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Leveraging Urban Open Spaces for Enhancing Flood Resilience in Cities

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Abstract

Rapid urbanization and climate change have exacerbated the vulnerability of urban areas to more frequent and severe flooding. Due to the lack of recent studies on the emerging trend of mitigation action to enhance flood resilience in cities, a thematic review was conducted to explore a more impactful flood mitigation strategy through leveraging urban open spaces for flood resilience in cities. A six-step methodology was employed to perform the thematic analysis, beginning with screening and selecting relevant articles published between 2018 and 2024 from four selected databases: Web of Science (WoS), Scopus, Emerald Insight, and ScienceDirect. Following code creation and theme identification, the findings derived from the code-to-document analysis were assessed using ATLAS. Ti software version 8. Based on the results, the search string yielded 141 peer-reviewed journal articles, of which 72 were selected after applying inclusion and exclusion criteria and further evaluated via quantitative and qualitative analysis. Accordingly, these studies placed significant emphasis on three main themes: open space strategy (56 codes), elements of open spaces (39 codes), and challenges of open space (20 codes). Overall, the comprehensive analysis of successful interventions in this thematic review offers new insights and valuable guidelines for policymakers, urban planners, and practitioners seeking to leverage urban open spaces to enhance flood resilience in cities, especially those that persistently face the impact of climate change.

Keywords: Disaster Management, Flood Resilience, Nature-Based Solution, Thematic Review, Urban Open Spaces

Introduction

The combined impact of rapid urbanization and the more frequent and severe extreme weather events due to climate change have increased the risk of flooding in cities worldwide. The catastrophic effects of urban floods due to rapid urbanization have significantly indicated the increasing need for cities to mitigate climatic catastrophes (Beshir & Song, 2021). According to Norizan et al. (2021), the increase in natural disasters, particularly hydrometeorological ones such as floods, is attributed to the impact of global climate change, which has led to extreme weather changes. This situation highlighted growing concern, as the World Bank (2021) estimated that 90 percent of the world's population will be exposed to flood disasters by 2035 to 2044. In this context, there is an urgent need to balance land development with flood mitigation needs, especially highlighting urban open spaces that offer untapped potential as dual-function assets, not only provide social and recreational value but also serve as adaptive infrastructures for mitigating urban flood risks (Khodadad et al., 2023; Venkataramanan et al., 2019; Sohn et al., 2021).

Hence, the concept of resilience proposed by Holling (1996) has gained traction in formulating contemporary disaster management, categorized into three categories: engineering, system resistance, and complex adaptive system resilience. According to McClymont et al. (2020), these categories provide a useful taxonomy for characterizing resilience. In this context, urban open spaces have gained recognition as invaluable resources for nature-based flood mitigation tools (Nivya et al., 2023; Jayakody et al., 2016). Furthermore, Staccione et al. (2024) claimed that urban open spaces, which serve as the equivalent of living rooms for city dwellers, offer socioeconomic and health benefits that are sometimes overlooked. Roggema (2020) recommends integrating open spaces into urban areas using a nature-based approach. Additionally, it has been demonstrated that creating a variety of open spaces as a flood control strategy in many cities is far more economical than making traditional hard infrastructure choices. Despite this potential, urban open spaces remain an underexplored component in flood resilience planning, especially in the Global South. Their multifunctional nature as both social infrastructure and flood mitigation assets makes them a valuable yet often overlooked strategy.

At the global level, the United Nations made a global declaration and a multi-year strategy by establishing the Sustainable Development Goals in 2015 and the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030, which have emphasized the importance of resilience-building and nature-based approaches to climate challenges. The SFDRR outlines four main objectives: comprehending disaster risk, strengthening governance, investing in risk reduction for resilience, and enhancing readiness for an efficient response. The Disaster Risk Reduction agenda, which includes SDG 13 and the SFDRR, encourages nations to shift from reactive to proactive strategies that prioritize resilience, mitigation, and sustainable development in the face of the escalating threat posed by climate change. So, this study aligns with these global goals by examining how urban open spaces can be operationalized as proactive, cost-effective solutions to urban flood risk

