needs and interests of each student, ensuring that they progress at their own pace and rhythm (Rathunde, 2001). Play is part of an integral component of Montessori education. The Montessori approach to play has been called "real pretend" where the children play and learn to mimic real-life situations without rules or restrictions. Children have the freedom to choose their play activities in the classroom towards established certain learning goals where subtly guided by teachers (Lillard, 2013). In a Montessori classroom, children won't be forced to participate in any activities, they enjoy and have stress-free moments during playtime, and they can focus on the activities in the prepared learning environment. Dr. Maria (1949) once stated, "The child who concentrates is immensely happy" (Kelly, 2022, pg3).

Montessori believes that a well-designed environment will enhance the children's learning and development (Yalçin, 2018). The Montessori classroom which is known as a "prepared environment" is designed based on the physiognomies of children of different ages with special learning materials (Badiei & Tajularipin, 2014) guided by teachers to create the optimal learning environment for children and stimulate children's learning (Kiran, et. al., 2021). The "prepared environment" is described as "simple but graceful" (Al, et. al., 2012). The learning environment for Montessori pedagogy is carefully prepared and specially designed to cultivate and support child-led hands-on activities for developing sensory sensitivity, focus, independence, self-exploration, and self-discovery (Kiran, et. al., 2021; Mavrič, 2020).

Consequently, this study will employ Gibson's theory of affordance to understand the correlation between the quality of the learning environment and children's play in a preschool context to create quality learning spaces to promote a positive and constructive LTP approach for the children.

2.3 Gibson's Theory of Affordance

The Theory of Affordance by James Jerome Gibson is an ecological psychology that describes the relationship that exists between an individual and their environment (Chong & Proctor, 2019). This concept shows what the environment possibly offers to the individual to possess possible actions and behaviors (Sando & Sandseter, 2020).

Play is an important childhood activity and it is a normative child's behavior where the affordances of the environment may support this behavior (Sando & Sandseter, 2020). In general, researchers used the theory of affordances in the studies of children and the environment to explore how children value the elements in the surrounding environment in terms of "playability" values and how the children perceive the function of the environment through their experiences (Aziz & Said, 2015). According to Gibson, affordances mean the functionally significant characteristics of the environment, explaining in terms of psychology to analyze the child-environment relationships (Kyttä, 2003). With children, the shaping of the environment depends on the environmental affordances interpreted by them (Aziz & Said, 2015).

Inarguable, there is some literature established that spatially defined areas will directly influence the positive behaviors and development of children. Therefore, learning spaces in preschool need to be designed with thoughtful consideration to offer rich and developmentally appropriate opportunities to support the holistic development of children and foster a positive and engaging LTP experience. The following section will describe on quality learning space and its indicators that will be used for analyzing the case study in this paper.

2.4 Quality Learning Spaces for LTP Implication in Preschool

Preschool is a society of miniature which is a lived "workspace" for children. Aleksić (2015) concludes that preschool should be attractive, responsive, and protective in both indoor and outdoor spaces, intertwined with the curriculum, to create the best childhood memories for the children. One of the research architects and development and environmental psychologist on environmental-behavior studies, Professor Gary Moore mentioned in his research that there is a direct effect on the quality of the designed spaces in preschool settings with children's growth, cognitive development, and social interactions (Mohammadreza, et. al., 2021). Moreover, Reggio Emilia states that a well-designed esthetical space is defined as the "third educator" (van Liempd, et. al., 2020). Hence, it is tremendously important to create a sense of place in the school environment where the children spend much of their time in school.

Sense of place is important during early childhood, as it is an essential element in enhancing children's cognitive, social, and emotional development. Through the sense of place, equipped with curiosity and the five senses, children can explore and develop certain understanding through their interaction with the surrounding environment (Mankiw, 2015) and are also able to create and engage in a wide range of play (Sandseter, et. al., 2023). Early childhood practitioner, Anita Rui Olds (1979) has well expressed that, "The motivation to interact with the environment exists in all children as an intrinsic property of life, but the quality of the interactions is dependent upon the possibilities for engagement that the environment provides." (Altenmüller-Lewis, 2014).

Lin (2021) mentions that children are more sensitive and attached to space compared to ordinary adults. So is the provision of space in school in this era-appropriate and suitable design for children? Children nowadays spend most of their time in schools, therefore preschools should create a quality design and suitable spatial planning to support all the children's activities and experiences in joy where they are engaged, enthusiastic, and motivated. The architect and designer who designs preschools will need to create a children's space that corresponds to the needs and wishes of the children, along with a stimulating environment to facilitate children's exploration and various activities. Anita Rui Olds (1987) mentioned, "When children feel comfortable in their physical surroundings, they will venture to explore materials or events around them" (Aleksić, 2015). A well-designed and appropriate environment in preschool will create a space for children to engage in a wide range of play and expand their development and ability to learn. Nevertheless, a good quality classroom spatial design inspires and encourages children to experience various LTP experiences. Alternatively, poor-quality classroom spatial design may affect children's behavior and development.

There are some important architectural design elements and techniques to create spatial quality in preschool. For this study, the five aspects of spatial architecture features are referred to the Montessori Architecture pattern mentioned by Association Montessori Internationale (AMI) (n.d.) and research study by Al, et. al (2012). These five spatial design features are - i) articulated space and form; ii) outdoor learning space; iii) social spaces; iv) personalized environment; and v) anthropometric design (Table 1).

Table 1: Five Aspects of Spatial Architecture Features in this Study

Spatial Design Features	**Descriptions**
Articulated space and form	Refers to the design or organisation of the space.
Outdoor learning space	Refers to the outdoor setting to facilitate dynamic educational activities and experience.
Social spaces	Refers to an area designed to encourage and facilitate social interaction and teamwork among a group of people.
Personalized environment	Refers to an area designed for diverse learning tailored to different needs or preference and individualized learning experience.
Anthropometry design	Refers to the furniture and facilities that are well-suited to the users in appropriate size.

LTP is not widely explored in the Malaysian preschool context due to the unsupportive learning environment with quality spatial design (Nazri & Shaari, 2023; Lim et al., 2015). Therefore, the following section in this paper will examine two case studies of successful Montessori preschools that indicate the LTP in its design environments towards producing quality learning paces.

3.0 METHODOLOGY

This study employed two case studies as the research strategy under qualitative methods and approaches. Interpretivism as a research paradigm is utilized that involves an in-depth study of the spatial design of two Montessori preschools in a global context. To have a better insight into the spatial design for both case studies, the spatial narrative is adapted principally to provide research direction on the selection of indicators in this study. Hermeneutics approach must be applied to this study theoretically to create a systematic framework to read and analyze the spatial design elements of the preschool to develop a better design framework for the children. Through this approach, researchers understand the social phenomenon clearly and can process data to answer why, how, and what happens, which involves reading documents, books, and others.

On the other hand, document analysis and direct observation are used as data collection methods for the selected case studies. The analysis was based on the explanation-building analytic technique built by Yin (2018) to explain the causes and outcomes of the phenomenon. Then the analysis findings from both case studies were compared to identify the similarities and differences. Finally, both analyses were combined then to outline a design framework of preschool that highlights the role of LTP pedagogy on quality spatial design for developing children's play behavior patterns in future Malaysian preschools.

The justification for the selection of case studies, which is the My Montessori Garden Preschool and Tabika KEMAS Keramat Nur Parlimen Titiwangsa, refer to two criteria. First, the two selected case studies have been categorized as single-story design complex preschools where they have ample compound spaces. Second, the preschools are located in residential areas in the urban settings. Moreover, the Tabika KEMAS is chosen as the case study in this paper as it has the highest number of preschools in Malaysia, which consists of 8,387 nationwide (KEMAS, 2023). It is considered a public preschool and the curriculum and program are also follow NPSC and accredited by the Ministry of Education (MOE) for the ECE program.

4.0 RESULTS

In this section, the background of the two case studies and the findings based on the data collection from text and documents will be described with the determinants of the spatial design features as mentioned earlier, which are the: - i) articulated space and form; ii) outdoor learning space; iii) social spaces; iv) personalized environment; and v) anthropometric design.

4.1 Case Study 1: My Montessori Garden Preschool

My Montessori Garden Preschool is the first case study in this study which is located in a residential area in Ha Long City, Quang Ninh. Quang Ninh is one of the fastest-growing cities in Vietnam. This preschool designed by HGAA Architects was established in 2020. The build-up area of this preschool is 340m^2. This preschool is built as a story building with an upper walkway with a steel structure as a simple construction solution for easy dismantling and relocating, the classrooms are in two blocks of steel-framed design surrounded by gardens to create a natural space and effective learning environment for children (Archdaily, 2024).

Fig. 1: My Montessori Garden Preschool and layout plan.
(Source: Archdaily, 2024)

Articulated space and form

There are two blocks of classrooms surrounded by a garden. This space layout shows the theory of linear spaces linked by a common space (garden) where the two blocks are separated by a distance and linked to each other by the garden. The space layout design of this preschool has a direct link between children and nature. In this linear arrangement, the classroom blocks are placed on one side of a verandah and a corridor where the garden is accessible to children and staff from the classroom to enjoy nature.

The classrooms in My Montessori Garden Preschool are in an open-plan facility with no interior wall where all the teachers and children will be working and interacting in the same, large area. However, the classroom can be divided into smaller areas with moveable furniture if needed and can be arranged and suited to larger group activities or individual work personal areas.

Fig. 2: Classroom arrangement in My Montessori Garden Preschool
(Source: Archdaily, 2024; Dezeen, 2021)

Outdoor learning space

Children have free access from the classroom to the outdoor garden. From the transitional space, such as the corridor and verandah, children can easily access the upper walkway garden with iron stairs. The connection between the ground floor level with the walkway garden created a continuous cycle of circulation with the stairs. This has formed an interesting discovery space for the children where they can freely move from the ground to the top and back down.

Fig. 3: The outdoor gardens in My Montessori Garden Preschool
(Source: Archdaily, 2024)

Social spaces

The classrooms are in open plan facility with no interior wall where the low-height furniture serves as soft partitions for certain spaces indication. Many communal spaces within the classrooms allow the children to interact with each other.

Fig. 4: The social spaces in My Montessori Garden Preschool (Source: Archdaily, 2024)

Personalized environment

The children have the freedom to have their preference to work on different issues on their own or with peers or in groups in the open plan facility either in the indoor classroom or outdoor garden. Besides, within the indoor classroom, they can also define their workspace either to work at tables, on the floor o or using any classroom equipment by rolling out mats to do their work comfortably where they can freely enjoy the garden experience outdoors.

Fig. 5: The personalized environment in My Montessori Garden Preschool
(Source: Archdaily, 2024)

Anthropometry design

There are no customary rows of school desks in My Montessori Garden Preschool. Referring to Fig. 6, the furniture and facilities, such as tables, chairs, and low-rise shelves in the classroom are in children's ergonomic and anthropometry design, all are appropriately scaled for the children. The play, teaching, and learning materials and equipment are easily reachable by children easily which organized properly in storage units, such as shelves and cubbies.

