

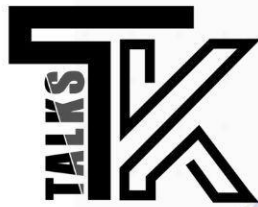
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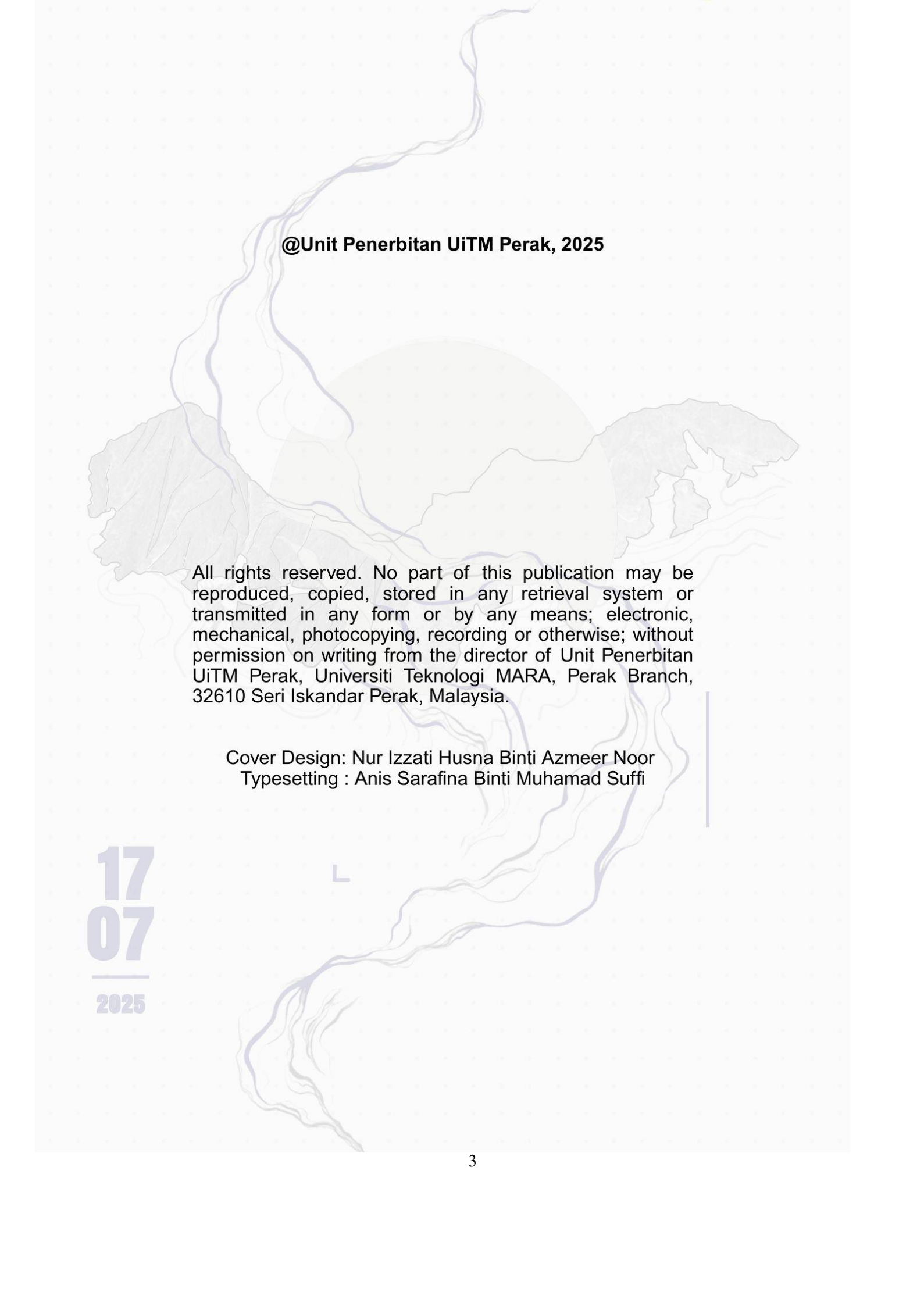
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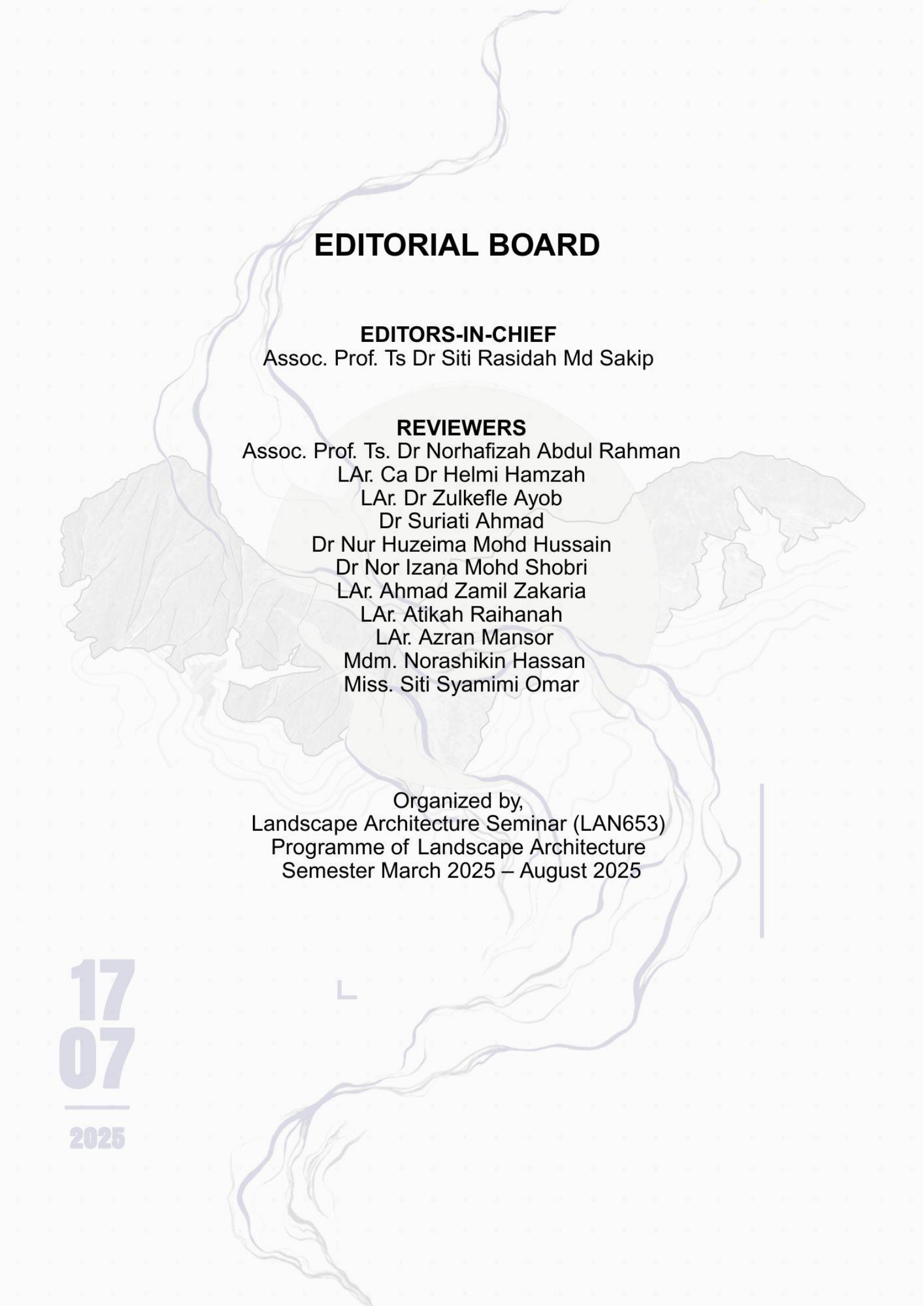