In Malaysia, flood risk management has been guided by the National Security Council (NSC) Directive No. 20 and supported by the National Disaster Management Agency (NADMA) since 2015. The country's disaster management employs top-down federal, state, and district governance. However, no specific organization has been established to manage flood

disasters holistically. Instead, this task is carried out by several technical agencies such as the Irrigation and Drainage Department (JPS), the Public Works Department (JKR), PLAN Malaysia, and local authorities, which carry out their respective roles according to their respective functions (Mohammad et al., 2023). Lack of coordination between these agencies has resulted in the implementation of flood mitigation and adaptation measures being uncoordinated (Ridzuan et al., 2022). This situation makes it challenging to implement effective long-term planning, especially in urban development that is increasingly exposed to disaster risks (Rosmadi et al., 2023; Chan, 2018). Although the government has implemented various mitigation strategies through policies, regulations and technical guidelines, disaster preparedness plans in Malaysia are still fragmented and reactive, with actions only taken after an event occurs, without integrated long-term resilience planning (Norizan et al., 2021; Osman, 2021). In particular, the potential of urban open spaces as a formalized part of flood management planning remains fragmented, lacking coordination among stakeholders and consistent policy direction.

Therefore, this study explores how urban open spaces can be systematically leveraged as dual-function strategy that supports both flood resilience and community well-being. This thematic review was conducted spanning publication from 2018 to May 2024. The findings in this study will provide significant insights and recommendations for enhancing flood resilience by leveraging urban open space in cities that persistently face the imminent threat of climate change. The findings aim to benefit urban planners, local authorities, policymakers, and environmental practitioners seeking to integrate nature-based solutions into flood-prone urban development. This review provides timely and actionable insights, especially for fast-growing cities in Asia, where land pressure and climate impacts converge.

Method and Study Area

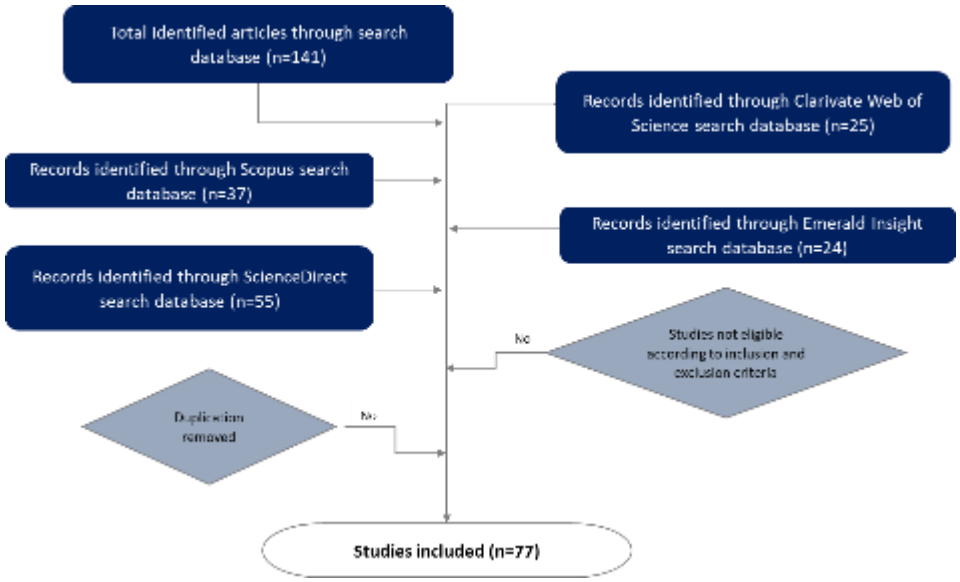
The present study employed thematic analysis, a methodological approach that identifies patterns and construct's themes through an extensive review of relevant literature (Clarke & Braun, 2013). This method utilizes diverse techniques to focus on detailed studies of specific issues or causes. Braun and Clarke (2006) described in detail the six-step methodology to conduct the thematic analysis. Primarily, a comprehensive understanding of the data must be attained. Secondly, initial codes are created to identify significant patterns and concepts from the data. The third step involves searching for significant themes that arise from the coded data, followed by a thorough examination and improvement of the underlying concepts or ideas. The concepts are explicitly delineated and elaborated before finally consolidating and conveying the results in a written form.