Fig. 6: Furniture and facilities arrangement in My Montessori Garden Preschool
(Source: Archdaily, 2024)

4.2 Case study 2: Tabika KEMAS Keramat Nur Parlimen Titiwangsa

Tabika KEMAS Keramat Nur Parlimen Titiwangsa is chosen as the second case study in this study which is located in a residential area in Kampung Datuk Keramat in Kuala Lumpur. It is considered a public preschool and the curriculum and program are also follow NPSC and accredited by the Ministry of Education (MOE) for the ECE programme. The build-up area of this preschool is 290m^2. This preschool is designed as a single complex type preschool and single story.

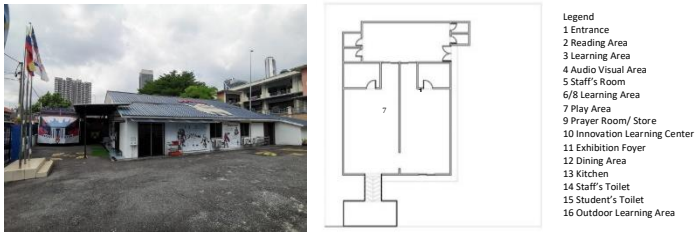

Fig. 7: Tabika KEMAS Keramat Nur Parlimen Titiwangsa and layout plan

Articulated space and form

The configuration of the Tabika KEMAS Keramat Nur Parlimen Titiwangsa spatial organization portrays an "adjacent spaces" spatial relationship. Each space in this preschool is clearly defined and responds to its function requirement. There are partitions to separate different areas that limit visual and physical access. Therefore, certain spaces need to traverse certain nodes along a fixed path to gain access to the deepest parts of the spaces.

Fig. 8: Classroom arrangement in Tabika KEMAS Keramat Nur Parlimen Titiwangsa

Outdoor learning space

Most of the time, children are limited to having play and learning activities indoors. There is no special design for the outdoor space that suits the children's needs and preferences.

Fig. 9: The outdoor space in Tabika KEMAS Keramat Nur Parlimen Titiwangsa

Social space

The rigid and structured learning environment is composed of children of the same age. Both learning areas segregate the children's activities and programs according to 5 years old and 6 years old.

Fig. 10: The rigid learning environment in Tabika KEMAS Keramat Nur Parlimen Titiwangsa

Personalized environment

Spaces are mainly occupied by the table arrangement and have fixed functions for different teaching learning and activities. Hence, children have limited choices in the freedom to have their preference to work.

Fig. 11: There is a limited personalized environment in Tabika KEMAS Keramat Nur Parlimen Titiwangsa

Anthropometry design

All furniture and facilities are appropriately scaled for the children. Besides, the play, teaching, and learning materials and equipment are easily accessible by children easily which organized properly in storage units, such as shelves and cubbies. The furniture is also in soft curves and gentle angles with colorful chairs and tables to provide comfort, support, and learning and promote positive behavior to the children.

Fig. 12: Furniture and facilities arrangement in Tabika KEMAS Keramat Nur Parlimen Titiwangsa

5.0 DISCUSSIONS

In light of the findings above, much needs to be done to ensure that the preschools in Malaysia are in enthralling spatial quality to fully implement the LTP as the main pedagogy in ECE for developing better children's play behavior patterns in preschool for Malaysia's future education. As highlighted earlier, there is a lack of design guidelines and adequate solutions for creating a quality spatial design to support LTP which is advocated in NPCS. To prepare children for the complexity of their future living and working environments, the new

generation of learning spaces should move forward from traditional teacher-centered teaching and learning to more children-centered learning. Therefore, the Malaysian preschool learning environment needs to be transformed by tacitly embodying LTP pedagogy to shape students' learning and play experiences and behaviors.

The paper proposes spatial design recommendations for Preschool in the Malaysia Context (Table 4), that are aligned with the design of a Montessori education preschool environment that supports LTP.

Table 2: Propose Spatial Design Recommendation for Preschool in Malaysia Context

Spatial Design Features	**Spatial Design Recommendation to Support LTP**	**Current Situation of Learning Spaces in Malaysia Preschool**
Articulated space and form	The learning environment are to be in open-plan design by interconnecting all the smaller spatial components with minimal of flexible separators or partitions to create a degree of seclusion for certain learning and activities whilst providing freedom to the children to access to all the spaces to have their desire activities.	The learning spaces are separated with fix partition for segregating the children's activities and program according into 5 years old and 6 years old. Therefore, it creates limitation in visual and physical access to the children.
Outdoor learning space	Classrooms are to be expanded to or integrated with a dynamic external learning area covered with nature, such as garden, where the transitional space, such as terraces or corridors, allows the children flow freely between indoor and outdoor settings to have different play experience in the unique and greater space.	The outdoor space isn't well design and most of the teaching and learning happens in the indoor settings. Children are prohibited to flow freely to between indoor and outdoor.
Social spaces	Social spaces to be designed in an inviting manner and sufficient accommodation that allow children to use it actively for a demanding social activity or gathering for interaction among each other.	The rigid learning environment with fix function of the spaces doesn't support children to have further activities based on their favorite and needs.
Personalized environment	The open-plan spatial environment with light-weight and moveable separators or partitions allows children to constantly personalize and reinvention the activities workspace to support their individual and collaborative work.	
Anthropometry design	The furniture and facilities to be special tailored made based on the principle of 'everything child-sized' to increase the level of independence and self-confidence where children are able to have immediate contact and independent use and operate all the elements in the space without adult's assistance.	Even though the furniture and facilities are in appropriately scaled for the children, the children are not able to use and operate the tools independently without teacher's instructions.

6.0 CONCLUSION

LTP is no doubt a widely recognized ECE approach that emphasizes play as significant in the learning process and has a positive impact on children's intellectual growth. In light of the issues discussed, the quality of learning space design in preschools in Malaysia is yet to be strengthened and improved urgently, it shouldn't be neglected or afterthought design and planning where the learning spaces should be designed to align with and support LTP as curricula towards positive children's play, learning, and development. Therefore, this paper has pointed towards the Montessori education reflecting on LTP and the affordance of quality spatial design in preschool context by emphasizing the five spatial design features as mentioned: - i) articulated space and form; ii) outdoor learning space; iii) social spaces; iv) personalized environment; v) anthropometric design, to serve as a benchmark and act as a vital reference for Malaysia preschools to develop quality learning space design reflective of LTP pedagogy enlisted in NPSC, and thereby providing comprehensive and valuable information for educators, designers, policymakers and scholars in the related field. It is recommended that future studies relating to the quality of the physical learning environment in preschools shall also focus on the spatial design and simultaneously concern on the relevant policies and guidelines to reduce the gap between the aspired and implementation.

ACKNOWLEDGMENTS

The authors would like to acknowledge the support of Jabatan Kemajuan Masyarakat Kementerian Kemajuan Desa dan Wilayah (KEMAS) for providing the facilities and documentation for this research.

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JOURNAL OF ARCHITECTURE, PLANNING & CONSTRUCTION MANAGEMENT
Volume 14 Issue 1, 2024 E-ISSN: 2462-2222 ISSN: 2231-9514

TRANSITIONING FROM TRADITIONAL TO DIGITAL METHODS: INSIGHTS ON DOCUMENTING AND EXHIBITING LANDSCAPE HERITAGE

Received: 18th April 2024 | Accepted: 10th June 2024 | Available Online: 30th June 2024

DOI: 10.31436/japcm.v14i1.877

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ABSTRACT

Documenting heritage is crucial for understanding the history and significance of a society and its surroundings. This process involves capturing a culture's tangible and intangible values through various mediums, such as written records, drawings, maps, photographs, videos, audio recordings, artefacts, and other forms of documentation. With the increasing use of technology, the methods of documenting and presenting heritage have evolved. This research explores the transition from traditional to digital methods in landscape heritage documentation and exhibition. The objectives are to review the instruments and techniques employed and then compare the documentation and exhibits across the studies. The investigation draws upon seven landscape heritage projects in Malaysia and Indonesia within the landscape architecture undergraduate program at International Islamic University Malaysia (IIUM). Each project's documentation and exhibition strategies are classified based on the tools, procedures, and outcomes. The different forms of documentation are subsequently evaluated in terms of their effectiveness and efficiency in recording and showcasing the results of the projects. The study reveals that combining traditional and digital methods offers numerous benefits for heritage documentation. Analysing these projects shows that reflecting, evaluating, exploring, adapting, and refining the documentation process are essential for successful heritage preservation efforts.

Keywords: Culture; digital; documentation; edutourism; heritage

1.0 INTRODUCTION

Heritage studies heavily rely on documentation for safeguarding, preserving, and understanding cultural and natural heritage. The evolution of heritage documentation has progressed from traditional methods to the incorporation of digital technologies (Nakip et al., 2022; Doğan & Yakar, 2018). The information gathered, including artefacts, drawings, and other documentation forms, undergo inventory, analysis, storage, and presentation within this process. Conversely, exhibitions function as platforms for disseminating heritage discoveries to the public. Institutions like museums and galleries document and exhibit their collections to educate the public about the cultural and natural significance of specific places, elements, or traditions. Tourists often seek out heritage sites due to their unique attributes that hold importance for the respective locations. Exhibitions act as extensions of these sites, conveying information through diverse forms of documentation and displays. This study aims to explore the various strategies of documentation and exhibition, tracing the shift from traditional to digital methods by examining a landscape heritage and cultural studies programme conducted over the past decade.

Understanding heritage is essential for students as it enhances their comprehension of the diverse cultural and natural heritage. Exploring cultural heritage allows students to appreciate various cultures' historical, social, and environmental richness. Cultural heritage shapes societies and individuals (Knežević, 2017). By delving into their heritage, students can advance in personal growth and confidence, fostering a sense of pride and connection to their cultural roots (Fernández et al., 2021). Moreover, heritage studies can cultivate intercultural empathy and understanding by exposing students to diverse perspectives and ways of life (Pinto & Ibáñez-Etxeberria, 2018). Engaging with heritage gives students a broader global outlook, a profound insight into cultural diversity, the historical development of settlements and cities, and the skills necessary to navigate an increasingly interconnected world.