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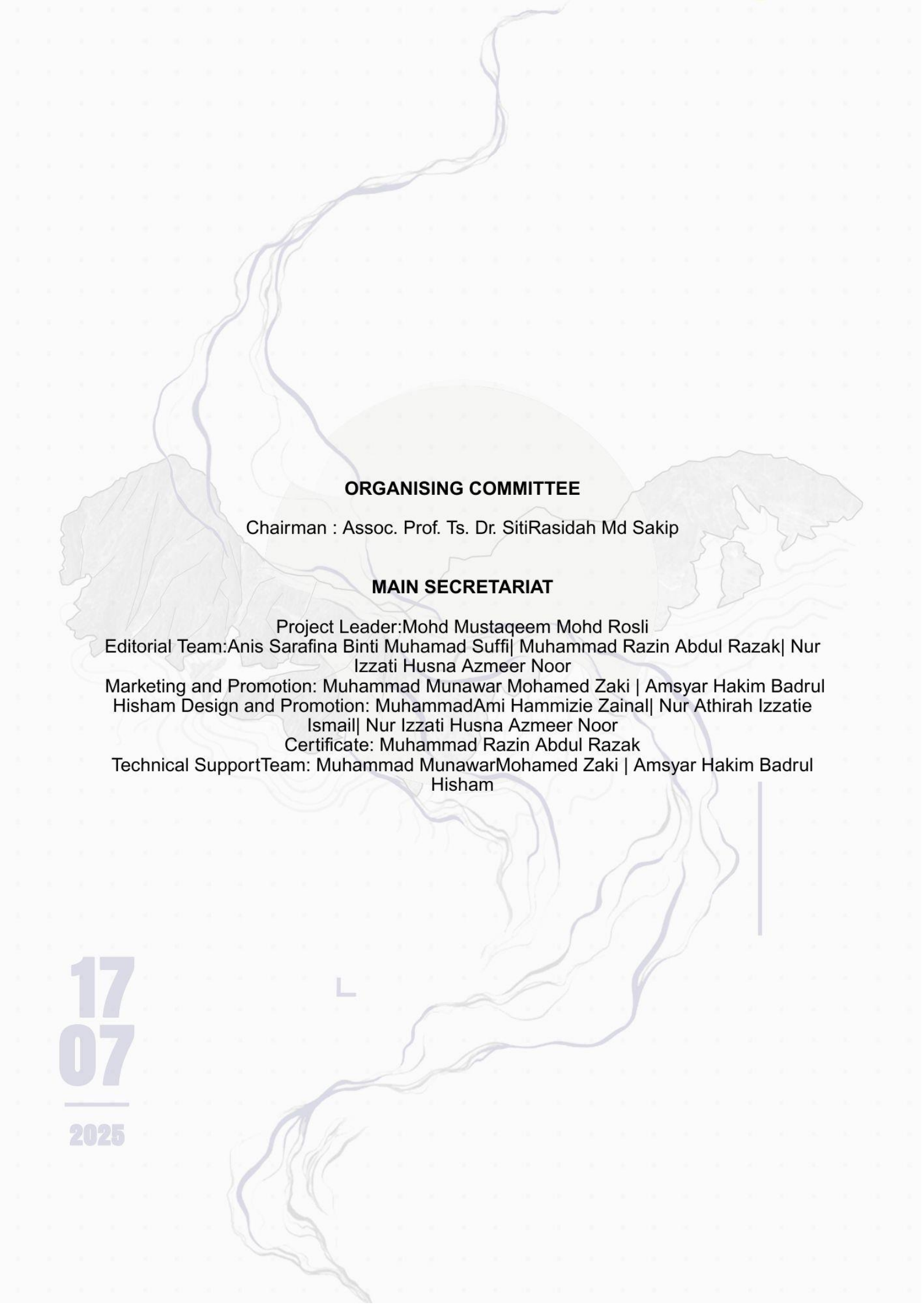
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# Public and Professional Perception regarding Nature-Based Solutions in Urban Street: A case study in Ipoh, Malaysia