For this study, the literature selection process adhered to three specific inclusion criteria: (i) articles published between 2018 and 2024, (ii) the selected literature contains the keywords "open space" AND "flood resilience", and (iii) the articles focus on open spaces for flood resilience. These keywords were selected to establish a clear scope of discussion regarding leveraging urban open spaces for enhanced flood resilience in cities. Subsequently, the selected articles were examined using ATLAS. Ti software version 8 to facilitate the thematic analysis based on the guidelines provided by Zairul (2020). The search string was conducted in four databases, namely Clarivate Web of Science (WoS), SCOPUS, Emerald Insight, and ScienceDirect, as shown in Table 1.

Table 1
Search string from four selected databases and their respective results.

Databases	Keywords	Number of Articles	
		Results	After Exclusion
Clarivate Web of Science (WoS)	"Open space" AND "flood resilience" Date range: 2018–2024	25	2
SCOPUS	"Open space" AND "flood resilience" Publication Year: 2018–2024	37	20
Emerald Insight	"Open space" AND "flood resilience" Year: 2018–2024	24	11
ScienceDirect	"Open space AND "flood resilience" Year: 2018–2024	55	24
	TOTAL	**141**	**77**

A total of 141 items from the four databases were returned by the search result; these included 25 articles from Clarivate WoS, 37 articles from SCOPUS, 24 articles from Emerald Insight, and 55 articles from ScienceDirect. The first screening was then conducted using the pre-established inclusion and exclusion criteria, which included assessing the articles' relevance to the topic, identifying and eliminating duplicate articles, and taking accessibility into account. As shown in Figure 1, 77 articles were selected following the first screening and imported into the Mendeley database platform, where they were stored as metadata. To simplify data organization, the metadata was later incorporated into the ATLAS. Ti software version 8. Six criteria—author, issue number, periodical, publisher, volume, and year of publication—were used to classify the articles. Critical information can be extracted more easily thanks to this methodology, which encourages a methodical and well-organized analysis of the data.



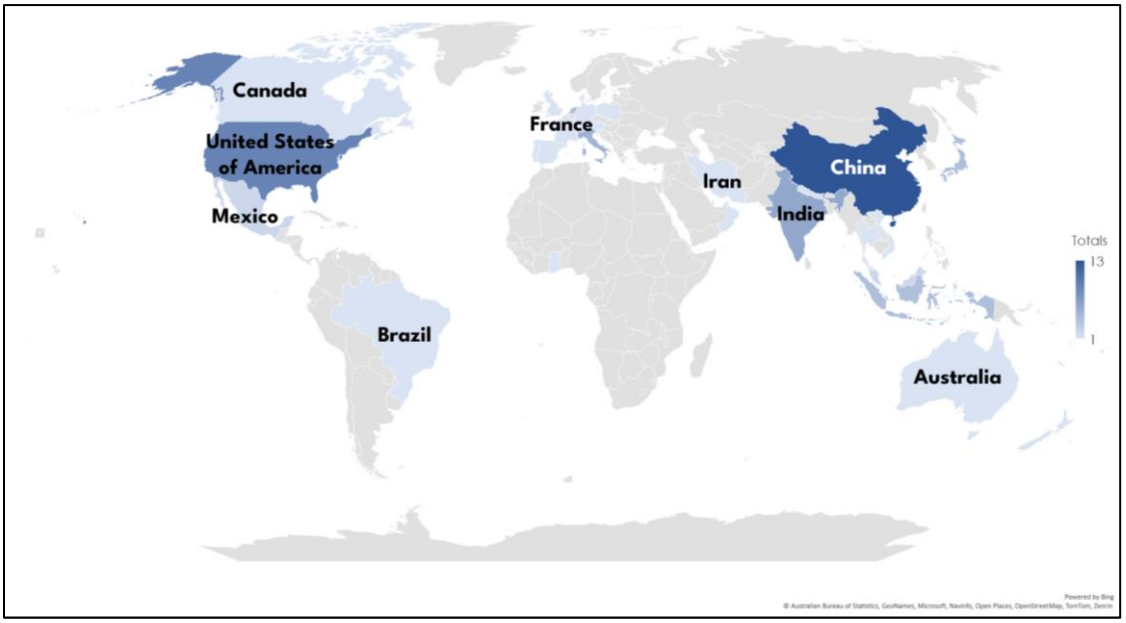
Source: Author's work
Figure 1. The screening process based on the inclusion and exclusion criteria via the thematic analysis.