2.0 LITERATURE REVIEW

2.1 Landscape Heritage

Landscape heritage encompasses a place's natural and cultural features with historical, aesthetic, cultural, and ecological importance. The heritage attributes include the landscape's natural elements like terrain, flora, fauna, water bodies, and the human-made structures and cultural traditions that have influenced them over time (Gullino et al., 2015). However, the ever-changing nature of landscapes, influenced by natural forces, human interventions, and environmental shifts, poses challenges for their preservation and protection. Sani et al. (2020) asserted that the natural environment generates a positive point of view on life and makes people feel more active and alive. Therefore, documenting heritage becomes crucial in capturing the evolving landscape dynamics (Yang et al., 2019). The subjective nature of how landscapes are perceived adds another layer of complexity, as different individuals and communities may have diverse interpretations and values regarding a particular environment (Lopez-Martinez, 2017). Hence, it is essential for documentation efforts to incorporate local perspectives to ensure a more balanced and authentic portrayal of the landscape, avoiding biases that may arise from an external viewpoint. Given heritage documentation's intricate and dynamic nature, interdisciplinary collaborations are imperative, as heritage encompasses social, cultural, environmental, and physical dimensions (Fairclough & Herring, 2016).

2.2 Heritage Documentation

Heritage documentation serves as a method to safeguard and conserve a landscape's cultural and natural attributes. By documenting these characteristics, the intrinsic value and significance of the landscape can be captured to support conservation endeavours, inform land-use planning decisions, and nominate specific sites for national and international recognition (Whitlock et al., 2017). The outcomes derived from this documentation can also be exhibited and disseminated to enhance public awareness and appreciation of cultural and natural diversity. Through this process, individuals can gain insights into the diverse customs, traditions, belief systems, and geographical elements that have influenced the landscape and its surrounding ecosystem (Feng et al., 2021). The observations and knowledge acquired from these records can expose students to the intricate connections between culture, the environment, and society, fostering a deeper appreciation for preserving landscape heritage (Fernández et al., 2021; Knežević, 2017). The cross-cultural comprehension attained through heritage exploration and studies can serve as a platform for students to refine their critical thinking, analytical abilities, and comprehension of the intricate and evolving processes within landscapes (Butler, 2016).

The initial phase of heritage documentation involves the development of tools and instruments for data collection. The choice of instruments and tools is contingent upon factors such as the characteristics of the heritage sites, the documentation objectives, and the desired outcomes. Researchers and students can utilise traditional analogue methods, modern digital techniques, or a blend of both approaches. Traditional methods of heritage documentation in architecture and landscape architecture have historically relied on manual surveying, hand-drawn sketches, and written descriptions to record and preserve historic buildings and sites. These conventional techniques involve meticulous measurements, detailed drawings, and written notes to document architectural features, cultural landscapes, construction materials, and historical attributes (Menshawy et al., 2022). These methods may include interviews, surveys, artefact measurements, site mapping, modelling, and manual drawings based on direct observations. Through interviews, researchers can extract oral accounts from residents, stakeholders, and custodians of heritage sites to document intangible narratives or information that may need to be more visible on-site. Oral histories and cultural traditions provide valuable insights into the site's significance to the local community and the broader population (Pragnell et al., 2010).

Moreover, traditional documentation methods often require significant time and may need to pay more attention to critical details, leading to potential inaccuracies and omissions in the recorded information (Baik & Boehm, 2015). Despite their limitations, these traditional approaches have laid the groundwork for architectural conservation and heritage preservation efforts. By conducting surveys, recording essential parameters, and visually communicating with conservation teams, traditional methods have formed the basis for understanding and safeguarding architectural heritage (Okpalanozie & Adetunji, 2021).

Conversely, digital methods encompass remote sensing technologies, geographic information systems (GIS), and three-dimensional modelling (Doğan & Yakar, 2018). Digital methods of heritage documentation in the built environment have advanced the field by integrating technologies such as photogrammetry, 3D scanning, and Building Information Modeling (BIM) (Remondino, 2011; Llamas et al., 2017). Using digital tools becomes essential in creating 3D models that capture intricate details of buildings, ornamentation and the sites (Menshawy et al., 2022; Zhang et al., 2022). Digital technologies also enable the visualisation and representation of heritage sites, which can aid the preservation of heritage sites at risk of deterioration through documentation, either for further analysis or as a detailed record of the assets (Günay, 2022). Using simpler digital tools such as photography, video recording, and drones and creating a website can also provide accessible and effective means to document architectural and landscape heritage. These tools allow for the capture of visual and aerial perspectives, aiding in the creation of immersive and informative digital content that can be widely shared to enhance the understanding and appreciation of cultural heritage sites (Chatzigrigoriou et al., 2021; Remondino et al., 2011). Digital methods offer the advantage of efficiently collecting and processing vast amounts of data that can be analysed differently. The utilisation of digital data enables more sophisticated analyses and simulations, thereby expanding the potential for comprehensive heritage documentation.

2.2 Heritage Exhibition

Exhibitions serve as a social approach for presenting information and discoveries related to

the heritage of a particular location to people. Museums and galleries utilise diverse formats in their display to provide visitors with an engaging experience, aiming to enhance their awareness and appreciation towards cultural and heritage values (Poria et al., 2010). Both tangible and intangible aspects of heritage are carefully curated into a coherent narrative, offering visitors an interactive and visually stimulating experience with the heritage. Exhibitions represent physical spaces where the public can delve into a site's historical, cultural, and environmental assets, fostering a sense of pride within the local community (Santoro et al., 2020). In tourism, temporary, seasonal, or permanent exhibitions can contribute to the local economy by drawing tourists to the region (Gkoltsiou et al., 2021). Through these storytelling platforms, exhibitions emerge to advocate for the preservation of heritage by promoting knowledge, awareness, and appreciation among the public for heritage values.

3.0 METHODOLOGY

This study is based on a selection of seven landscape heritage and cultural studies projects carried out in Malaysia and Indonesia as part of the Bachelor of Landscape Architecture (Hons.) programme at IIUM (see Table 1 for details). The primary objective of these projects is to familiarise students with the process of investigating and documenting heritage information, followed by raising public awareness about the heritage values of the specific study area through the organisation of an exhibition. Each year, the project involves a varying number of students, typically ranging from 20 to 50 participants based on the intake, with the project site being either local or international. The project spans eight weeks during the short semester and is conducted through collaborative group work. By engaging in project-based learning, students are tasked with showcasing their understanding of the local culture and history of the landscape heritage in the study area by creating multiple outputs, including presentations, reports/publications, physical or digital models, exhibitions, and other relevant media.

Table 1: Selected landscape heritage and cultural studies project sites

Project Site	**Year**
Bali, Indonesia	2013
Bandung, Indonesia	2014
Kota Bharu, Kelantan	2015
Palembang, Indonesia	2017
Johor Bahru, Malaysia	2018
George Town, Penang, Malaysia	2019
Taiping, Perak, Malaysia	2022

In this study, the focus is on reviewing and analysing these projects according to three key aspects: i) instruments that were used during the site visits and documentation phase, ii) the process of teaching and learning, and iii) the output approach for the exhibition. By categorising and evaluating these criteria, the study analyses the transformations in teaching and learning methodologies within the course throughout the previous decade.

4.0 RESULTS

4.1 Instruments and Tools

Various tools and equipment were utilised during the fieldwork and documentation phase (see Figure 1). All the projects implemented the on-site data collection technique for their visits, a common practice in studies related to the built environment. The tools employed encompass mapping, site inventory, observation checklist, interviews, surveys, digital photography, videography, moulding, and tracing. Mapping activities were carried out on physical base maps prepared before the visit, highlighting existing heritage sites, significant landmarks, study areas, and other essential information gathered during the desktop study (see Figure 2). The observation was structured according to the checklist to aid the mapping process and record how individuals engage with the heritage sites through their movements, activities, and other observable behaviours contributing to the insights and discoveries. These observations were documented on the maps using traditional methods like pen and paper and through measured drawings, sketches, digital photographs, and videos captured during the site visit. Critique sessions were conducted nightly to review and discuss the findings (Figure 3).

PROJECT SITE	YEAR	INSTRUMENTS	Mapping	Observation Checklist	Interview	Survey	Photography	Videography	Moulding	Tracing	TOOLS	Measured Drawing	Maps	Sketches	Camera and Video	Voice Recorder	Charcoal Tracing	Plaster Modelling	Drone
Bali	2013		*	*	*		*	*	*	*		*	*	*	*	*	*	*	
Bandung	2014		*	*	*		*	*	*			*	*	*	*	*		*	
Kota Bharu	2015		*	*	*		*	*	*			*	*	*	*			*	
Palembang	2017		*	*	*		*	*	*			*	*	*	*			*	
Johor Bahru	2018		*	*	*		*	*	*			*	*	*	*			*	
Georgetown	2019		*	*	*		*	*	*			*	*	*	*			*	
Taiping	2022		*	*	*	*	*	*					*	*	*				*

Fig 1: Instruments and tools used during site visit and documentation phase

Fig. 2: Mapping and inventory conducted for the Johor Bahru project

Fig. 3: Measured drawings and sketches for the Palembang project

The manual drawing tools used were portable and did not rely on batteries, making them durable for swift observations and annotations throughout the day at any location. Nonetheless, manual tools' downside was their constraints in confined spaces when using large base maps and in adverse weather conditions when exposed to sudden outdoor rainfall. Sketchbooks have emerged as the most dependable portable tool for recording observations and creating rapid maps that can later be transposed onto base maps at a more convenient time. Digital viewing of photos and videos was conducted using laptops, with printing reserved for the post-site visit analysis and documentation intended for exhibitions. In the latest project, Taiping, students used a more advanced drone tool to document the heritage site (see Figure 4). The drone facilitated capturing aerial perspectives of the site on a larger scale and with greater precision than Google Earth, offering the potential for generating alternative mapping formats if necessary.

Fig. 4: Drone usage for aerial photos and videos for the Taiping project

Interviews were conducted with local authorities, site custodians, residents, and visitors to understand better their perceptions, challenges, and strategies concerning the heritage sites. The project team organised a briefing session led by the local municipality to gather additional information about the site, existing documentation, and conservation plans and posed inquiries about heritage preservation. Video recordings and photographs were used to document the interview sessions. The students transitioned from utilising dedicated voice recorders to their smartphones for recording interviews, given the widespread use of

smartphones as a primary communication tool equipped with voice recording capabilities. Surveys served as an additional tool to evaluate public perceptions and experiences regarding the site, with the survey method being introduced during the 2022 Taiping project. In this project, students devised survey boards featuring concise and targeted questions, applying coloured stickers to differentiate responses from various age groups as an engaging strategy to encourage public participation.

To document samples of the intricate heritage elements, such as patterns and motifs, the students employed moulding and tracing techniques to recreate a life-sized version of the component (see Figure 5). The moulding process involved clay and plaster, with most of the work done on location. However, a limitation of this method was the time needed for the clay to dry and the delicate nature of storing, packing, and transporting the plaster moulds back to the studio without damage, particularly when travelling to international locations. As a result, students have chosen only to create clay moulds on-site and produce plaster moulds upon their return. The patterns and motifs were also documented through measurements, sketches, and photographs, which were later digitised to generate technical drawings. Tracing on paper with charcoal was another tool to document the intricate heritage elements. However, this method was only used in the Bali project. It was not continued for other projects because the moulding and drawings output was sufficient to capture the essence of the elements.