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## Abstract

This research critically evaluates the application of Nature-Based Solutions (NBS) against conventional Drainage systems along the urban corridor from KTM Station Ipoh to Dataran Dato Sagor, Malaysia. In a region experiencing escalating climate pressures and rapid urbanisation, the study investigates the perceived relative effectiveness of these approaches in addressing interconnected challenges: vegetation (planting) integration, pollution control, aesthetic enhancement, urban resilience, and climate change adaptation. A quantitative research methodology was employed, utilising structured online surveys with targeted sampling to capture divergent public perceptions and professional perceptions (academia, local authorities, and private sector practitioners). Data were analysed through statistical comparative tests to identify significant differences in stakeholder evaluations. Findings reveal a notable divergence: professionals demonstrate statistically significant preference for NBS strategies, particularly emphasising their superiority in planting integration, pollution control, aesthetic value, and long-term urban resilience. Conversely, public views show considerable variation. While some residents and visitors recognise additional benefits of NBS, many express uncertainties or a clear preference for conventional Drainage systems. This scepticism appears linked to practical concerns: doubts about system performance during heavy storms, the burden of ongoing maintenance, or space limitations in built-up areas. The comparative analysis thus exposes tensions between technical advocacy for Nature-Based solutions and practical implementation barriers rooted in public receptivity. It further emphasises context-specific advantages and potential limitations of Nature-Based solutions in mitigating environmental degradation within complex urban infrastructures, suggesting that perceived "effectiveness" is contingent not only on biophysical performance but also socio-institutional acceptance and behavioural adaptation.

**Keyword:** Nature-Based Solutions (NBS), Urban Street, Public Perceptions, Professional Perceptions

## INTRODUCTION

Urbanisation has resulted in numerous environmental challenges, including poor drainage, pollution, and the loss of green spaces, which significantly impact the quality of urban life. Conventional Drainage systems, such as scupper drains, roadside drains, and monsoon drains, have been used to control water flow in urban areas. However, these systems often fail to address broader environmental issues such as vegetation integration, pollution control, and urban resilience to climate change. As cities continue to expand, there is an increasing need for more sustainable solutions that can integrate nature into urban spaces and help mitigate environmental degradation (Cohen-Shacham et al., 2019; Seddon et al., 2020).

Nature-Based Solutions (NBS), which include strategies like permeable pavers and bioswales, offer a promising alternative. These solutions leverage natural processes to manage stormwater, improve air quality, enhance biodiversity, and provide aesthetic and recreational benefits (Raymond et al., 2017). Nature-Based Solutions (NBS) are not only effective in managing water but also contribute to urban resilience by addressing climate variability and enhancing the ecological health of cities (Kabisch et al., 2016). Despite the known benefits, there is limited research comparing Nature-Based Solutions (NBS) approaches with Conventional Drainage systems in specific urban contexts.

This study investigates the application of Nature-Based Solutions (NBS) within urban streets, specifically comparing permeable pavers and bioswales with conventional drainage systems along the urban corridor from KTM Station Ipoh to Dataran Dato Sagor. The primary goal is to evaluate the effectiveness of these approaches in addressing urban challenges, including vegetation (planting) integration, pollution control, aesthetic enhancement, urban resilience and climate change adaptation.

## **LITERATURE REVIEW**

### **Definitions of Nature-Based Solutions (NBS)**

Nature-Based Solutions (NBS) are increasingly recognised as effective strategies to address climate change and enhance urban sustainability by harnessing natural processes. These solutions include green infrastructure such as permeable pavements, bioswales, green roofs, and urban forests, which help manage stormwater, improve air quality, enhance biodiversity, and mitigate urban heat islands (Mahmoud, 2024; Cilliers et al., 2022). Nature-Based Solutions (NBS) contribute to climate adaptation and mitigation by reducing vulnerability to climate change impacts while promoting biodiversity and ecosystem health. They also offer socio-economic benefits, such as improving urban liveability, creating recreational spaces, and generating green jobs, particularly in urban areas (Balzan, 2023; Debele et al., 2023).

Successful implementation of Nature-Based Solutions (NBS) requires collaboration among stakeholders, including local communities, policymakers, and urban planners. Effective strategies involve ecosystem service assessments to prioritise Nature-Based Solutions (NBS) based on local needs and environmental conditions. Case studies from cities like Nice, Utrecht, and Milan demonstrate the successful integration of Nature-Based Solutions (NBS) into urban planning, addressing climate challenges and promoting social regeneration (Mahmoud, 2024). In cities like Amersfoort and Lephalale, scaling-up Nature-Based Solutions (NBS) has proven effective in climate adaptation planning, showcasing their flexibility in addressing diverse urban and environmental challenges (Cilliers et al., 2022).

### **Public and Professional Perception of Nature-Based Solutions**

#### **1. Public Perception**

Public perception is a critical factor influencing the successful implementation of Nature-Based Solutions (NBS). Research shows that perceptions are significantly shaped by socio-demographic factors, including age, education, and income levels. In cities like Ouagadougou, positive attitudes towards urban nature were linked to proximity to green spaces, emphasising the importance of accessibility for enhancing public support (Combary & Atchrimi, 2024). The more people experience green spaces, the more likely they are to support NBS. Trust in the implementers of NBS also plays a crucial role in public acceptance. Scepticism about their effectiveness can lead to demands for evidence and greater transparency (Anderson et al., 2021).

Educational initiatives are essential for improving public perceptions and fostering participation in NBS projects. For example, Ningbo's Sponge City Programme has shown how public education can increase awareness of NBS benefits, such as climate resilience and water management, leading to stronger community connections to nature (Ka et al., 2023). However, challenges remain in overcoming scepticism, and effective communication strategies that consider local values and needs are necessary to bridge gaps and encourage broader public engagement (Anderson et al., 2021).

## 2. Professional Perception

Professional perception of Nature-Based Solutions (NBS) is largely positive, with various fields acknowledging their importance for addressing environmental and health challenges. Allied health professionals (AHPs) recognise the effectiveness of NBS in managing physical and mental health outcomes but stress the need for more robust evidence and increased education to support their integration into healthcare practices (Stanhope et al., 2024). Urban planners also view NBS as essential for sustainable development, though they face challenges related to socio-demographic factors and the necessity of participatory planning to ensure local community needs are met (Combary & Atchrimi, 2024). In marine contexts, practitioners emphasise the importance of policy frameworks and stakeholder collaboration to successfully implement blue NBS, which are vital for coastal resilience (O'Leary et al., 2024).

Despite the positive views, there are concerns about oversimplifying the role of NBS in addressing complex urban and environmental issues. The European Commission promotes NBS as a transformative tool for urban resilience yet acknowledges the need for a balanced understanding of their limitations (O'Sullivan et al., 2020). Policy support, education, and funding initiatives are essential to overcome the challenges of integrating NBS into urban and environmental strategies, with a strong emphasis on collaboration and evidence-based approaches to ensure their long-term success.