Results and Discussion

This thematic analysis presented a selection of relevant articles over six years of research regarding the strategies of implementing urban open spaces for effective flood resilience in cities. The results of this thematic analysis are divided into two parts: quantitative and qualitative. The quantitative results focused on several analyses, such as the number of articles according to the year of publication, the geographical dispersal of the selected articles, the number of articles according to periodical, and the themes according to the respective authors. Meanwhile, the results for the qualitative part emphasized the themes analysed.

Quantitative Results

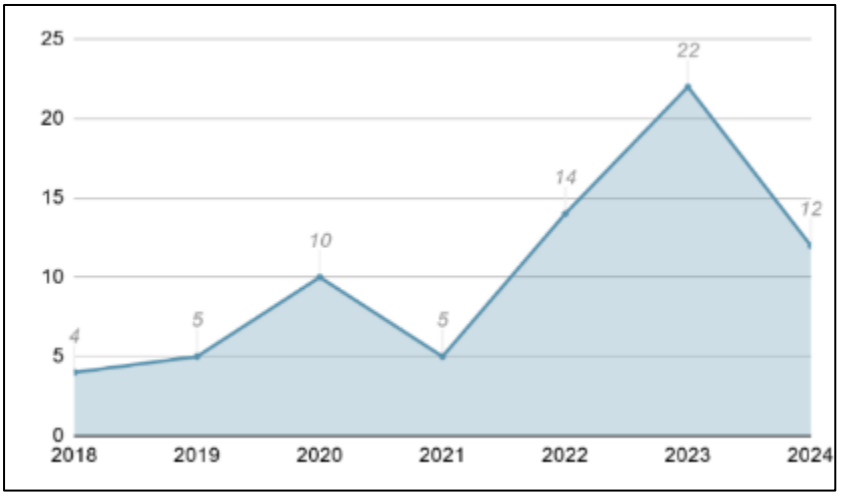
The first coding phase consists of 38 codes that identified the articles according to their year of publication. As shown in Figure 2, the geographical dispersal of the selected articles for thematic analysis highlights their origin, including Australia, Austria, Brazil, Canada, China, Denmark, England, France, Germany, Ghana, India, Indonesia, Iran, Italy, Japan, Malaysia, Malta, Mexico, Nepal, the Netherlands, New Zealand, Oman, Poland, Portugal, Singapore, Slovenia, Spain, Switzerland, Thailand, United Kingdom, United States of America (USA), and Vietnam. A darker color signifies a higher number of papers published in the country, with the darkest represented by China (13), followed by USA (9), India (6), and Italy (5). In contrast, a lighter color indicates that the number of publications in the country is less than five. The dispersion analysis reveals that the use of urban open spaces as a strategy for enhancing flood resilience in cities is most prevalent in China. This analysis corresponds to the 'sponge city' concept that was introduced by the Chinese government in 2015. Ideally, the concept refers to a plan to construct sponge cities that can capture and reuse 70% of rainfall. This approach allows rainwater to be distributed and retained as a clean water source, slows down the runoff as it flows away from its source, and able to adapt to varying water levels in drainage areas when water accumulates (Pamungkas & Purwitaningsih, 2019).



