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RETROFITTING GREEN INFRASTRUCTURE IN KUALA LUMPUR: A DOCUMENT ANALYSIS OF POLICY GAPS AND CLIMATE RESILIENCE

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Abstract

Urban green spaces play a critical role in enhancing environmental sustainability, climate resilience, and the well-being of urban populations. However, the fragmentation of green spaces in Kuala Lumpur presents significant challenges to sustainable urban planning and climate adaptation efforts. This study examines the policy gaps that hinder the effective integration of green infrastructure into Kuala Lumpur's urban planning framework. A qualitative document analysis is conducted to assess national policies, planning guidelines, and international best practices related to green infrastructure and climate resilience. The findings reveal that while Malaysia's policies accentuate the provision of green spaces, they lack comprehensive enforcement mechanisms, leading to inconsistencies in green infrastructure implementation. Key challenges include policy fragmentation, decentralised governance, inadequate financial incentives, and the absence of explicit regulatory frameworks supporting green infrastructure retrofitting. By analysing international models, such as the United Kingdom's Green Infrastructure Standards and Singapore's Green Plan 2030, this study identifies policy strategies that could enhance Malaysia's urban resilience. The study concludes that a systematic retrofitting framework is required to address the existing policy gaps and ensure the strategic integration of green infrastructure into urban development. It recommends adopting international best practices, strengthening regulatory enforcement, and fostering cross-sectoral collaboration to enhance climate adaptation and ecological connectivity. These measures are essential for improving urban sustainability and mitigating the adverse effects of rapid urbanisation and climate change in Kuala Lumpur.

Keywords: Green Infrastructure, Climate Resilience, Policy Gaps, Green Spaces and Networks, Urban Area

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INTRODUCTION

Urban green spaces play a critical role in enhancing environmental sustainability, economic viability, and the overall well-being of urban dwellers. These spaces contribute to biodiversity conservation and climate regulation by improving bioclimatic conditions, mitigating pollution, managing excessive heat, and facilitating rainwater retention and flood control. Additionally, urban green spaces stimulate local economies by attracting businesses, fostering tourism, and generating employment opportunities. Furthermore, research indicates that green spaces within urban residential areas significantly enhance physical health, mental well-being, and overall quality of life.

Despite widespread discussions and policy initiatives promoting urban green space development, the issue of fragmented urban green spaces remains a persistent challenge in Kuala Lumpur. Rasli et al. (2019) argue that ineffective policies have accelerated urban expansion, leading to the fragmentation of green spaces in the city. According to Yeo et al. (2022), this fragmentation is a result of Malaysia's policy emphasis on green space provision rather than the development of green infrastructure. Green infrastructure, as a nature-based solution, enhances climate resilience, ecological connectivity, and sustainable urban development (Anderson & Gough, 2021).

The absence of a comprehensive and coordinated approach to green infrastructure underscores the urgent need for a retrofitting framework to address the fragmentation of urban green spaces in Kuala Lumpur. Fragmented green spaces contribute to the urban heat island (UHI) effect, significantly impacting urban thermal comfort (Akbari et al., 2016). The continued degradation of the urban thermal environment due to rapid urbanisation necessitates robust mitigation strategies through the implementation of green infrastructure (Hou et al., 2022).

This paper aims to highlight the policy gaps and challenges related to retrofitting green infrastructure in Kuala Lumpur to enhance climate resilience. The specific objectives are (i) to analyse the policy gaps and inconsistencies hindering the integration of green infrastructure in Kuala Lumpur's urban planning framework, (ii) to examine the existing national policies in addressing urban green space fragmentation and climate resilience, and (iii) to examine international best practices in green infrastructure implementation that could inform policy improvements in Kuala Lumpur. To bridge the policy gaps and improve climate resilience, Malaysia can adopt international best practices such as the Green Infrastructure Standards, Planning and Design Guide from Natural England (UK), the Urban Green Infrastructure Handbook from the Australian Institute of Landscape Architects (AILA), and Singapore's Green Plan 2030. By incorporating lessons from these global frameworks, Kuala Lumpur can develop

an integrated and strategic approach to retrofitting green infrastructure, ensuring sustainable urban development and enhanced climate resilience.