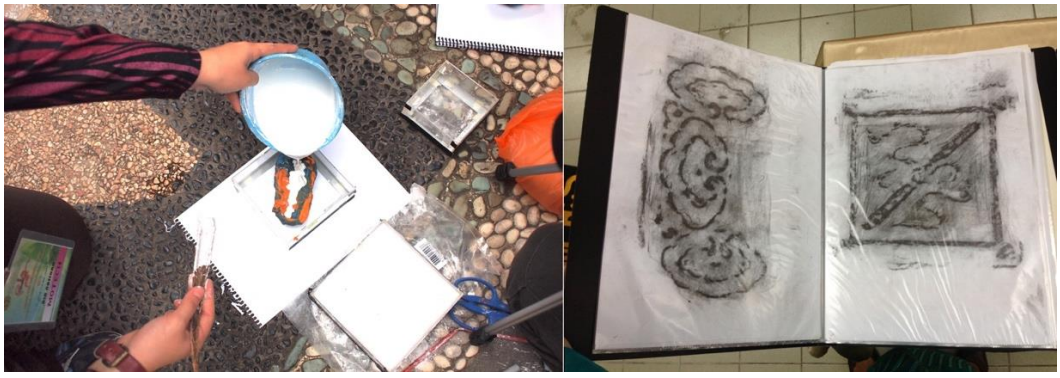

Fig. 5: Clay and plaster modelling and tracing for the Bali project

4.2 Process of Teaching and Learning

The process of teaching and learning for landscape heritage and cultural studies can be delineated into three primary stages: i) pre-site visit, ii) site visit, and iii) post-site visit (refer to Figure 6). In the initial phase, students engaged in desktop study to explore secondary sources of information about the site. This desktop study enabled students to research the historical background and heritage significance of the site, review previous studies conducted, identify key features and attributes for analysis, identify locations of historic areas and points of attractions and understand the broader context of the site. Subsequently, based on the desktop study findings, students formulated data collection strategies during the site visit. Moreover, course lecturers provided lectures and occasionally guest speakers to enrich the student's knowledge about the landscape heritage. In the case of the Taiping project, students have organised a series of webinars featuring subject matter experts to share knowledge about heritage with the university community and the public.

Throughout the site visits, students engaged in first-hand experiences, observations, and documentation of heritage sites based on a checklist, attributes, and study scope that had been prepared. The investigation of these sites was centred around four fundamental dimensions: the physical environment, natural environment, beliefs, and practices. Central to these aspects are the people and their historical interactions that have influenced and shaped the environment over time. Students could directly see the site, engage with the local communities, and gather information about the site's heritage values. During the COVID-19 pandemic, the landscape heritage and cultural studies project had to transition into a virtual format due to domestic and international travel restrictions. The shift to virtual site visits facilitated an international collaboration between Malaysia and Tunisia. It allowed students to collaborate with peers from different countries, exchange insights on heritage sites within their regions, and develop remote and online work skills. Nonetheless, a drawback of remote learning in heritage studies was the need for on-site experiences that could only be attained through physical visits to heritage sites.

PROJECT SITE	YEAR	PRE-SITE VISIT	Desktop Study	Input Lectures	Preparing Instrument	Webinars	SITE VISIT	Data Collection	On-Site Discussions	POST-SITE VISIT	Progress Presentations	Book Preparation	Video Documentary	Drawings	Exhibition Materials	Webinars
Bali	2013		*	*	*			*	*		*	*	*	*	*	
Bandung	2014		*	*	*			*	*		*	*	*	*	*	
Kota Bharu	2015		*	*	*			*	*		*	*	*	*	*	
Palembang	2017		*	*	*			*	*		*	*	*	*	*	
Johor Bahru	2018		*	*	*			*	*		*	*	*	*	*	
Georgetown	2019		*	*	*			*	*		*	*	*	*	*	
Taiping	2022		*	*	*	*		*	*		*	*	*	*	*	*

Fig. 6: Process of teaching and learning

Another critical process during the site visit was the on-site discussions, where students presented their discoveries and initial analyses. These discussions were vital in enabling students to reflect and interpret their data while actively engaging at the site and strategising for the next day's data collection activities. On-site discussions, depicted in Figure 7, have proven to be indispensable across all projects, as they served as the starting point for fostering critical thinking, analysis, and synthesis during the site visit. Utilising maps, sketches, photographs, and information gathered from interviews and surveys, students collaborated to examine and deliberate on various aspects of the heritage sites, including their status, potential, and challenges. These attributes were documented and analysed, encompassing the site's historical background, natural characteristics, public and green spaces, urban layout, architectural designs, notable landmarks, people, and culture, as well as scenic vistas and sensory experiences, among others, which may vary depending on the site's distinctiveness. While most of the fieldwork process and flows were prearranged before the visit, the projects maintained a flexible and adaptable approach that allowed refinement and adjustments.

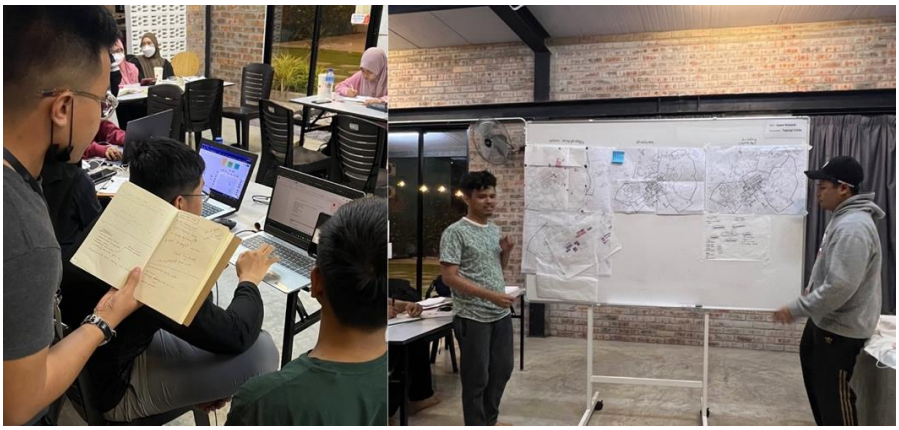

Fig. 7: On-site discussions and presentations for the Taiping project

In the phase following the site visit, students would digitally transfer their collected data to prepare for the final documentation and exhibition. The exhibition deliverables included a range of outputs, such as books, video documentaries, various types of drawings (such as technical drawings, sketches, and digital 3D renderings), and exhibition materials like posters, models, moulding displays, drawing exhibits, and infographic displays. Students were assigned to work in groups according to specific tasks, with each group conducting analyses of the heritage sites according to their designated topics. Regular presentations were conducted every week to evaluate the progress of the work. In previous projects spanning from 2013 to 2019, progress presentations were predominantly carried out digitally utilising software such as Microsoft PowerPoint, Microsoft Publisher, AutoCAD, SketchUp, Adobe Photoshop and Adobe Illustrator, supported by manual drawings, physical models, and handcrafted exhibition items (see Figure 8). In the post-pandemic era, university students and educators have been introduced to collaborative and innovative platforms like Canva, Miro and Google Shared Documents. These applications have been integrated into the Taiping project, offering advantages for group collaboration by enabling each member to contribute to their respective sections while working on a shared document in real-time.

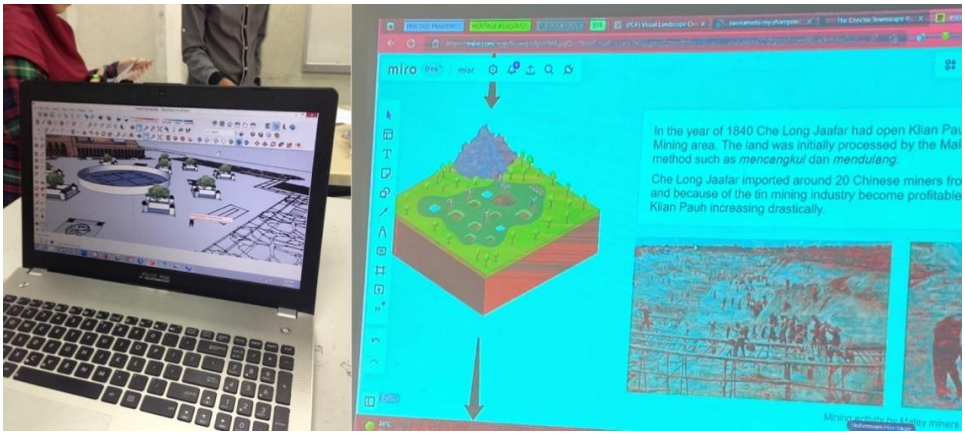

Fig. 8: Progress work for the Bandung project (left) and the Taiping project (right)

The teaching and learning phase was the most critical, offering the opportunity to introduce new approaches to students. Transitioning from analogue to digital posed several challenges during this phase, necessitating careful consideration of appropriate approaches while

considering time constraints, budget limitations, and the technological proficiency of lecturers and students. Different lecturers teach the course each semester, so instructional methods may vary while still achieving consistent learning outcomes. The technological competencies of lecturers would also differ based on their expertise, preferences, familiarity with various tools and platforms, and the student's willingness to explore diverse techniques and technologies available at the time. Nevertheless, these challenges did not impede the development of the teaching and learning process, as the course's nature encourages students to employ creativity in any form, whether through analogue or digital means.

4.3 Exhibition Output

The exhibition is the pinnacle of the landscape heritage and cultural studies course. Outputs from the documentation process were showcased in physical and digital formats (see Figure 9). The most consistent forms of physical displays included books, models, posters, mouldings, sketches, and infographic presentations. These tangible deliverables were also displayed in digital forms during the exhibition. The books were composed based on the research findings of the heritage sites, featuring descriptive narratives, photographs, illustrations, and graphical representations. Technical drawings were compiled into categories: streets, squares, furniture, gardens, parks, and other elements.
Conversely, models highlighted vital areas within the heritage sites. Infographic posters were designed to present historical descriptions, timelines, and detailed descriptions of various facets of landscape heritage, complemented by sketches and images. Figure 10 illustrates the diverse array of exhibition displays showcased in the projects.

The benefits of utilising physical exhibition materials could be seen in their tangible nature, allowing for detailed observation within the exhibition setting. These physical resources can be customised, organised and exhibited according to the student's creativity. Visitors could interact with diverse presentation forms and techniques that vary from one exhibition to another. However, due to their sizes and materials, physical display materials have disadvantages regarding post-exhibition storage. Mainly for this course, where the exhibition is held for only one week and only once, the durability of the physical materials becomes a critical concern, especially when storing fragile or perishable items post-exhibition.