Source: Author's work

Figure 2. Geographical dispersal of the 77 selected articles.

The second coding phase describes the number of publications evaluated based on the year of publication, as shown in Figure 3. This analysis reveals a notable rising trend in the frequency of publications that focus on leveraging urban open spaces for flood resilience in cities. Nevertheless, a lower number of research publications was observed in 2021 and 2024. The drop in publication numbers in 2021 than in other years could be related to the destructive impact of COVID-19, which was declared a global pandemic. Meanwhile, the lower publication number in 2024 is understandable, as this study was conducted until May 2024. Thus, the number of publications in 2024 may rise higher by the end of the year. Overall, the statistical analysis shows the emergence of urban open spaces to enhance flood resilience in cities over the past six years. These findings are discussed further in the qualitative result section to answer the research questions on how to leverage urban open spaces for enhancing flood resilience in cities.



Source: Author's work
Figure 3. Number of articles reviewed according to the year of publication.

In short, this comprehensive quantitative analysis underscores the growing interest among the scientific and academic communities and the practical importance of integrating urban open spaces into flood resilience planning and policy-making. These findings were elaborated further in the qualitative result section to address the research questions on how to leverage urban open spaces for enhancing flood resilience in cities.

Qualitative Results

There are three themes discussed in the selected articles that are open space strategies, elements of open spaces, and challenges. The majority of the reviewed articles (56 codes) discussed the open space strategy for enhancing flood resilience in cities, followed by the discussion on the elements of open spaces (39 codes). The remaining articles (20 codes) represent the challenges to leveraging open spaces for enhancing flood resilience in cities.

a. Open Space Strategies

Based on the analysed themes, a significant number of the selected articles discussed vital strategies to improve flood resilience in cities, highlighting the increasing focus on adapting to the impacts of climate change. This trend aligns with the discussion in the introduction section, which describes the advantages of integrating open spaces, such as implementing GIs, in developing a more flood-resilient city. For example, Jamali, Khaledi, &

Razavian (2021) stressed the importance of employing GIs in city neighborhoods to reduce stormwater runoff and support heat mitigation in cities. GIs were hence included in urban planners' development models (Gupta & Dixit, 2024). The NBS is one of the well-liked GI concepts for handling floods brought on by climate change. The International Union for the Conservation of Nature (IUCN, 2009) developed this concept to emphasize how important biodiversity preservation is to lessening the consequences of and getting ready for the global temperature change. NBS transcends traditional ideas for biodiversity preservation and management by stressing human-centered approaches and considering society concerns including well-being, socioeconomic development, and governance principles (Ramísio et al., 2022). This enlarged framework uses biological diversity to help social-ecological systems overcome challenges and recover from unexpected events and changes in the global temperature.

The NBS's primary objectives are to reduce rain-related flooding and pollution entering the ecosystem. But in recent years, environmental, social, and financial factors have taken the front stage over flood control and health preservation alone (Boateng et al., 2023). The shifting trend supports White et al. (2023) claim that NBS, including wetlands and urban forests, can increase social-ecological resilience and assist metropolitan communities in better managing environmental stresses including climate change. Moreover, Meng et al. (2022) found that including NBS and non-structural solutions in the planning system helps the city to adapt to changing socioeconomic needs and catastrophic floods. Thus, including technical and social elements into NBS such as vegetated swales and bioretention cells will help to improve flood risk management and minimize the consequences of flooding events. Su et al. (2024) also underlined how fresh ideas—such as including plants in road designs—can assist in supporting grey infrastructure. This approach helps stakeholders see new angles on using open areas and balancing technical viability with conservation needs.