LITERATURE REVIEW

Fragmented Urban Green Spaces

The fragmentation of urban green spaces presents a significant challenge in Malaysia, as evidenced by various studies. Yeo et al. (2022) and Rasli et al. (2018) highlight that inadequate policies and rapid urban expansion have contributed to the fragmentation of green spaces in Kuala Lumpur. This issue is not confined to the capital city; Kemarau (2021) examines spatial-temporal changes in urban green spaces in Kuching, Sarawak, demonstrating that green space fragmentation is a nationwide concern. Furthermore, the provision and establishment of urban green spaces in Malaysia face several obstacles, as outlined by Maryanti et al. (2016), who critically assess the implementation of green space provision standards and associated challenges. Li et al. (2019) further emphasise the role of urbanisation in exacerbating green space fragmentation, underscoring the need for a comprehensive understanding to inform effective planning policies.

Efforts to address urban green space fragmentation are evident in studies such as Nor and Abdullah (2019) and Nor et al. (2017), which focus on developing classification systems and ecological connectivity networks to enhance Kuala Lumpur's urban green spaces. Beyond ecological connectivity, fragmented green spaces may also contribute to increased levels of secondary air pollutants and associated health risks (Shen & Lung, 2017). The implications of fragmented green spaces extend beyond environmental concerns; Lee et al. (2015) underscore their role in promoting healthy living, while Rasidi et al. (2018) explore their influence on social interactions within urban neighbourhoods.

Moreover, urban green space fragmentation has profound implications for biodiversity conservation and ecological connectivity. Nor et al. (2017) stress the importance of ecological connectivity networks in rapidly urbanising cities, emphasising the role of green space structure in sustaining wildlife habitats and enhancing biodiversity. Li et al. (2019) further explore the relationship between urbanisation and green space fragmentation, advocating for a spatiotemporal perspective to address the growing challenges associated with urban expansion. These dimensions collectively underscore the multifaceted significance of mitigating urban green space fragmentation in Malaysia to promote environmental sustainability, public health, and climate resilience.

Green Infrastructure for Urban Areas

Green infrastructure is a fundamental component of sustainable urban planning and environmental management in Malaysia. The integration of green spaces,

including parks, gardens, and green corridors, within urban landscapes plays a critical role in enhancing biodiversity, mitigating climate change impacts, and improving the overall quality of life for urban residents. Artmann et al. (2019) and Monteiro et al. (2020) emphasise the necessity of incorporating green infrastructure planning principles within spatial planning frameworks to promote urban sustainability and resilience. In the Malaysian context, green infrastructure development is essential for addressing environmental challenges and strengthening urban resilience. Faisal et al. (2022) identify green infrastructure as a sustainable and adaptive solution that delivers ecological, economic, and social benefits through nature-based approaches.

Similarly, Chen et al. (2022) highlight the importance of considering the spatio-temporal dimensions of green infrastructure implementation to effectively manage the impacts of rapid urbanisation and increasing impervious surface areas. On another note, softscape elements play a crucial role in enhancing environmental quality and increasing the value of the surrounding landscape which may contribute to the overall success of green infrastructure initiatives, ensuring sustainable urban development while meeting user expectations and promoting ecological well-being (Sani, et al., 2020). Mohammad Sabri & Ponrahono (2024) emphasise the importance of small urban parks in enhancing urban resilience to climate change by serving as green infrastructure for stormwater management while also offering recreational and social benefits.

The expansion of urban agglomerations in Malaysia has led to the fragmentation of green spaces, adversely affecting ecological connectivity and biodiversity. Studies by Chu et al. (2022) and Li et al. (2019) explore the link between urban expansion and green space fragmentation, underscoring the need for strategic planning to preserve and enhance green infrastructure networks. Yeo et al. (2022) and Nor et al. (2021) propose conceptual frameworks for green infrastructure and examine the transformation of urban green spaces in rapidly growing cities such as Kuala Lumpur. Their findings emphasise the role of green corridors and sustainable landscape development in mitigating the effects of urban expansion. Well-designed and well-maintained green spaces not only enhance urban residents' experience and mental well-being but also serve as vital green infrastructure, strengthening climate resilience by improving overall environmental quality (A.A, et al., 2021).