### Urban Streets and Their Role in Sustainable Cities

Nature-Based Solutions (NBS) offer a promising approach to transforming urban streets by integrating ecological components into city planning. These solutions address key urban challenges such as flooding, climate resilience, and biodiversity loss, while simultaneously improving the quality of life for urban residents. NBS, such as permeable pavements, bioswales, and strategically planted street trees, enhance urban drainage by increasing permeability and reducing runoff. For instance, the use of bioswales and the Memorial Parking Trees (MPTs) concept, which repurpose underutilised spaces like parking areas, not only help improve drainage but also provide valuable ecological benefits (Acosta & Haroon, 2021). These green interventions contribute to urban resilience, particularly by mitigating the urban heat island effect and improving the aesthetic quality of urban streets, as demonstrated in cities like Grad Velika Gorica, where street trees significantly shaded cycle lanes and footpaths, reducing temperatures (Weidmüller et al., 2024).

NBS also play a crucial role in supporting urban carbon neutrality by sequestering carbon and offsetting emissions, as exemplified in Stockholm, Sweden, where a framework for identifying suitable NBS interventions maximised local environmental benefits (Cong et al., 2023). Beyond mitigating climate change, NBS enhance urban biodiversity and ecosystem services by improving green space quality and fostering ecological resilience (Ronchi & Salata, 2022). However, their successful implementation requires careful consideration of local socio-economic conditions, financial constraints, and land-use changes. Collaborative efforts among communities, public authorities, and academia are essential to ensure that NBS are integrated effectively into urban planning and management (Valéria Borges Yonegura et al., 2024; Weidmüller et al., 2024).

## Relationship Between NBS, Public and Professional Perception, and Urban Street/Street Plaza

*Table 1: Table for Literature Review*

| Domain                                            | Key insights                                                                                                                                        | Author                                                                                                                    | Findings                                                                                                                                       |
|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Definition of Nature-Based Solutions (NBS)</i> | 1.NBS help reduce the impacts of climate change, enhance resilience, and provide environmental benefits like improved air quality and biodiversity. | Mahmoud (2024); Cilliers et al. (2022); Faivre et al. (2017); IUCN (2022); UNEP (2022)                                    | NBS manage stormwater, reduce heat islands, and support biodiversity, leading to more sustainable urban environments.                          |
|                                                   | 2.NBS contribute to socio-economic benefits, such as providing green jobs and improving urban liveability                                           | Balzan (2023); Debele et al. (2023)                                                                                       | NBS can mitigate social challenges, such as inequality and community fragmentation, by creating recreational spaces and green jobs.            |
| <i>Public Perception</i>                          | 1.Public support for NBS is influenced by visible, immediate benefits like aesthetics, recreational areas, and green spaces.                        | Combary & Atchrimi (2024); Chan et al. (2023); Seddon et al. (2020); Faivre et al. (2017); Kabisch et al. (2016)          | Positive public perception is linked to the visible benefits of NBS, but scepticism remains regarding long-term maintenance and effectiveness. |
|                                                   | 2.Public education and engagement are essential to increase awareness and support for NBS initiatives.                                              | Anderson et al. (2021); Yonegura et al. (2024)                                                                            | Effective education and participatory planning are crucial for addressing concerns and fostering public trust in NBS.                          |
| <i>Professional Perception</i>                    | 1.Professionals view NBS as effective strategies for addressing environmental challenges, particularly for climate resilience and sustainability.   | Anderson et al. (2021); Yonegura et al. (2024); Cohen-Shacham et al. (2019); Raymond et al. (2017); Kabisch et al. (2016) | Professionals emphasize the need for evidence-based approaches and policy frameworks to ensure the long-term success of NBS.                   |
|                                                   | 2.The technical feasibility of NBS and their ability to address complex urban challenges are key concerns among professionals.                      | Anderson et al. (2021); Cohen-Shacham et al. (2019); Raymond et al. (2017)                                                | Professionals focus on the practical aspects of NBS, such as cost, maintenance, and integration into urban planning frameworks.                |
| <i>Urban Streets/Street Plaza</i>                 | 1.NBS in urban streets enhance drainage systems, reduce runoff, and provide aesthetic and ecological benefits.                                      | Maes & Jacobs (2017); Raymond et al. (2017); Seddon et al. (2020); Eggermont et al. (2015); UNEP (2022)                   | NBS improve urban street functionality, creating multi-benefit spaces that address environmental challenges while promoting social well-being. |
|                                                   | 2.Incorporating NBS into urban streets supports climate resilience by mitigating heat islands and increasing green spaces.                          | Maes & Jacobs (2017); Raymond et al. (2017)                                                                               | Integrating green infrastructure into streets enhances urban resilience and supports sustainable, liveable cities.                             |

The relationship between Nature-Based Solutions (NBS), public and professional perceptions, and urban streets is central to the successful integration of NBS into urban environments. Nature-Based Solutions (NBS) utilise natural processes to address urban challenges such as climate resilience, stormwater management, and biodiversity (Mahmoud, 2024; Cilliers et al., 2022). Applied to urban streets, NBS provide visible benefits such as improved air quality, green spaces, and enhanced social well-being, which positively shape public perception (Combary & Atchrimi, 2024; Chan et al., 2023). While public support is driven by these immediate benefits, concerns about long-term maintenance persist, making education and community engagement important (Anderson et al., 2021; Yonegura et al., 2024). Professionals, however, focus on technical aspects such as feasibility and sustainability, viewing NBS as essential for climate action and sustainable development, but requiring evidence-based approaches (Raymond et al., 2017). Successfully integrating NBS into urban streets necessitates balancing public support with professional expertise.

## The research working Definition

The working definition for this research positions Nature-Based Solutions (NBS) as strategic interventions in urban streets and plazas that harness natural processes and green infrastructure, specifically permeable pavements and bioswales, to address interconnected environmental and socio-urban challenges. While proponents emphasise their multifunctionality in enhancing stormwater management, air quality, biodiversity, and mitigating urban heat islands (Mahmoud, 2024; Cilliers et al., 2022), their efficacy remains context-contingent and subject to trade-offs. NBS are framed as advancing climate resilience and urban quality of life through ecological, hydrological, and social co-benefits (Faivre et al., 2017; UNEP, 2022). However, claims of inherent social equity or green employment generation (Balzan, 2023; Debele et al., 2023) require empirical validation, particularly in rapidly urbanising Southeast Asian settings like Ipoh, where site-specific constraints (e.g., space limitations, institutional capacity) critically influence implementation viability and benefit realisation.