As revealed by Wang et al. (2024), the NBS concept has proven that GI is more effective in mitigating flood risks in most urban areas compared to its blue infrastructure counterpart. On the contrary, grey infrastructure exacerbates flood risks. Given this, the GI concept must be recognized and adopted worldwide to facilitate its widespread application to mitigate flooding and enhance ecological and human welfare (Venkataramanan et al., 2019). Therefore, urban open spaces can be utilized to create cities that are more liveable and more resilient through the incorporation of NBS and restoration of a green environment, including increasing vegetated land cover, promoting tree planting programs, preserving ecological values, reserve areas for green stormwater infrastructure, construct designated ponds for stormwater collection, and improve rainwater and stormwater management (Lehman, 2023; Sutapa et al., 2023; Dubois et al., 2024; Atoba et al., 2021; Szpak et al., 2022; Zhou & Wu, 2023; Boothroyd et al., 2023).

Apart from that, key stakeholders demand credible information to establish the NBS concept and secure funds for improving flood resilience (Soto et al., 2023). They found that NBS implementation in peri-urban catchments located upstream offers a more economical option compared to investing in flood-related expenses or alternative grey infrastructure. In addition, it is essential to consider the shifting viewpoint towards 'living with floods and the need for closer engagement and collaboration with vulnerable populations due to their socio-spatial imbalances (Forrest, Trell & Woltjer, 2020). Since flood events are regarded as regional

events, each of them has particular effects that lead to different degrees of coping and adaptation ability. Local governments are thus compelled to approve the development of urban planning including a multidisciplinary design process. This calls for designers, urban planners, and decision-makers to re-evaluate their roles in adjusting to floods and enhancing resilience (Nilubon & Laeni, 2024).

Previous research indicates that urban open spaces effectively raise flood resilience in metropolitan areas by including mitigating and adaptable strategies into place. For instance, Gupta & Dixit (2023) underlined the need for urban open spaces for effective urban flood risk control. In another study, Jayakody, Amarathunga, & Haigh (2018) examined how urban public open space layout and design included disaster management strategies. The five main solutions they found included a range of public open spaces, making sure daily activities were sufficiently planned for, integrating flexible and adaptable spaces, making the most use of urban areas, and building networks of public open spaces. Furthermore, French et al. (2019) advised building bigger public open areas to raise flood resilience in cities. Nonetheless, the success of rebuilt urban open spaces depends also on the involvement of stakeholders and the application of appropriate governance systems (Scheiber, 2022; Thoban & Hizbaron, 2020). Thus, all relevant parties—local communities, government officials, and environmentalists—must cooperate and help during the planning process (Staccione et al., 2024). It follows from the process of enhancing flood resilience in urban areas by open-space approaches that GIs, sustainable urban designs, stakeholder cooperation, and community involvement are necessary. This strategy seeks to maximize the general quality of urban living, minimize the risk of flooding, and efficiently manage rainfall.

b. Elements of Open Spaces

The subsequent theme is the elements of open spaces which refers to specific physical components or features within urban areas that contribute to flood resilience. These elements are tangible and can be directly integrated into the landscape to manage stormwater, reduce runoff, and enhance ecological functions. Based on the analysed articles, numerous authors have explored the potential use of open spaces, particularly GIs, as an alternative technology to mitigate stormwater and improve flood resilience in cities, as covered in the open space strategy's topic. The results highlighted several elements of open spaces that can be executed to enhance urban open spaces' ability to withstand flooding. Firstly, rain gardens are an example of GI elements that successfully lowered the risk of floods, as reported by Fu et al. (2021). In addition, Nordman et al. (2018) stated that rain gardens are deliberately designed to catch and filter rainfall, reduce the load on municipal drainage systems, and improve biodiversity in the surrounding area. Similar components to rain gardens, such as concave vegetated fields and bioretention cells, are also frequently utilized to enhance urban GI (Khodadad et al., 2023). However, rain gardens are a familiar sight in cities and may not add significant value from a social standpoint (Sharma et al., 2023). Moreover, runoff volume reduction from rain gardens is less satisfactory and thus needs to be improved (Manucci et al., 2022).