PROJECT SITE	YEAR	PHYSICAL	Book	Drawings	Models	Posters	Mouldings	Tracings	Sketches	Infographic Displays	DIGITAL	Book	Drawings	Mapping	Models	Video Documentary	Website	Hologram	Virtual Reality	Augmented Reality
Bali	2013		*	*	*	*	*	*	*	*			*	*	*	*				
Bandung	2014		*	*	*	*	*		*	*			*	*	*	*				
Kota Bharu	2015		*	*	*	*	*		*	*			*	*	*	*				
Palembang	2017		*	*	*	*	*		*	*			*	*	*	*				
Johor Bahru	2018		*	*	*	*	*		*	*			*	*	*	*				
Georgetown	2019		*	*	*	*	*		*	*		*	*	*	*	*	*	*		
Taiping	2022		*	*	*	*			*	*		*	*	*	*	*	*	*	*	*

Fig. 9: Forms of exhibition output

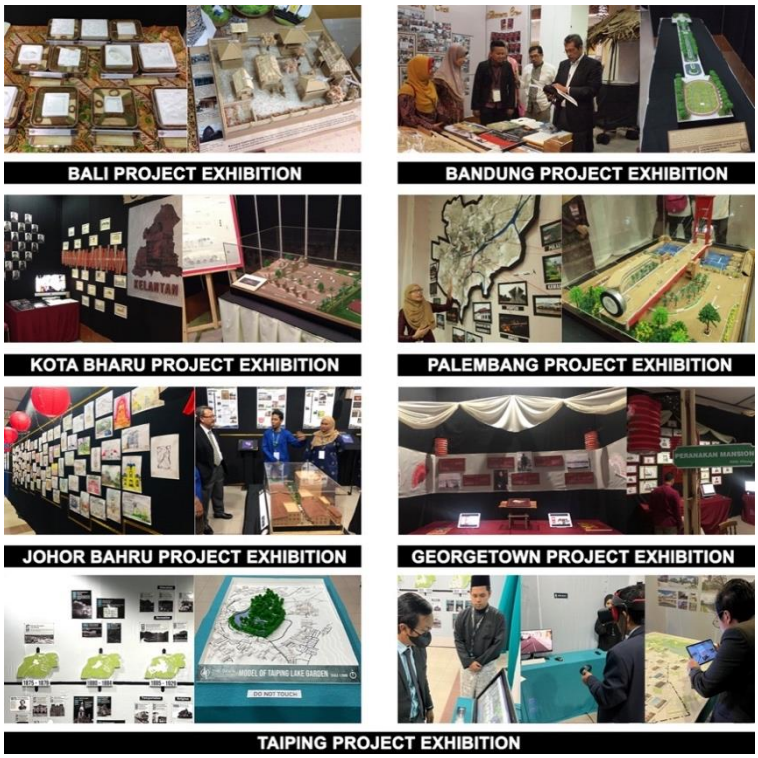

Fig. 10: Project exhibitions

Between 2013 and 2018, the documentation and materials were exclusively exhibited and accessible for physical viewing only during the exhibition week. In 2019, the Georgetown project team established a website (https://bhinekastudio.wixsite.com/georgetown) to archive and disseminate their findings online. The development of the heritage website marked a pivotal milestone in the project, showcasing the potential of utilising online platforms to share the project's outcomes to a broader audience and establish a digital repository for future reference. Additionally, the Georgetown project introduced an interactive digital presentation enabling visitors to interact with the maps, clicking on specific locations to explore details about various sites (see Figure 11). Furthermore, the project incorporated holographic technology to showcase two of their models.

Fig. 11: The Georgetown project website

In 2022, the Taiping project continued the digitalisation efforts by creating a website (https://taiping-heritage-exploration.webflow.io/), as depicted in Figure 12. The website is an online platform for visitors to engage during the exhibition while also serving as a comprehensive heritage portal accessible to individuals worldwide. Through interactive maps, narratives, graphics, video documentaries, and e-books, visitors can explore and learn

about the rich heritage assets of Taiping (Zakariya et al., 2023). The Taiping project team also developed innovative methods to enhance visitors' Taiping experiences, incorporating holographic displays, virtual reality simulations, and augmented reality features. These digital tools have piqued visitors' interest and significantly enriched the educational experience of exploring and appreciating Taiping's heritage.

Fig. 12: The Taiping project website

5.0 DISCUSSION AND CONCLUSION

The projects aimed to expose students to the heritage attributes and values of the heritage sites. Using a project-based learning strategy, students conducted pre-visit research on the sites and then gathered on-site data to gain a first-hand understanding. Analysis of the seven projects revealed that both traditional and digital methods have advantages and disadvantages. Digital technology provides a broader scope of data collection and analysis in the contemporary digital era. For instance, drones facilitate the capture of up-to-date, precise, and real-time aerial imagery and mapping. Future projects could incorporate additional data capture techniques like Geographical Information System (GIS), Light Detection and Ranging (LiDAR), and sensors, as highlighted by recent literature that shows the advancement of digital methods in heritage documentation. Most drawings were prepared digitally during the documentation process, providing convenience and efficiency in editing, updates, and collaborative work. Digital content could be easily converted to create digital representations that offer novel experiences to visitors, such as through virtual reality, augmented reality, and mixed realities. Moreover, website digital content extends heritage learning opportunities beyond physical boundaries. Nonetheless, digital exhibitions may involve higher expenses and need more tangible experience provided by digital exhibitions.

Traditional methods were utilised to capture tangible records and material records of heritage. Through the implemented projects, the analogue approaches for data collection, such as utilising clay and plaster for mouldings and tracings, conducting measured drawings, and engaging in interviews with individuals, were integrated into the students' experiential learning process. The physical data gathering stimulated senses and feelings towards the sites that cannot be replicated in a virtual setting. Within the documentation phase, analogue methods like constructing models, developing physical infographic displays, and arranging exhibition spaces fostered critical spatial reasoning and enhanced motor skills among students. During the exhibition, physical exhibits provided a more tactile experience as visitors could visually see and interact with the displays. Various techniques, materials, shapes, sizes, and textures can be employed in designing displays to generate diverse intended experiences. Nevertheless, the limitations of physical exhibits lie in their

susceptibility to wear and tear, challenges in mobility, and the necessity for adequate storage facilities.

Combining traditional and digital methods in documenting and exhibiting landscape heritage yields substantial advantages. Firstly, integrating these methods enhances comprehension of heritage sites that come in tangible and intangible aspects of heritage. Through the documentation process, students can deepen their understanding of the sites and generate more comprehensive learnings to be shared with others via the exhibitions. Secondly, hybrid exhibition displays can engage diverse audiences, catering to individuals of varying age groups. Digital technology enables the creation of immersive and interactive exhibits that appeal to the younger demographics, while physical displays offer a more conventional exhibition format for other visitors. Exhibitions are an integral platform for raising awareness by disseminating knowledge in an informal setting and facilitating experiential learning. By enhancing public awareness regarding the significance of heritage preservation, visitors are instilled with a sense of appreciation as they engage with and learn about the site. Thirdly, integrating diverse tools and technologies encourages interdisciplinary approaches in heritage documentation, fostering novel learning opportunities and facilitating the exchange of knowledge and experiences among students and visitors. Findings from this study alluded to the contributions of integrated methods in landscape heritage documentation that can be further expanded as an effort to research how heritage values can be conserved in the future, particularly in landscape architecture.

Heritage documentation projects require continuous reflection, evaluation, exploration, adaptation, and refinement. Each project can determine what works best and could be improved, areas for enhancements, advantages and disadvantages, and insights for refining future projects. Throughout the course, the methodologies employed have gradually evolved. In conclusion, incorporating traditional and digital methods in landscape heritage documentation and exhibition offers numerous educational benefits in heritage studies and the landscape architecture field. Interactive exhibitions captivate the public, draw visitors to heritage sites, and promote understanding of the diverse techniques for documenting heritage. The utilisation of various approaches in executing these projects underscores the importance of reflection, review, exploration, adaptation and refining in heritage documentation. By integrating the strengths of traditional and digital techniques, landscape heritage researchers can create richer heritage documentation, ensuring its safeguarding and appreciation by future generations.

ACKNOWLEDGMENTS

The authors would like to thank all the lecturers and students involved in the Landscape Heritage and Cultural Studies course from the Department of Landscape Architecture, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia.

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JOURNAL OF ARCHITECTURE, PLANNING & CONSTRUCTION MANAGEMENT
Volume 14 Issue 1, 2024 E-ISSN: 2462-2222 ISSN: 2231-9514

MORALISTIC DA'WAH VALUES IN RELIGIOUS INSTITUTIONS FOR SOCIETAL DEVELOPMENT: THE CASE OF TABLIGHI JAMAAT AND BENGALI MOSQUE IN MALAYSIA

Received: 20th April 2024 | Accepted: 14th June 2024 | Available Online: 30th June 2024

DOI: 10.31436/japcm.v14i1.878

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ABSTRACT

Islamic religious institutions like mosques are essential buildings for the Muslim community's needs. However, the usage and construction of current-day mosques are unlike those in the days of the Prophet Muhammad S.A.W. This is due to the influences of patrons who utilized these built forms as a symbol of politics and economic stature, the effect of designers who considered religious institution as an aesthetic symbol, and the misconceptions of the society who perceived the religious institution as a house of God. Based on these issues, this paper aims to elucidate how the architecture of heritage mosques by the Tablighi Jamaat group can translate the moral values of da'wah based on the meaning and method of their da'wah for the development of society. This is because each element of the mosque plays a role as a code to translate and convey a message to the community through its architectural features with its users and environment through its architectural elements. This study applies two research paradigms: Interpretivism (hermeneutics) to translate the patron's ideology and structuralism (semiotic) to understand the meaning behind the physical construction of a building. This study contributes to the study of communication in the architecture of buildings, which was devoted to the influences of Tablighi Jamaat da'wah movement ideology towards heritage Islamic religious architecture in Malaysia as a centre of da'wah for societal development in acclaiming the value of tolerance among the Muslim and non-muslim communal members alike. In addition, it portrays that heritage Islamic religious institutions can function as a sign and symbol for transnational dimensions of cultural da'wah towards unity, equality, and spiritual rejuvenation.

Keywords: Moralistic Da'wah Values, Tablighi Jamaat, Societal development, Bengali Mosque

1.0 INTRODUCTION

Islamic religious institutions like mosques are considered the most essential existence for Muslims. According to scholars, two factors drive this: its diverse roles and consumerism. This is because they can become the centre to strengthen the fraternal ties that build the spirit between Muslims as houses of worship to promote the spiritual values of the individual and the universal Muslim community (Baharudin & Ismail, 2014). As a result of the above, Islamic religious institutions can symbolize the identity and presence of the Muslim community and represent the unity of Muslims. Indirectly, Islamic religious institutions can also highlight the

glory of civilization and the achievements of Muslims in the eyes of the world. Based on the above scholar's opinion, it is clear that Islamic religious institutions have played an essential role as a centre of Islam for centuries. During the time of the Prophet PBUH in the 622-646th century AD, Islamic religious institutions were the first structure of Islamic administration and worship, later increasing in the role as a place of education, worship, business, political and administrative, protection, community activities, welfare and charity, detention, treatment and medical including as military centres (Masridin & Ismail, 2022).