## RESEARCH METHODOLOGY

### Site Selection

*Figure 1: Site plan of KTM Ipoh to Dataran Dago Sagor*



*Source: Google Earth 2024*

Site selection for this quantitative assessment of public and professional perceptions of Nature-Based Solutions (NBS) versus conventional drainage systems was guided by three criteria: (1) representation of high-footfall urban streets and civic spaces, (2) reliance on Conventional Drainage systems (scupper drains, roadside drains, monsoon drains), and (3) exposure to documented urban stressors (e.g., flooding, heat island effects).

The 1.11-km urban corridor from Station KTM Ipoh to Dataran Dato Sagor was selected as a critical case meeting these parameters. This stretch encapsulates high-traffic streets adjacent to Station KTM Ipoh and a civic urban plaza at Dataran Dato Sagor, both exclusively dependent on ageing Conventional Drainage systems. However, this selection invites scrutiny: while the site offers spatial diversity for comparing NBS (permeable pavers, bioswales) with Conventional Drainage systems, its limited perimeter (1.11 km) risks underrepresenting Ipoh's hydrological heterogeneity. The corridor's focus on centralised zones may overlook peri-urban drainage challenges, and its existing infrastructure could bias perceptions against NBS due to public familiarity with conventional approaches. Nevertheless, its concentrated urban character, experiencing recurrent pollution, inadequate planting integration, and climate change pressures, provides a controlled context to evaluate perceived effectiveness in aesthetic enhancement, urban resilience, and pollution control.

## **Ethical Considerations**

This study will uphold strict ethical standards to ensure the protection of participants' rights and confidentiality. Participants will be fully informed about the study's purpose, procedures, and their voluntary involvement before providing informed consent. All survey responses will remain anonymous and confidential, with no identifying information collected. Participants will be assured that their data will be used solely for academic purposes and stored securely. They will also be informed of their right to withdraw from the study at any time without consequences. The research will comply with the ethical guidelines set by Malaysia's academic and governmental institutions, ensuring no harm or discomfort to participants. Efforts will be made to minimize biases and ensure transparency in the data collection process, with a commitment to protecting the privacy and dignity of all participants.

## **Limitations**

This research acknowledges several limitations. The study relies on a relatively small sample size of 31 respondents, which could limit the broader applicability of the findings. However, according to the Central Limit Theorem, a sample size of 30 is generally considered adequate for assuming a normal distribution of data, making it suitable for conducting inferential statistical tests like t-tests and ANOVA (Ghasemi & Zahediasl, 2012). Additionally, the research focuses on the urban corridor from Station KTM Ipoh to Dataran Dato Sagor, which may not fully reflect perceptions or challenges in other areas of Ipoh or different urban environments. The use of an online survey may also exclude participants who are less familiar with digital platforms, potentially affecting the diversity of the sample. While the study aims to provide a comprehensive comparison of NBS in an urban street and conventional drainage systems, the findings are exploratory and may not capture all perspectives or nuances related to the implementation of NBS in urban planning.

## **Sample Size**

The target sample size consists of two primary groups:

- Public respondents: A total of 13 participants, randomly selected from residents or visitors in Ipoh. This

includes individuals who have lived in Ipoh for over three years as well as those who have visited the city more than five times.

- Professional respondents: A total of 18 participants, including academics, local government authorities, and professionals working in urban planning, environmental management, or related fields.

A random sampling technique will be employed to select a mix of residents, visitors, and professionals, ensuring a diverse representation of perspectives. This approach is appropriate for the study as it allows for the collection of a broad range of opinions, minimizing biases in the sample. By including participants from different backgrounds and areas of expertise, the study can capture varied insights based on both lived experience and professional knowledge. Random sampling ensures that every individual in the target population has an equal chance of being selected, which is critical for obtaining unbiased, representative data (Creswell & Creswell, 2018).

## **Data Collection and Analysis**

This research utilises a quantitative approach to gather data on public and professional perceptions of Nature-Based Solutions (NBS) compared to conventional drainage systems within urban streets. The study focuses on the urban corridor from Station KTM Ipoh to Dataran Dato' Sagor, comparing NBS interventions such as permeable walkways, bioswales, and semi-bioswales with conventional drainage systems like scupper drains, roadside drains, and monsoon drains. Data will be collected through two structured surveys: one for public respondents (residents and visitors) and one for professional respondents (urban planners, local authorities, and environmental experts). Both surveys will be identical in structure to ensure consistency in the data collected.

This research examines the perceptions of Nature-Based Solutions (NBS) and conventional drainage systems based on five key urban challenges: planting integration, pollution control, aesthetic value, urban resilience, and climate change adaptation.

1. Planting Integration: NBS, such as bioswales and permeable surfaces, are known to enhance green spaces and improve urban ecology by integrating vegetation, which contributes to climate resilience and carbon sequestration (Raymond et al., 2017).
2. Pollution Control: NBS effectively manage urban runoff and pollution by filtering stormwater, whereas conventional systems do not offer the same environmental benefits (Giles et al., 2016).
3. Aesthetic Value: NBS improve the visual appeal of urban spaces, promoting environmental engagement and enhancing liveability (Kabisch et al., 2017).
4. Urban Resilience: NBS contribute to social resilience by enhancing community well-being, providing spaces for recreation, and mitigating urban climate risks (Cohen-Shacham et al., 2019).
5. Climate Change Adaptation: NBS play a crucial role in adapting to climate change by managing heat islands, improving water retention, and supporting biodiversity (Seddon et al., 2020).

Demographic data, including age, gender, education level, and professional background, will also be collected to analyse how these factors influence perceptions of NBS and conventional drainage systems. The survey will be distributed via Google Forms, using WhatsApp and email, and will remain open for two weeks, from May 17, 2025, to May 30, 2025. The data will be analysed using IBM SPSS Statistics software, and the analysis will include the following techniques Percentage of Agreement. This measure will calculate the percentage of respondents who agree or strongly agree with specific statements related to NBS effectiveness, pollution control, and other factors. This will provide insights into the overall acceptance and perceived impact of NBS and conventional drainage systems on urban environments.