Implementing detention basins, including retention ponds, represents the next potential element of open spaces that offers comprehensive stormwater management. This option uses both natural and engineered solutions to capture, store, and treat stormwater runoff, thus reducing flood risk and improving water quality (Fu et al., 2021; Sharma et al.,

2023; Khodadad et al., 2023). However, retention ponds are less safe and exposed to issues regarding drowning hazards and personal safety, especially if they are located near community homes and households with children under 12 years old (Li et al., 2022). Therefore, the location of detention basins or retention ponds must be precisely planned to mitigate such risks. Furthermore, Manucci et al. (2022) found that wetlands that were constructed to address climate change, specifically related to altered rainfall patterns, elevated sea level, and increased impervious surfaces, have minimal effectiveness and poorly reduce the runoff volume.

Several authors also explored the idea of constructing versatile recreational spaces that can serve multiple functions. These recreational spaces, for example, parks, athletic fields, pedestrian and cycling paths, and communal gardens, can be used for leisure and recreational activities during dry periods and transform into flood retention areas during heavy rainfall. As discussed earlier, the NBS strategy also establishes various direct and indirect links between humans and the ecosystem. Previously, Zhou et al. (2024) explored the potential of mangrove restoration as a means to protect coastal areas from extreme tides, as well as the effectiveness of tree planting in riparian zones for mitigating floodwaters. In view of this, urban and interurban regions should incorporate versatile open spaces, such as green corridors, green streets, formal parks, and street trees, to enhance disaster resilience and provide other benefits, including improved air quality, flood prevention, and erosion management (Gearin et al., 2023). For instance, the Grand Mall Park in Tokyo, Japan, was developed under the Minato Mirai (MM21) project to enhance disaster resilience and environmental sustainability. The 23,000 m² park area, surrounded by commercial buildings, museums, and retail businesses, features a 25 m pedestrian axis connecting the waterfront to the station, with tall Zelkova trees and sea-wave patterned furniture adorning the landscape. The Park was first completed in 1989 and underwent further renovations in 2015 to install vertical water circulation for effective stormwater management (Nivya et al., 2023).

Additionally, the development and upkeep of green corridors and habitats, such as habitat corridors, pollinator gardens, natural meadows, and urban forests, can improve urban biodiversity and ecosystem services, as well as effectively absorb and reduce the speed of stormwater flow. Green roofs have a substantial impact on delivering several ecosystem services and adaptation benefits, such as regulating runoff and climate (Aghaloo et al., 2024). Moreover, green roofs can regulate and manage local stormwater runoff. Recently, Twohig et al. (2022) installed a low-altitude green roof with low water retention rates and reported a significantly decreased average flood depth by 1%. In fact, a maximum green roof scenario recorded a 13% decrease in the average flood depth and a marked decrease in the number of vulnerable areas. In addition, porous pavement, also known as permeable or pervious pavement, is a practical stormwater management approach that can substantially enhance flood resilience in urban open spaces (Manucci et al., 2022; Khodadad et al., 2023; Sharma et al., 2023; Fu et al., 2021; Pappalardo et al., 2017). Porous pavement mitigates surface runoff by facilitating water infiltration from stormwater runoff into storm drains and rivers. Subsequently, water that enters the pavement can replenish aquifers and groundwater. Porous pavement can also mitigate urban flash floods by decreasing peak flow rates during intense rainfall events.

In summary, urban open spaces have the potential to significantly improve flood resilience in cities through different physical elements that effectively control rainwater and minimize flow. Figure 6 illustrates an ideal city planning that employs various elements of open space to enhance its resilience against flood and other climate change impacts. GI elements, such as rain gardens, detention basins, and retention ponds, can be installed to collect and purify rainfall efficiently, thus reducing the strain on existing drainage systems and enhancing water quality. Besides, the multipurpose role of parks and sporting fields makes them practical as recreational areas during dry months and as flood retention areas during heavy rainfall. In addition, the construction of green corridors, natural meadows, and urban woods promotes the preservation of biodiversity and slows down stormwater runoff. Similarly, green roofs assist in local stormwater runoff management and mitigate flood depths by effectively holding water, while porous pavement reduces surface runoff by enhancing water infiltration that ultimately replenishes groundwater sources and decreases peak flow rates during heavy rainfall. Altogether, these comprehensive solutions mitigate flood hazards, provide broader ecological and socio-economic advantages, and improve the quality of life in cities.