Islamic religious institutions then developed in every place that Islam patronized during the spread of Islam. It carries the Islamic mandate through its building as a sacred building for Muslims and is comprehensive in the principles of Islam. Indirectly, the construction of Islamic religious institutions since the time of the Prophet PBUH can carry Islam's religious decree, values, and principles through its form. In summary, the role of Islamic religious institutions as the centre of the development of Islamic da'wah began due to a string of advances in the spread and movement of Islam since the time of the Prophet PBUH. However, the modern Muslim community no longer adopt the actual values and concepts of the role of Islamic religious institutions, such as in the time of the Prophet PBUH, especially in the Malaysian context. It changes in tandem with the development of culture and civilization of society and, at the same time, is influenced by Western thinking, thus forming an architecture that is not in line with Islamic principles (Shah et al., 2014).

Scholars state that modernism causes many to adapt and incorporate architectural elements that produce a new type of architecture without regard to the local cultural needs. This resulted in the Islamic religious architecture in Malaysia being formed based on three ideological specificities, namely the 'Middle East inferiority complex', the symbol of Islamic theology, and the religious formalities, in addition to the suppression of the current understanding of Islamic religion which led the Islamic religious institution to become a threat to the local multiethnic communities that restrict the proper development of da'wah. The emphasis on the mosque as a centre of da'wah is declining, and only a few Islamic religious institutions in Malaysia can present their role as the centre of da'wah, similar to the time of the Prophet PBUH.

Concerning this, the study will focus on the religious institution built by the Tabligh da'wah movement in Malaysia as a reference for restoring the value and role of Islam, like the leadership days of the Khulafa' Ar-Rashidin and the teachings of the Prophet PBUH. The Tabligh da'wah movement is viewed as a neutral drive, one of the longest-lasting movements in Malaysia. It is influential and actively adopts religious institutions as the primary medium. They are not involved in any political arena, are not confrontational, and strictly focus on tarbiyah (focus on education and training of themselves, families, and community) or Islah (improving oneself's quality). Besides, they propagate the da'wah peacefully and adhere to the traditional reformative Islamic thought stream based on the Sunnah and the Quran. However, so far, there is no comprehensive literature done by local scholars who highlight the issue of madrasa and mosques as a centre and symbol of da'wah by taking the example of the Tabligh da'wah movement as the main subject in Malaysia. Furthermore, not many detailed studies discuss the being of mosques in Malaysia as a new phenomenon for the cultural da'wah approach towards negotiating Muslim identities in Malaysia. Past studies on religious institutions in Malaysia primarily focused on seven aspects, which are

documentation on a) history and development, b) aesthetics and ornamentations in design, c) the technology and technical aspect in construction, d) the role of the institution from the quranic and hadith perspective, e) maintenance and restoration of heritage religious institutions, f) crises in contemporary religious architecture and g) study of social aspects and gender roleplay in religious design.

Hence, to restore the value and role of Islamic religious institutions as the centre of da'wah and society as in the days of the leadership of the Prophet PBUH and Khulafa' Ar-Rashidin, this study will focus on Islamic religious institutions built as a centre of da'wah patronized by the Tabligh movement in Malaysia as a reference which is the Bengali mosque. It is important to elucidate how and why the ideology of da'wah is translated into the mosque's architecture as the centre of da'wah. Therefore, this study's main objective is to identify and analyze the features, elements, and role of the mosque architecture, which was used as the centre of da'wah by the Tabligh movement in Malaysia. This is essential in understanding by what means the features, elements and architectural role of this mosque can help in the process of da'wah and how the moralistic da'wah values are reflected in the design of their mosque as the centre of da'wah. The outcome will be a framework for designing a religious institution that can universalize Islam to develop a local Muslim community that permits Muslims and non-Muslims from different ethnic groups to gather and interact, thus leading to inclusivity as a shared space for all.

The Bengali Mosque was chosen as a case study because this religious institution built by this community has become a social establishment that can benefit society in two aspects. First, displaying communal-friendly characters in terms of design can serve as a centre to strengthen the brotherhood ties in the Muslim community. Secondly, it serves as a place of worship that can foster efforts towards fortifying spiritual values for the Muslim and non-Muslim ummah and universally for the sake of overall social development.

For the benefit of the study and to fulfil the objectives, the literature review section is divided into three parts. The first part will define the characteristics of moralistic da'wah values through architectural interpretation. The second part will elucidate the role of the Jemaat Tabligh movement in Malaysia, focusing on their approaches and methods of promulgating Islam, followed by their Islamic ideologies to develop the Muslim community in Malaysia. The third part will review and establish relevant indicators of how the Tabligh Islamic doctrines influenced the shaping of religious institutions like mosques in Malaysia to showcase the da'wah moralistic values. This also includes documenting the characteristics of mosques in Malaysia to establish appropriate design guidelines as a symbol of religious inclusivity or, in other words, for the manifestation of cultural pluralism and religious tolerance. These three sections are explained in turn in the following.

2.0 LITERATURE REVIEW

2.1 Da'wah and the need for moral values

Da'wah is an Arabic term da'a, yad'u, da'watun, da'wan and du'aan and is defined as issuing a summon, a call or an invitation to embrace Islam. From the language point of view in the Quran, the da'wah has three primary meanings: worshipping Allah SWT, proselytizing and preaching to religion. In other words, da'wah relates to human actions relating to reform (islah) and tajdid (renewal), which involves human moral values based on the Quran and

Hadith (Ibrahim & Riyadi, 2023). However, da'wah requires a systematic process to ensure its effectiveness in delivering a more explicit mandate. Da'wah is not only meant as an effort to invite someone to be better (amar ma'ruf nahi munkar), but at a particular time, the da'wah also leads to Islamizing the state. In this context, Da'wah may be conducted individually and in groups to invite people (Muslims and non-muslims) to the teachings of Allah SWT, comprising two aspects relating to aqidah (belief) and Syariah (Islamic law). However, the Prophet PBUH advocates preaching peacefully by showing the moral values of a Muslim, and it is done with wisdom (bi al hal) using two main methods: inviting and adapting to the local situation. Through this moral value, da'wah can be implemented through three intermediaries: speech, writing and social actions.

In da'wah, moral values are human actions guided by the Quran focused on life. Scholars outline Islamic morality values through 4 aspects, namely equality (wisdom), fairness (execution of something beneficial), Iffah (self-control), and Syajaah (transparent and trustworthy)(Badriah & Norazmila, 2018). Scholars also highlighted that the basic principles of spirituality and Islamic values are peace, compassion, social justice and respect. This basic principle is the backbone of Islam to make it easier for Muslims to understand the responsibilities and way of life recommended by Islam despite the cultural differences. This method of da'wah through moral values can create human acceptance, integration and respect, tolerance, responsibility to society, happiness, and a good atmosphere in the process of self-improvement.

In summary, the da'wah in principle-based Islam requires these moral values. This is important for this study as it relates to the moralistic value of da'wah and how it is reflected in architecture. Before discussing the relevance of da'wah and translation in architecture, the following sections will explain the concept and moral values in general and from an Islamic perspective.

2.2 Moral values in the process of conveying Islamic ideology in a da'wah manner

Scholars define value as a theoretical structure of an organization's belief system and is a crucial component of the belief system. It can consolidate differences in importance concerning human behaviour. Each religion is formed based on a sound value system to guide every human being (Roccas, 2005). Scholars state that values are ideals, depictions, schemata and meanings that lead to norms, standards, expectations and rules. According to scholars, values consist of aesthetics (a measure of exquisiteness), instrumental (important in the achievement of goals), ethics and morals (principles and methods of a behaviour). Therefore, value is the main component of the religious belief system, and it is based on an essential guide that a human should follow. However, this study focuses on moral and ethical values as they parallel human actions in the built environment.

The term 'Moral' is quoted from mos or mores, Latin, which means custom or manners. In this sense, morality is associated with a good or bad character, a right or wrong thing and upholding something true. This moral treatment is widespread and different from the viewpoint of monotheistic, polytheistic and pagan religions. According to Al-Qardawi (1998), morality is not the same as ethics because moral values discuss human nature internally and comprehensively, consisting of principles, philosophies, and ethical methods. Maududi (1996) also stated that morality is divided into two parts: moral from belief in God (religion) and

moral from without religion (moral philosophy). Morality in religion states that the whole source of morality is from religious sources (books) (Bloom, 2012).

In contrast, morality without religion is based on moral philosophy under the ethics of the established moral code. Morality and religion are also inseparable as they lead to implications for an organization (Doetzel, 2001). This is evidenced by a previous study by Bloom (2012), which saw the association between religion and morality more emphasized by society than by those without faith. Thus, the association between morality and religion is significant because it involves the activities and joys of a person's daily life (Bloom, 2012). Past scholars have focused on the concept of values and morals in Islam and the Quran and Sunnah as a guide. These primary sources form Islamic ideology (Masitah, 2020). Moral values based on the Quran and Sunnah are essential in delivering the Islamic mandate during the da'wah process.

2.3 Jemat Tabligh Islamic ideology and moralistic dawah values

Da'wah is considered a social movement and categorized as a religious movement. According to scholars, the da'wah movement can be divided into 4 phases, namely the arrival phase (initial phase 609-632 AD), the development phase (632-661 AD), the stability phase (661-750 AD) and the fall phase or revival phase (750-1517 AD-emergence of the early 20th-century da'wah movement to date) (An-Nabhani, 2002). During the early 20th century, the method of da'wah was greatly influenced by movements such as traditionalism, fundamentalism, reformism, and radical Islamism. According to scholars, many factors contribute to the emergence of these Islamic movements, such as the influence of social organizations, reactions to the failure of state-led modernization projects, and general socioeconomic problems (An-Nabhani, 2002). Although there is a variety of methods in the da'wah movement, their main objective is the same, which is to expand the Islamic understanding to Muslims and non-Muslims as expressed in the Qur'an and the Sunnah.

The development of Islamic da'wah in Malaysia grew more dynamic from the time of the Malacca Malay Sultanate until the arrival of the colonial (British) to Malaya and, finally, the post-independence period (Aljunied, 2019). According to Mutalib and Kua (1993), the da'wah of the Islamic movement can be divided into three stages. First, the da'wah movement exists because local people want to defend Islamic traditions and values based on the Quran and Sunnah. Second, the da'wah activity brought by outsiders is then assimilated with the local context, and the third type of da'wah movement is based on sufi influence that solely focuses on spiritual practices and is not on economics and politics. This call towards Islamic da'wah is usually to restore society towards a proper Islamic way of life in a world of clashes with secular groups brought by Western imperialists (Mutalib & Kua,1993).