The survey responses will be analysed separately for the public and professional groups to understand any differences in perspectives, while maintaining consistency across both surveys in terms of structure and focus (Bryman, 2016; Fowler, 2014).

## DATA ANALYSIS FINDING

This analysis presents a comparison of public and professional survey responses regarding Nature-Based Solutions (NBS) and conventional drainage systems in addressing vegetation (planting) integration, pollution control, aesthetic enhancement, urban resilience, and climate change adaptation along the urban streets and street plaza from Station KTM Ipoh to Dataran Dato' Sagor, to evaluate their relative effectiveness.

### Demography Respondent

The survey sample consisted of 31 respondents, predominantly male (64.5%), with a significant representation of younger individuals, particularly within the 20–29 age group (54.8%). Ethnically, the sample was primarily Malay (83.9%), which aligns with the demographic composition of the region, with smaller contributions from Chinese (12.9%) and other ethnicities (3.2%). Educationally, the respondents were well-educated, with the majority possessing at least a bachelor's degree (51.6%), indicating a high educational attainment across the sample. Additionally, 29% held diplomas or certificates, and 12.9% had postgraduate qualifications. This suggests that the sample may be more familiar with technical concepts, such as Nature-Based Solutions (NBS) and urban design.

In terms of employment, the majority were employed in the private sector (58.1%), followed by students (16.1%) and those in the government sector (9.7%). Notably, a significant portion of the respondents worked in design-related fields (landscape architects, designers, and academicians), representing 58.1% of the sample. This professional background provides valuable insights into the perceptions of NBS and conventional urban solutions. Geographically, 48.4% of respondents were Ipoh residents, with the majority living in the city centre (25.8%) and suburban areas (19.4%). Some respondents had lived in Ipoh for over 10 years (25.8%), suggesting familiarity with the local urban environment. The remaining respondents (51.6%) were visitors to Ipoh, with 41.9% visiting frequently. This mixture of local and external perspectives is critical for understanding the broader perception of urban challenges and potential solutions in Ipoh.

### Exposure to understanding urban issues (heat, pollution, aesthetics, etc.), nature-based solution (NBS) vs conventional method.

Figure 2: *Exposure Respondents towards NBS (N=31)*

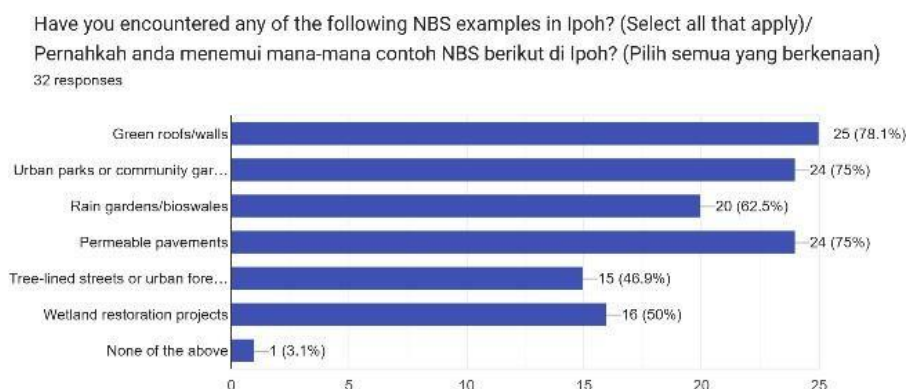
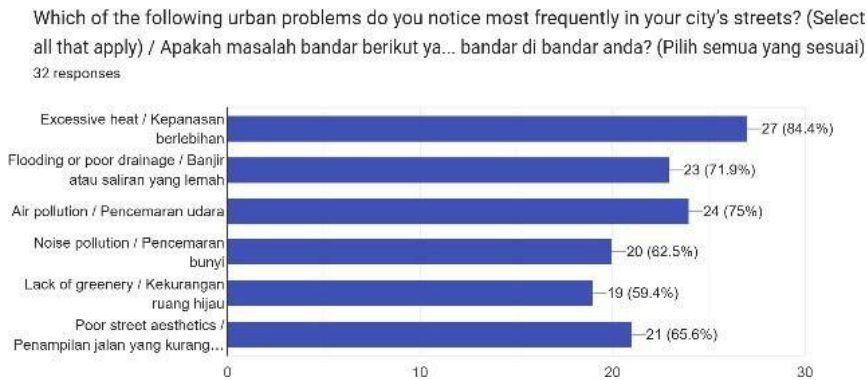


Figure 3: *Exposure Respondents towards NBS (N=31)*



Respondents were asked about their exposure to Nature-Based Solutions (NBS) and urban problems in Ipoh. The most encountered NBS were green roofs/walls (78.1%), urban parks (75%), and rain gardens/bioswales (62.5%), with wetland restoration projects being the least familiar (3.1%). Regarding urban issues, excessive heat was the most frequently noticed problem (84.4%), followed by flooding/poor drainage (71.9%) and air pollution (62.5%). Other concerns included a lack of greenery (59.4%) and poor street aesthetics (65.6%), highlighting key urban challenges in Ipoh.

This questionnaire section explored respondents' familiarity with Nature-Based Solutions (NBS) and their views on urban environmental priorities and infrastructure adequacy. Most respondents (n=23, 71.9%) were familiar with the NBS concept, while (n=5, 15.6%) had never heard of it, and (n=4, 12.5%) were unsure. This indicates a relatively strong awareness of sustainable design strategies among the surveyed group. Environmental improvement was widely regarded as essential, with (n=28, 87.5%) rating it as *very important* and (n=4, 12.5%) as *important*. Similarly, the importance of green urban spaces for sustainable city development was affirmed by (n=29, 90.6%) as *very important* and (n=3, 9.4%) as *important*.

When evaluating existing conventional drainage systems, perceptions were more critical. (n=8, 25.8%) strongly disagreed and (n=11, 35.5%) disagreed that these systems sufficiently address urban flooding and pollution. (n=8, 25.8%) was neutral, while only n=5 (16.1%) agreed. This reflects growing scepticism about conventional infrastructure and highlights the perceived relevance of NBS for urban resilience and sustainability.