Beyond ecological and environmental functions, green infrastructure holds significant cultural and social value in urban settings. Research by Gómez-Villarino et al. (2020) and Riechers et al. (2019) highlights the diverse cultural ecosystem services provided by green infrastructure, contributing to community well-being and enhancing urban liveability. Additionally, urban green spaces serve as crucial adaptive measures for mitigating the adverse impacts of climate




change, including extreme weather events such as heatwaves and droughts, which are becoming increasingly prevalent (Kraemer & Kabisch, 2022). Green infrastructure offers significant potential in enhancing urban resilience to climate-related challenges, such as urban heat islands, increased flooding, stronger wind patterns, and episodic rainfall, particularly in high-density urban areas where large green spaces are limited.

Furthermore, the effectiveness of urban greening initiatives depends on both the rate of greening and the spatial configuration of green spaces, which are pivotal factors in mitigating climate change impacts (Yin et al., 2021). By integrating green infrastructure into urban planning and design, Malaysian cities can enhance climate resilience while simultaneously promoting environmental conservation, social well-being, and economic sustainability.

Policies and Guidelines on Green Infrastructure and Climate Resilience

Green infrastructure is integral to promoting urban sustainability, enhancing climate resilience, and safeguarding environmental well-being. A wide range of national and international policies and guidelines underscore its importance, offering valuable insights that Malaysia can adopt to strengthen its urban planning framework. The following official documents in Table 1 provide key examples of these frameworks:

Table 1: List of policies and guidelines on green infrastructure and climate resilience

<i>National Policies and Guidelines</i>	<i>Documents</i>
<p><i>i) National Urbanisation Policy 2 (2019) – PLANMalaysia</i> This policy underscores the need for enhancing both the size and quality of green spaces within urban areas. It advocates for sustainable urban expansion by integrating ecological networks and green spaces to improve environmental health and urban resilience.</p>	
<p><i>ii) Implementation Guidelines on Urban Regeneration (2023)</i> These guidelines emphasise the importance of green networks and corridors in urban redevelopment projects. By incorporating green infrastructure into regeneration strategies, cities can improve air quality, reduce heat island effects, and enhance biodiversity.</p>	
<p><i>iii) National Landscape Policy 2.0 – National Landscape Department, Malaysia</i> Under Thrust 3, Strategy 3.1, this policy calls for the provision of green infrastructure to mitigate climate change impacts. It promotes sustainable landscape planning, advocating for urban parks, green corridors, and ecological connectivity as essential climate adaptation measures.</p>	

<i>National Policies and Guidelines</i>	<i>Documents</i>
<p>iv) Garis Panduan Rancangan Kawasan Lapang – PLANMalaysia This guideline provides a framework for planning open spaces, emphasising their multifunctional benefits, including flood mitigation, urban cooling, and social well-being. It aligns with broader sustainability goals by integrating green infrastructure into urban development.</p>	
<p>v) Kajian Keperluan Kawasan Hijau dalam Pembangunan – Jabatan Landskap Negara This study assesses the necessity of green spaces in urban planning and their role in enhancing environmental sustainability. It supports data-driven decision-making in designing green infrastructure to optimise ecosystem services.</p>	
<p>vi) National Policy on Climate Change – Ministry of Natural Resources and Environment Malaysia This policy aims to bridge the gap between climate action and green infrastructure development. It emphasises the need for nature-based solutions to combat climate change, highlighting urban forests, permeable surfaces, and ecosystem-based adaptation as crucial components.</p>	
<p>vii) National Physical Plan 4 (RFN4) – PLANMalaysia RFN4 focuses on spatial sustainability and climate resilience, with a strong emphasis on green infrastructure as a strategy for urban climate adaptation. It promotes nature-based solutions to enhance urban liveability, flood management, and carbon sequestration.</p>	
<p>viii) Kuala Lumpur Structure Plan 2040 – Dewan Bandaraya Kuala Lumpur The Kuala Lumpur Structure Plan 2040 highlights the integration of green infrastructure in urban planning to ensure a sustainable, climate-resilient city. It emphasises the creation of green corridors, public parks, and sustainable water management systems as essential elements for mitigating climate change impacts and enhancing the city’s environmental quality.</p>	
<i>International Policies and Guidelines</i>	<i>Documents</i>
<p>i) Green Infrastructure Standards – Natural England, UK These standards establish best practices for integrating green infrastructure into urban planning. They provide a reference for policymakers to ensure that green spaces contribute effectively to biodiversity conservation, climate resilience, and public health.</p>	