For the benefit of this study, the research will focus on the third type of da'wah movement, known as the Tabligh da'wah group, which originated in India. It is a neutral da'wah movement that is not involved in any political arena, does not adopt confrontational preaching, and converges towards tarbiyah or Islah diri. Besides, they carry out the da'wah peacefully, as outlined in the Quran and Sunnah. They adhere to the traditional reformative Islamic thought stream based on the Sunnah and the Quran and still maintain the teachings and way of life of the Prophet PBUH. This da'wah movement is one of Malaysia's long-lasting and most influential movements that utilizes mosques and madrasas as the primary medium. The terminology of the Tablighi Jamaat

movement derives from two words in Arabic: Jama'at, which means a group of people, and Tabligh, which means reaching out, making known, or letting people be informed, which is one of the attributes of the Prophet PBUH (Noor, 2012).

The Tablighi Jamaat preaching movement began in Malaysia in 1952 due to the vast arrival of pilgrims from Tamil Nadu to Penang under the leadership of Maulana Yusuf. Initially, this movement only focused on Indians who converted to Islam, but in 1969, social and economic issues drove locals' interest in being involved with this movement. Nevertheless, the expansion of the Tabligh movement spread throughout Malaysia due to influential figures who actively propagated Islamic beliefs in society, such as Mira Hussin, a trader who brought the glory of the Tabligh da'wah movement to Malaysia. In line with this, Hafiz Yaaqob Al-Ansari has also successfully expanded this movement in Penang by making the Bengali Mosque the state da'wah centre in Penang (Noor, 2012).

The second phase began in 1970, when ijtima' was implemented, thus attracting many influential figures among the middle and upper-class Malays. This Tablighi Jamaat Movement also spread to Malaysia's east coast due to the pilgrims led by Haydar Ali. Nevertheless, the arrival of the third amir, Maulana Ina'mul Hasan, in Malaysia in 1971 further accelerated the Tablighi Jamaat da'wah movement (Sharep, 2018). This phase showed significant growth and erection of da'wah centres in each state throughout the country. The locals readily and quickly accepted the da'wah method and approach propagated by the Tablighi Jamaat movement due to its moderate ideology that emphasizes inclusive moralistic values in line with the Sunnah life and principles practised by the Prophet PBUH (Sharep, 2018). For the benefit of this paper, the following will elucidate these moralistic values: Ihsan, Islah and Ikram, which will later be referred to as determinants to analyze the selected case studies (refer to Table 1).

2.4 Moralistic da'wah Values Through Architectural Interpretation

As highlighted above, all the moral values of the da'wah process are closely related to the built environment and can be translated into architecture to convey a specific meaning to society through its architectural elements. In detail, morality in the built environment is associated with how humans work on nature with good values because the built form needs to interact with the users. According to scholars (Chan, 2015), humans explore the universe within the framework rendered by revelation and try to make their existence as convenient, comfortable, and meaningful as possible. Hence, humans are responsible for taking care of the well-entrusted nature. Therefore, scholars stated that human beings with moralistic values are responsible for shaping nature's universality. It ensures that every development built by humankind respects the existing context. In fact, according to Islamic scholars like Kamali (2003), humans should take fair care of the built environment because, in Islamic belief, humans are posited as caliphates. The built environment is a powerful element that connects human civilization; therefore, moral values in the built environment are essential to safeguard the universality of nature (Chan, 2015). Thus, according to scholars, "architectural work should embody meaning that reflects the positive impact of its community's ethos".

The need for this aspect of moral value in architecture has long been raised by past thinkers such as Pugin and Violet-le-duc since the 17th century. The emergence of the need for moral values in architecture occurred when past designers in the era of eclecticism emphasized architecture in the form of imitation of mere style and aesthetics (Barker, 1992). By the 18th century, this had

created opposition and forced the birth of fitness for purpose. "The real form of things were covered over. In this period, the revolt against the falsification of forms and the past was moral revolt" (Giedion, 2009). Morris, Ruskin, Wright and Le Corbusier further expanded the idea. For example, Wright highlights architecture's moral value by displaying humble architecture to illustrate man's close relationship with God. This indirectly shows that Wright demonstrates a Christian religious ideology of sound ethical values through its organic architecture (Heney, 2020). This is where the concept of moral values in architecture begins. A study by scholar states that when a person adopts morality in shaping the built environment, the moral qualities that integrate with one religious belief may validate and decide how humans should act (Heney, 2020). Hence, this forms a direct relationship between man and the created world. Thus, the need for moral values in architecture has been the mainstay of the formation of modern architecture from the early 19th century until now (Zakharin et al., 2023).

2.4.1 Mosque Architecture as a Medium of Moral Values Representation in da'wah

Architecture forms the social context's physicality and influences human nature and behaviour (Rapoport, 1990). This happens because the embodiment of architectural aesthetics can drive human feelings. The physical appearance of the architecture not only unites the user with the built form but also, when the user uses their physical senses, the role of architecture becomes significant. Due to this interactive atmosphere, two-way communication between users and architectural elements exists. This is because architectural elements play a role in determining human behaviour (Matravers, 2001). In other words, architecture can be used to communicate and be understood. This is due to his ability to transfer a message to society when meaning is invested in architecture. Architecture can also be a tool and translation of moral values as it can demonstrate the belief in 'supernatural' power, which gives an idea of the beliefs and theology of a religion. Architecture can also shape experiences, human behaviour (community values), and feelings. Indirectly, the meaning of architecture may produce unification in society or a group that can benefit specific individuals, especially in religion and worship.

This process occurs because the architecture impacts the perception of human feelings, creating an experience. Architecture embodies unique qualities made of a 'sign' system, where architecture can communicate as a medium for translation. Architecture as a 'sign' system acts similarly to a language that can be read like text and translatable (Whyte, 2006). This is because the elements that make up the architecture include space (access, circulation, space arrangement, function and use of space), and the appearance (location and placement, scale and size, as well as façade and structure) can be understood as a language or code capable of communicating to the user (Whyte, 2006). All the elements of the design and space in the religious building, such as ornamentation, symbols (domes, stars, crosses), typology, roles, structures, and characters, can give the meaning of moral value to da'wah and the religious ideology in the form of codes that explicitly and implicitly may convey a specific message or meaning. In this regard, architecture becomes a medium to portray religious ideology and moral values in two phases, namely to individuals and society (masses) (Ismail, 2018).

Previous researchers have stated that mosque symbols such as prayer hall, minaret, dome, minbar (qibla direction), mihrab, sahn, dikka, wudhu' space, and the use of geometric elements are seen as tools to convey Islamic ideology and message to the community (Hoteit, 2015). Scholars like Ismail et al. (2010) explain that the architectural elements of the mosque can

indirectly reflect the nature of the Tauhid and Ihsan in Islam because they are symbolically connected with human principles and events. In this regard, the mosque's architecture demonstrates direct and indirect interaction with the Muslim community and the surrounding context through its physical symbolism and architectural role, which may be utilized as a tool for da'wah. In other words, the architecture of mosques translates Islamic principles and moralistic values to preach to the masses about real Islamic life. The following section explains the study method and analysis technique of the mosque owned by the Tabligh movement to reflect their Islamic ideology in promulgating moralistic da'wah values through the design of the architectural elements before elucidating the interrelationship between moralistic dawah values ideology and architectural elements in the findings section.

3.0 METHODOLOGY

This study utilizes case studies as the research strategy under qualitative methods and approaches. Since the study focuses on two branches of study, namely the study of mosques and studies on texts, books, documents, and records by Tablighi Jemaat, the appropriate type of paradigm is chosen- structuralism and Interpretivism. Structuralism involves an in-depth study of the structural logic of a cultural product, while Interpretivism consists of the study of reality that an individual shapes through an implicit meaning. The study will focus on the mosque and madrasa building structure that was built and used by the Tablighi Jamaat missionary movement. Interpretations will be conducted to find out why and how this movement shaped the construction of their mosque. Since this study requires an understanding of the hidden meaning behind an object, semiotics is applied to unveil the meaning behind the construction of two built forms by Malaysia's Tablighi Jamaat movement.

On the other hand, Interpretivism processes data subjectively adjusted to the selection of hermeneutic approaches. This approach makes it easier for researchers to understand and process data in a social phenomenon that can answer why, how, and what happens when reading speech texts, documents, books and others. Hermeneutics allows researchers to understand the purpose of a person or an organization for their actions. In this study, the Tablighi Jamaat moralistic values of da'wah were studied regarding their principles and actions. This is conducted to identify Tablighi Jamaat Islamic values, which influence their ideological thinking, and evaluate the relevance of the Tablighi Jamaat movement towards shaping the mosques and madrasa architecture as the centre of da'wah. This multiple case study will include an analysis of two types of buildings by the Tablighi Jamaat da'wah movement since their arrival to Malaysia in the 1950s until now based on the context of the ideological holdings of the founders of the Pilgrims as well as their involvement in their da'wah activities in mosques in Malaysia. The centre of the Tablighi Jamaat da'wah movement consists of mosques, surau, madrasahs, houses and halls. However, in the interest of the study, only the prominent mosques that disseminate da'wah and their activities were chosen as case studies. This is because Mosques are the central heart of their da'wah. In addition, the selection is also made based on history to see the changes that occurred after the arrival of the Tabligh da'wah movement in the mosque until now. As for the data collection method, direct observation is used to observe the selected case studies.
In contrast, interviews with specified officials and professionals are used to obtain knowledge of the history and background of the mosque and the purpose of the elements and architecture of the mosque. The analysis was based on an explanation built by Yin (2011). This analysis can explain the phenomenon based on specific causes and effects. Therefore, the study of the Mosque by Tablighi Jamaat is divided into two phases:

The first phase of the analysis is done separately, based on the observational study of the heritage Bengali Mosque, followed by documentation analysis and interviews related to mosques. The research also includes studying da'wah documents from the Tablighi Jamaat movement and its activities in Malaysia. The second phase of analysis identifies the similarities and differences between each mosque to underline the characteristics and elements of mosques and madrasas patronized by Tablighi Jamaat. Later, studies on the ideology of the Tablighi Jamaat missionary movement were linked to identify the factors that shaped their Islamic da'wah ideology. Finally, both analyses were combined to determine how the Islamic da'wah ideology brought about by the movement affected the mosque used as the centre for da'wah to showcase moralistic values (refer to Figure 1)