## The Perception Regarding Nature-Based Solutions (NBS) vs. Conventional Drainage between Public and Professional

### Planting Integration

Table 2: *Planting integration question section*

| question no. | Response (N=31) |                       |                     |      |
|--------------|-----------------|-----------------------|---------------------|------|
|              | Participants    | Nature-based solution | Conventional method | Both |
| S1           | Public          | 7                     | 1                   | 5    |
|              | Professional    | 16                    | 1                   | 1    |
| S2           | Public          | 9                     | 0                   | 4    |
|              | Professional    | 15                    | 1                   | 2    |
| S3           | Public          | 9                     | 0                   | 4    |
|              | Professional    | 14                    | 1                   | 3    |
| S4           | Public          | 8                     | 2                   | 3    |
|              | Professional    | 14                    | 2                   | 2    |

The comparative findings reveal a clear professional consensus on the superior capacity of Nature-Based Solutions (NBS) to facilitate effective planting integration within urban streetscapes. Landscape architects overwhelmingly endorsed NBS, drawing on their informed perspective of ecological design and spatial functionality. In contrast, public responses were more heterogeneous, with a notable proportion either favouring conventional infrastructure or expressing no clear preference. This divergence highlights a perceptual gap rooted in differing technical understanding and exposure to NBS principles. The results underscore the imperative for knowledge transfer and public engagement to better align societal perceptions with best practices in sustainable urban greening.

## Pollution Control

*Table 3: Pollution Control question section*

| question no. | Response (N=31) |                       |                     |      |
|--------------|-----------------|-----------------------|---------------------|------|
|              | Participants    | Nature-based solution | Conventional method | Both |
| S1           | Public          | 6                     | 1                   | 6    |
|              | Professional    | 14                    | 2                   | 2    |
| S2           | Public          | 6                     | 2                   | 5    |
|              | Professional    | 14                    | 1                   | 3    |
| S3           | Public          | 3                     | 5                   | 5    |
|              | Professional    | 12                    | 2                   | 4    |
| S4           | Public          | 4                     | 6                   | 3    |
|              | Professional    | 9                     | 3                   | 6    |
| S5           | Public          | 4                     | 4                   | 5    |
|              | Professional    | 12                    | 1                   | 5    |

The data reflect a consistent trend among professionals, particularly landscape architects, who overwhelmingly perceive Nature-Based Solutions (NBS) as more effective in managing urban pollution, particularly in filtering stormwater to reduce contaminants such as oil, chemicals, and solid waste. This view reflects their technical grounding in ecological infrastructure and sustainable drainage strategies. Among the public, responses were more balanced, with equal support for NBS, conventional methods, and both systems, suggesting less certainty or limited exposure to the mechanisms behind pollution mitigation. The second indicator, perceived effectiveness in reducing urban runoff and pollution during storms, reinforces this professional-public divide. Landscape architects again demonstrated high confidence in NBS, while public perceptions leaned more toward conventional systems, likely due to their visibility and familiarity in the urban environment.

## Aesthetic value

*Table 4: Aesthetic Value question section*

| question no. | Response (N=31) |                       |                     |      |
|--------------|-----------------|-----------------------|---------------------|------|
|              | Participants    | Nature-based solution | Conventional method | Both |
| S1           | Public          | 8                     | 1                   | 4    |
|              | Professional    | 14                    | 2                   | 2    |
| S2           | Public          | 7                     | 3                   | 3    |
|              | Professional    | 12                    | 3                   | 3    |
| S3           | Public          | 10                    | 1                   | 2    |
|              | Professional    | 13                    | 2                   | 3    |
| S4           | Public          | 8                     | 2                   | 3    |
|              | Professional    | 10                    | 3                   | 5    |

The assessment of aesthetic value, in terms of how visually appealing different urban solutions are, reveals significant divergence between professionals and the public. For landscape architects and designers, there is a strong preference for Nature-Based Solutions (NBS). The overwhelming majority of landscape architects rated NBS as the most visually appealing, reflecting their deep understanding of green infrastructure's spatial and environmental aesthetics. In contrast, the public exhibited more varied responses. While a substantial portion favoured NBS, there was also a notable share that either preferred conventional methods or selected both, indicating a mixed perception regarding the visual appeal of green solutions versus traditional infrastructure.

## Urban Resilience

*Table 5: Urban Resilience question section*

| question no. | Response (N=31) |                       |                     |      |
|--------------|-----------------|-----------------------|---------------------|------|
|              | Participants    | Nature-based solution | Conventional method | Both |
| S1           | Public          | 8                     | 0                   | 5    |
|              | Professional    | 14                    | 2                   | 2    |
| S2           | Public          | 6                     | 0                   | 7    |
|              | Professional    | 15                    | 1                   | 2    |
| S3           | Public          | 5                     | 2                   | 6    |
|              | Professional    | 14                    | 1                   | 3    |
| S4           | Public          | 9                     | 2                   | 2    |
|              | Professional    | 13                    | 2                   | 3    |
| S5           | Public          | 6                     | 2                   | 5    |
|              | Professional    | 12                    | 1                   | 5    |

In evaluating the contribution of Nature-Based Solutions (NBS) to urban resilience, particularly in enhancing the quality of life for urban residents, professionals overwhelmingly favoured NBS. Among landscape architects, NBS was regarded as the primary contributor to improving the comfort and safety of urban spaces. This preference aligns with their ecological urban design expertise, emphasizing the long-term benefits of green infrastructure in fostering more resilient, healthier, and socially inclusive urban environments. Public perceptions, however, were more varied. While a significant portion of the public also favoured NBS for enhancing urban liveability, a notable number supported conventional methods or selected both systems, reflecting a more cautious or balanced approach to urban resilience. This suggests that, although the public recognises the value of green infrastructure, it may not fully appreciate the broader, long-term resilience benefits that professionals associate with NBS, likely due to limited exposure to, or understanding of, its full potential.