<p>ii) Green Infrastructure Planning and Design Guide – Natural England, UK This guide outlines design principles for effective green infrastructure, focusing on ecological connectivity, sustainable drainage systems, and urban heat mitigation.</p>	
<p>iii) Urban Green Infrastructure Handbook – Australian Institute of Landscape Architects (AILA) This handbook provides practical insights into designing and implementing green infrastructure within Australian cities, highlighting case studies on climate adaptation and resilience.</p>	
<p>iv) Singapore's Green Plan 2030 – Government of Singapore Singapore's national strategy integrates green infrastructure into urban planning to achieve sustainability and resilience. It prioritises nature-based solutions, urban greenery, and sustainable water management in response to climate challenges.</p>	

RESEARCH METHODOLOGY

This study conducts qualitative research using document analysis, guided by the objective of assessing policy gaps, urban green space fragmentation, and climate resilience strategies related to green infrastructure in Kuala Lumpur. The analysis focuses on policy documents, government reports, and international frameworks published between 2015 and 2024, as tabulated in Table 1. This document analysis aims to determine whether Malaysia's current policies effectively integrate green infrastructure solutions and whether existing frameworks align with global standards for climate adaptation and urban sustainability. The study identifies policy strengths, gaps, and potential areas for improvement to support the development of a retrofitting framework for green infrastructure in Kuala Lumpur.

For data analysis, the documents are analysed using Quirkos, a qualitative data analysis tool that facilitates thematic coding and visualisation of recurring patterns within textual data. Additionally, policy comparison tables are developed to assess variations in green infrastructure integration across different policy documents. The findings highlight policy inconsistencies, regulatory limitations, and gaps in implementation, providing a structured basis for evaluating the effectiveness of Malaysia's green infrastructure policies in addressing urban resilience challenges.

The results of this document analysis are expected to reveal gaps in green infrastructure implementation, policy misalignment, and the need for a more integrated planning approach. The analysis highlights whether Malaysia's existing policies provide adequate regulatory mechanisms for enhancing green connectivity in Kuala Lumpur. Findings from this study aims to provide

evidence-based recommendations for policymakers and urban planners to strengthen green infrastructure integration within urban development strategies.

ANALYSIS AND DISCUSSION

This analysis examines key national policies, international frameworks, and planning guidelines that influence green infrastructure strategies in Kuala Lumpur. Specifically, it evaluates policy gaps, urban green space fragmentation, and climate resilience strategies, providing a comprehensive assessment of Malaysia’s existing policies and their alignment with international best practices. Section 1 examines national policies that address green infrastructure planning and implementation, while Section 2 explores international frameworks and their relevance to Malaysia. Section 3 identifies key policy gaps related to green infrastructure, urban fragmentation, and climate change adaptation. Finally, this analysis aims to offer insights into how Malaysia can enhance its green infrastructure planning to improve climate resilience and urban sustainability.