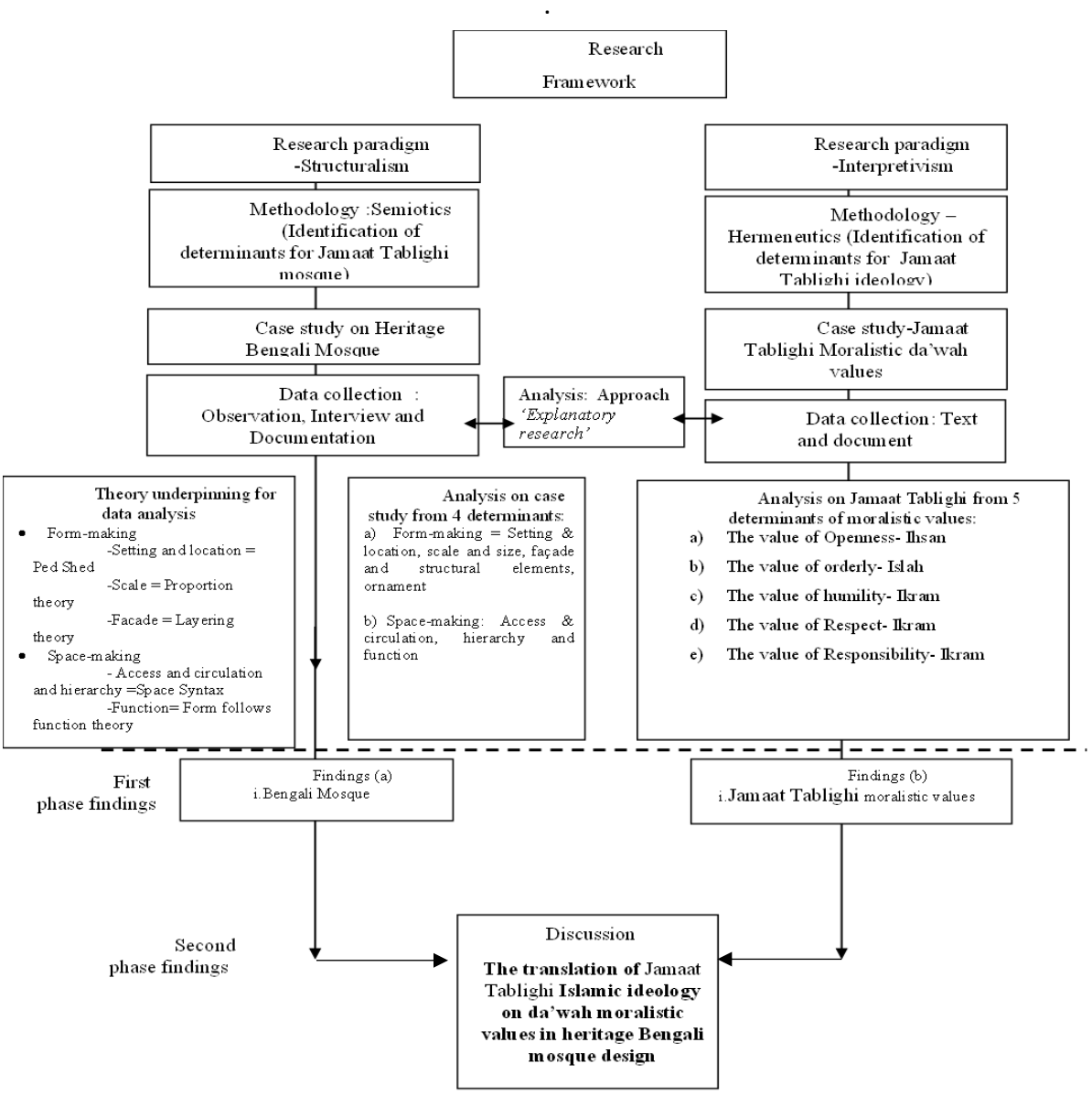


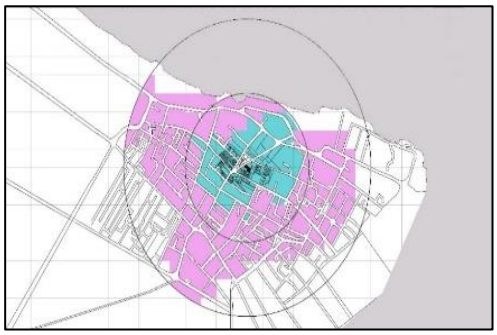
Fig. 1: Research framework

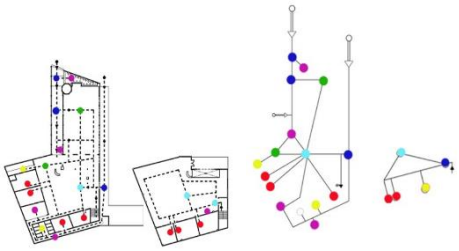
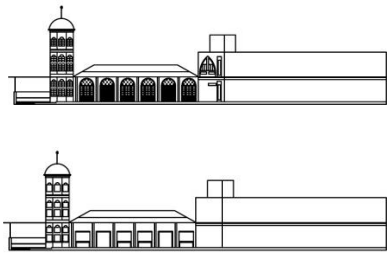
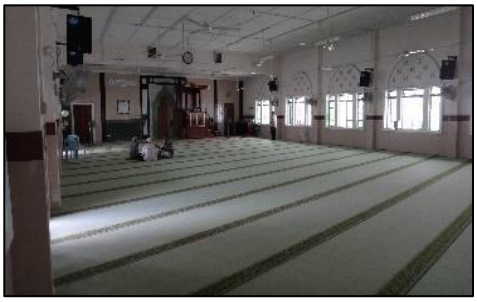
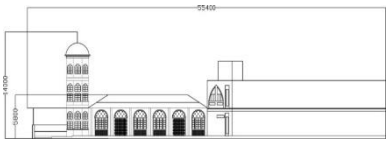
Fig. 2: Image of Bengali Mosque

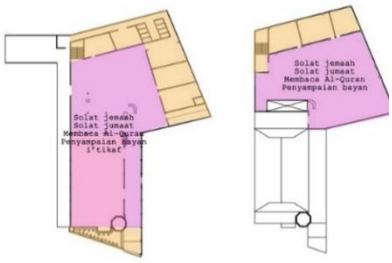
4.0 RESULTS AND DISCUSSION

This section will elucidate findings from the heritage Bengali Mosque, which is one of the primary da'wah centres of the Tablighi Jamaat da'wah movement in Malaysia, whose selection is based on the criteria set to reflect the moral values of da'wah through architectural elements. Each of these buildings is explained individually in terms of its background, followed by an analysis of variables. The variables are divided into two phases: building form (location and placement, scale and size, façade and structure) and spatial organization (access and circulation, hierarchy of space arrangement and function). These architectural elements can be a translation for communicating with users and their environment. In this sense, the mosques' form-making and spatial arrangement can convey the da'wah message to the community (Refer to Table 1)

Table 2: Relationship between Tablighi Jamaat Islamic ideology with Bengali Mosque architecture

Jamaat Tablighi's moralistic da'wah values	**Values influence on the heritage of Bengali Mosque architecture**	**Diagram of Bengali Mosque as a case study**
Ihsan (performing good deeds and to others, doing something in the best way): Openness	**Location and Placement (Figure 3)** The mosque is located in the middle of the city's populated urban area. It is beside the main road and has no fencing. The strategic location makes it easier for the public to see the mosque from far away, thus increasing community involvement with the mosque. **Access (Figure 4 & 5)** The mosque has permeable access, but the main primary access faced the populated areas and the main road. Hence, the number of mosque accesses provides a welcoming nature for visitors to enter the mosque. The direct access is directed towards the main prayer hall, which can quickly be identified as free flow. Therefore, it can be seen that the entrance to the main prayer hall is directed and not limited (unrestricted).	 **Figure 3**: Site plan of the heritage Bengali mosque, surrounded by shophouses

	<u>Facades & Structures</u> (Figure 6) Due to its axial nature, the mosque has a straightforward façade arrangement and hierarchy. The façade of the Bengali mosque consists of a mixture of architectural styles based on local history, such as Art Deco, Moghul, and North Indian architecture. The mosque's transparent external access façade, with a rhythmic expression and a clear axial structure, makes it easier to identify. The façade's openness is essential not only to facilitate the public's view into the mosque to see the activities but also to facilitate the overflow of activities to be conducted externally and internally within the mosque compound. This provides interaction with the public, either Muslims or non-Muslims, to see the natural way of Muslim life.	 **Figures 4 & 5**: The site plan of the ground and first-floor mosque have various access that is directed to the main prayer hall (blue node)  **Figure 6**: Facade of Bengali mosque with rhythmic expression
Islah: (To improve and to perform something better that benefits others) Order and functional	**<u>Hierarchy and functions of space</u>** **(Figure 7)** The mosque utility areas are segregated from the main prayer hall. The wudhu space acts as a secondary node and is connected to the men's and women's prayer spaces within a few steps in the distance. However, the mosque has properly separated pathways between spaces for women and men and particular pathways for the public and dawah (Jemaah) activities. This is evident for privacy purposes and to protect women's dignity (aurah). This mosque space arrangement follows the correct Islamic principles in providing an example of manners or adab to show good morals and practices. **<u>Scale & Size</u> (Figure 8)** The mosque is built modestly according to the human proportion that integrates with the context and is not monumental. The scale of the built form is well integrated with the overall building function, showing the practice of simplicity and humility in the Islamic religion.	 **Figure 7**: The Bengali Mosque prayer hall exclusive arrangement according to appropriate zoning  **Figure 8**: The Bengali Mosque scale built form integrates with existing context

Ikram : (Righteous manners) Responsible and responsive to context	**<u>Spatial organization</u> (Figure 9)** The hierarchical space arrangement is according to worship and community facilities. The mosque spaces functioned well, following the user's requirements for ibadah. The evolvement of the mosque spaces is based on the needs of da'wah and the congregation. The mosque's social interaction space is categorized as the primary node. Spaces are well arranged to cater to all levels of activities like worship, dawah, and social space. For the use of space, the mosques provide universally usable space. The percentage of multifunctional space is maximum. **<u>Structure and construction</u> (Figure 10)** The mosque shows an attempt to integrate with the local climate and culture in line with local building materials and technology. This mosque maximizes the placement of openings in the area that have maximum lighting in the mosque and interact with the local climate, showing how it reflects an architecture responsive to the context.	 **Figure 9**: The Bengali Mosque spatial layout  **Figure 10**: The Bengali Mosque structural interior

5.0 CONCLUSION

In sum, this study can explain the relationship between the da'wah movement and architecture, which is the ideological method of the Islamic movement by Tabligh whereby the message of da'wah is conveyed to the Muslim community through the design of mosques. This research demonstrates how the Tabligh patrons influence the mosque architecture as a sign. In this sense, it shows how architecture is an intermediary agent that communicates the builder's message in the form of architectural physical manifestations through systems of codes. This study has merit as it adds new knowledge to existing studies focused on the role of Bengali mosques not only significantly as a heritage religious building but also as a centre for the da'wah movement.

ACKNOWLEDGMENTS

The authors thank and acknowledge Universitas Negeri Malang for the International Grant 4B870 and Universiti Teknologi Malaysia for the Matching Grant 04M46 provided for this research.

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