## Climate Change Adaptation

*Table 6: Climate change adaptation question section*

| question no. | Response (N=31) |                       |                     |      |
|--------------|-----------------|-----------------------|---------------------|------|
|              | Participants    | Nature-based solution | Conventional method | Both |
| S1           | Public          | 8                     | 1                   | 4    |
|              | Professional    | 15                    | 1                   | 2    |
| S2           | Public          | 2                     | 4                   | 7    |
|              | Professional    | 9                     | 5                   | 4    |
| S3           | Public          | 1                     | 5                   | 7    |
|              | Professional    | 9                     | 3                   | 6    |
| S4           | Public          | 3                     | 2                   | 8    |
|              | Professional    | 11                    | 2                   | 5    |
| S5           | Public          | 5                     | 0                   | 8    |
|              | Professional    | 14                    | 1                   | 3    |

The analysis of perceptions regarding climate change adaptation reveals significant differences between professionals and the public in understanding how effectively different solutions address the impacts of climate change, such as flooding and extreme temperatures. Among landscape architects, Nature-Based Solutions (NBS) were overwhelmingly favoured as the most effective approach for adapting urban areas to climate change, particularly in managing flooding during heavy rainfall and mitigating extreme temperatures. This preference is grounded in professional expertise, where NBS are recognised for their capacity to enhance urban resilience by promoting natural water absorption, reducing urban heat island effects, and improving overall environmental sustainability. Public responses, however, were more varied. While a majority still viewed NBS as effective, there was considerable support for conventional methods or a combination of both approaches.

## Comparative Perception Analysis between Professional and Public respondents

Table 7: Comparative Perception Analysis of Nature-Based Solutions (NBS) vs. Conventional Methods

| Urban Issues / Systems    | Professionals' Perception (NBS) | Professionals' Perception (Conventional Methods) | Public Perception (NBS) | Public Perception (Conventional Methods) |
|---------------------------|---------------------------------|--------------------------------------------------|-------------------------|------------------------------------------|
| Pollution Control         | 4                               | 1                                                | 3                       | 2                                        |
| Planting Integration      | 4                               | 1                                                | 2                       | 3                                        |
| Urban Resilience          | 4                               | 1                                                | 2                       | 2                                        |
| Climate Change Adaptation | 4                               | 1                                                | 3                       | 2                                        |
| Aesthetic Value           | 4                               | 1                                                | 3                       | 2                                        |

(Median order response: More effective=4, Effective=3, Neutral=2, Less effective=1)

The table compares the perceptions of public and professional respondents regarding Nature-Based Solutions (NBS) and conventional drainage systems in addressing urban challenges. Professionals consistently approved of NBS, rating them as more effective in areas such as pollution control, planting integration, aesthetic value, urban resilience, and climate change adaptation. They emphasised the multifaceted benefits of NBS, including improved air quality, reduced urban heat islands, enhanced biodiversity, and long-term sustainability. Professionals view NBS as essential for holistically addressing urban environmental challenges.

In contrast, the public exhibited more neutral opinions. While they acknowledged the aesthetic and environmental benefits of NBS, many still chose conventional systems, such as drains and monsoon systems, particularly for managing pollution control and stormwater. This preference reflects the familiarity and perceived reliability of conventional methods. The public showed greater hesitance in fully embracing NBS for climate resilience and flood prevention, suggesting the need for increased public education to enhance understanding and acceptance of Nature-Based Solutions in urban planning.

## CONCLUSION AND DISCUSSION

This study examined the divergent perceptions of public and professional stakeholders regarding Nature-Based Solutions (NBS) and conventional drainage systems in addressing urban challenges such as pollution control, planting integration, aesthetic value, urban resilience, and climate change adaptation. The findings emphasise a consistent professional preference for NBS, attributed to their long-term environmental, social, and climate resilience benefits. Professionals highlighted the multifunctionality of green infrastructure, such as bioswales and permeable pavements, noting their capacity to enhance stormwater management, improve air quality, mitigate urban heat island effects, and contribute to the aesthetic and ecological quality of urban environments (Cohen-Shacham et al., 2019; Yonegura et al., 2024). These perspectives align with a growing body of literature that positions NBS as integral to climate adaptation and community resilience, particularly in urban areas increasingly vulnerable to extreme weather events (Seddon et al., 2020; Weidmüller et al., 2024).

Conversely, public responses revealed a more ambivalent stance, with a discernible preference for conventional drainage systems such as monsoon and scupper drains. This inclination appears rooted in familiarity bias and a perceived reliability of traditional infrastructure, which has historically demonstrated functional efficacy. While this trust in legacy systems is understandable, it may also reflect a limited awareness of the broader co-benefits offered by NBS. For instance, in pollution control, the public's reliance on conventional systems suggests a narrow framing of effectiveness, focused primarily on immediate, visible outcomes (O'Sullivan et al., 2020). Nonetheless, the emergence of public support for hybrid approaches, integrating NBS with conventional systems, signals a potential shift in perception. This hybrid preference emphasises the pragmatic recognition that while NBS offer long-term sustainability, conventional systems still play a critical role in addressing immediate urban drainage needs (Ka et al., 2023; Cong et al., 2023).

However, while appealing in theory, this integrative approach raises questions about implementation complexity, cost, and governance. The assumption that green and grey infrastructure can be seamlessly combined warrants further scrutiny. Such integration risks becoming tokenistic or operationally fragmented without robust institutional frameworks and cross-sectoral collaboration. Moreover, the public's cautious stance

may reflect deeper concerns about the maintenance, performance reliability, and cost-effectiveness of NBS, issues that remain underexplored in many urban contexts. As cities confront escalating climate risks, the imperative for adaptive, resilient infrastructure becomes increasingly urgent. While this study affirms the potential of NBS to contribute meaningfully to climate adaptation, it also highlights a critical gap in public understanding and acceptance. Bridging this gap requires more than awareness campaigns; it necessitates participatory planning processes that empower communities to co-design and co-own green infrastructure initiatives. Future research should therefore prioritise longitudinal studies on the performance and lifecycle costs of NBS, as well as comparative analyses across diverse socio-ecological settings (Valéria Borges Yonegura et al., 2024; IUCN, 2022).

In conclusion, Nature-Based Solutions represent a promising pathway towards urban sustainability and resilience. However, their mainstreaming hinges on inclusive governance, interdisciplinary collaboration, and sustained public engagement. Policymakers and urban planners must advocate for NBS and address legitimate public concerns through transparent communication and demonstrable outcomes. Only through such integrative and participatory approaches can cities transition towards more climate-resilient, equitable, and liveable futures (Seddon et al., 2020; IUCN, 2022; Ronchi & Salata, 2022).

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