Section 1: Key Insights from National Policies and Guidelines

Figure 1 is a visual representation from Quirkos, illustrating an analysis of various policies concerning green spaces and networks, biodiversity initiatives, open spaces and spatial multifunctionality, as well as regulations and financial initiatives. The following is a refined summary of the key findings:



Figure 1: National Policies and Guidelines Analysis on Green Spaces and Sustainability

Green Spaces & Networks emerge as the most significant category, comprising 62% (17 highlights). The analysis underscores the prioritisation of urban green spaces and integrated ecological networks. Policies such as the National Urbanisation Policy 2 (2019) by PLANMalaysia and the National Landscape Policy advocate for specific green space allocations, including a minimum of 10% of total development areas and at least two square meters per person in urban environments. Despite these provisions, challenges persist in implementation, particularly in high-density areas, due to weak enforcement and inadequate cross-sectoral collaboration. Biodiversity Initiatives, accounting for 18% (six highlights), emphasise the necessity of integrating urban green corridors and ecological elements into urban planning. The Implementation Guidelines on Urban Regeneration 2023 recommend incorporating green elements in 50% of new developments; however, the absence of stringent regulatory enforcement poses a risk to long-term sustainability. Open Spaces & Spatial Multifunctionality, representing 10% (three highlights), focus on establishing standards for multifunctional urban open spaces. The National Physical Plan 4 (RFN4) – PLANMalaysia advocates for sustainable urban resilience strategies, while the *Kajian Keperluan Kawasan Hijau* study reveals that Malaysia's 7.5% urban green space coverage falls below international benchmarks. The findings highlight a need for structured policy integration and stronger regulatory mechanisms to address this gap.

Regulation & Financial Initiatives, constituting 12% (four highlights), address the financial and policy frameworks supporting green infrastructure. The National Policy on Climate Change underscores the role of green infrastructure in climate mitigation, targeting a 40% reduction in greenhouse gas emissions by 2030. Nevertheless, the lack of a cohesive implementation framework across national, state, and local levels hampers effective execution. Additionally, the Kuala Lumpur Structure Plan 2040 aims to achieve 20% tree canopy coverage by 2040 yet requires clearer implementation roadmaps and alignment with national policies. Overall, while Malaysia has developed comprehensive policies promoting urban green infrastructure, significant challenges remain in enforcement, regulatory clarity, cross-sectoral integration, and financial incentives. Addressing these gaps will be critical in advancing sustainable and resilient urban development.

Section 2: Best Practices from International Policies and Guidelines

Figure 2 below shows an analysis of international green infrastructure policies and their relevance to Malaysia, particularly Kuala Lumpur. It highlights key contributions, quantitative measures, and how these strategies can be adapted to enhance urban resilience and sustainability in the Malaysian context.

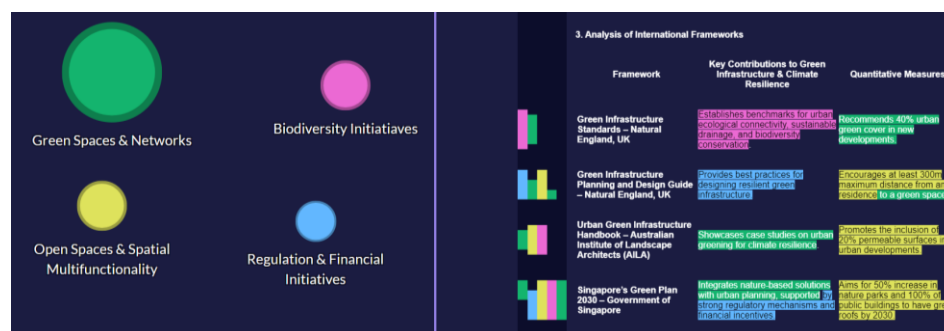


Figure 2: International Policies and Guidelines Analysis on Green Spaces and Sustainability Using Quirkos

The Green Infrastructure Standards by Natural England, UK, establish benchmarks for ecological connectivity, sustainable drainage, and biodiversity conservation, recommending 40% urban green cover in new developments. Implementing similar benchmarks in Kuala Lumpur could enhance ecological corridors, reduce urban heat island effects, and improve air quality, addressing the city's rapid urbanisation and environmental concerns. Additionally, the Green Infrastructure Planning and Design Guide from the UK promotes best practices for designing resilient infrastructure, advocating for at least 300 meters maximum distance from any residence to a green space. Adopting this strategy in Kuala Lumpur could enhance public access to green areas, improve residents' well-being, and support active urban lifestyles.

Meanwhile, the Urban Green Infrastructure Handbook by the Australian Institute of Landscape Architects (AILA) emphasises case studies on climate resilience, recommending the inclusion of 20% permeable surfaces in urban developments. This approach is particularly beneficial for Kuala Lumpur, where flooding and poor drainage systems are ongoing challenges. Increasing permeable surfaces would help manage stormwater, reduce flash floods, and promote groundwater recharge. Furthermore, Singapore's Green Plan 2030 integrates nature-based solutions with urban planning, reinforced by strong regulatory mechanisms and financial incentives. This model could serve as a blueprint for Kuala Lumpur, encouraging policy-driven urban greening and incentivising private sector participation in sustainability efforts.

Notably, Singapore aims for a 50% increase in nature parks and mandates 100% of public buildings to incorporate green roofs by 2030. Implementing similar targets in Kuala Lumpur could enhance biodiversity, create cooling microclimates, and support Malaysia's broader climate adaptation goals. These international policies highlight the importance of structured policy enforcement, cross-sectoral collaboration, and financial support in achieving urban sustainability. By integrating these best practices, Kuala Lumpur can

strengthen its resilience against climate change, improve liveability, and position itself as a leading green city in Southeast Asia.

Section 3: Policy Gaps, Limitations and Lessons Learned

This analysis highlights critical policy gaps, regulatory inconsistencies, and the need for an integrated planning approach to enhance green infrastructure in Kuala Lumpur. Current frameworks do not fully align with global standards for climate adaptation. To address these gaps, policymakers should prioritise cross-sectoral collaboration, develop enforceable regulatory frameworks, and integrate financial incentives for green infrastructure investment. Strengthening Malaysia's policy landscape can enhance urban resilience and promote sustainable development in rapidly growing cities.

Malaysia's urban and environmental policies, particularly in Kuala Lumpur, face significant gaps that hinder the effective implementation of green infrastructure and climate resilience strategies. Key issues include the lack of clear implementation mechanisms and weak enforcement across policies such as the National Urbanisation Policy 2 (2019), the Implementation Guidelines on Urban Regeneration (2023), and the National Landscape Policy. These gaps lead to fragmented and unstructured urban greening efforts, especially in high-density areas where space constraints and competing land-use priorities further complicate matters. Additionally, policies like the National Policy on Climate Change lack a cohesive framework to integrate national, state, and local planning processes, limiting the effectiveness of climate adaptation strategies.

Furthermore, land use policies and the National Physical Plan 4 (RFN4) lowly prioritise interconnected green corridors or enforce mandates for green infrastructure, restricting biodiversity conservation and the resilience of urban ecosystems. Kuala Lumpur's urban planning, as outlined in the Kuala Lumpur Structure Plan 2040, also lacks detailed implementation roadmaps and alignment with national policies. As mentioned by Seng Yeo, et al., (2022), Malaysia aims to protect the environment, but its policies on green infrastructure remain fragmented, requiring a national-level framework with strategic, operational, and reflexive measures for effective implementation and continuous monitoring. To address these issues, stronger regulatory frameworks, cross-sectoral collaboration, and financial incentives are needed. Integrating best practices from international policies—such as mandating green space access, permeable urban surfaces, and private sector participation—could improve Kuala Lumpur's climate resilience and green infrastructure.

CONCLUSION

This study underscores the urgent need for a cohesive and enforceable framework to integrate green infrastructure into Kuala Lumpur's urban planning policies.

Despite the presence of national guidelines promoting green space development, the lack of clear enforcement mechanisms and regulatory inconsistencies impedes the effective implementation of green infrastructure strategies. The findings highlight that fragmented governance, financial constraints, and limited policy coherence hinder Malaysia's ability to develop resilient urban ecosystems. Drawing on international best practices, this study emphasises the importance of adopting structured green infrastructure standards, enhancing policy integration, and implementing targeted financial incentives to support sustainable urban development. A coordinated, cross-sectoral approach involving policymakers, urban planners, and stakeholders is essential to retrofitting green infrastructure and strengthening Kuala Lumpur's resilience to climate change. By aligning Malaysia's urban planning policies with global benchmarks, the nation can advance sustainable development goals, enhance ecological connectivity, and foster a more climate-resilient urban environment.

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