c. Challenges

The final theme of this thematic review pertains to the challenges associated with leveraging urban open spaces for enhancing flood resilience in cities, which have been extensively discussed by various authors. The two most significant issues are the lack of urban preparedness and the lengthy response and recovery processes that follow flood occurrences (Prashar et al., 2023). Rus et al. (2018) and Ibrahim et al. (2023) revealed various factors that impede the successful implementation of urban planning, including the standard practice in urban planning that usually overlooks the need to develop open spaces, the lack of accountability and transparency, and weak governance principles.

In Malaysia, the Federal government formulates a 10% policy in development management that guarantees a balance between physical growth and urban environment preservation. Although developers are required to comply with this policy, which is enforced through legal provisions, PLANMalaysia (2018) identified several implementation issues that influence the provision of open spaces in Malaysia. These include: (i) Unplanned provision of open spaces in which developers often provide open land areas that are unsuitable for use due to safety reasons, undermining their intended purposes; (ii) Some developers can pay a certain fine to sidestep the requirement to provide open land, resulting in the lack of designated open spaces or recreational area; (iii) Local authorities often delay the gazetting of open land after the completion of development projects, leading to legal and administrative complications; (iv) The often ineffective gazetting mechanism under Section 62 of the National Land Code 1960 hinder the formal recognition and protection of open spaces; and (v) Open spaces are occasionally misused for non-recreational activities, which diminishes their availability and utility for public recreation. These drawbacks necessitate a more stringent and effective implementation and monitoring of open space provisions to ensure they serve their intended purpose and contribute to the overall quality and sustainability of the urban environment.

Often disregarded during the planning process, the influence of natural infrastructure calls for more technical knowledge and direction to include NBS in climate planning (Boateng

et al., 2023). The high expenses connected with NBS initiatives, the conflicting interests of many entities, the lack of knowledge, interest, and appreciation of the topic among urban residents, and the lack of green and blue infrastructure make NBS implementation even more challenging, though (Szpak et al., 2022). Moreover, some of the particular issues that impede attempts to build flood-resilient cities are traditional city plans, unplanned areas, especially in the city center, and the unequal distribution of urban open spaces (Mabrouk & Haoying, 2023; Afriyanie et al., 2020). Although urban areas have open spaces, their location usually leaves them exposed to little flood protection. Compartmentalized government policies, unclear obligations among stakeholders, and knowledge gaps (Punt et al., 2023) complicate the coordination process considerably more). Nasiri et al. (2020) also mentioned institutional racism, the change in urban ecology, and restricted access to basic knowledge and resources as several other important difficulties. Implementing well-governed, integrated, inclusive policies with a strong focus on social equality and environmental sustainability will help one to effectively handle these challenges (Gearin et al., 2023).

Conclusion

In conclusion, this study emphasizes that urban open spaces play an essential and strategic role in strengthening urban resilience against the increasingly severe flood risk due to the impact of climate change. These open spaces, including multi-purpose spaces such as recreational parks, detention ponds, and reservoirs, have been identified as public spaces that contribute to social well-being and as natural infrastructure components that effectively absorb and accommodate surface runoff. Integrating green infrastructure elements and nature-based solution concepts such as rain gardens, green roofs, and permeable pavements is an essential combination to highlight the potential of open spaces in flood risk management that has not been fully utilized. Therefore, the contribution of this study is to strengthen the understanding of the potential of urban open spaces as an integrated approach to minimizing flood disaster risk in urban areas. However, this strategy's widespread implementation still faces challenges such as hampered governance, financial constraints, unbalanced distribution of open spaces, and limited technical capacity. Therefore, an integrated and proactive approach is required to mainstream the role of urban open spaces, which needs to be translated into policies, land use planning, and the implementation of development projects. Strengthening collaboration between technical agencies, local authorities, and local communities is a vital asset to fully utilize the potential of open spaces, especially as a strategy towards a more adaptive, inclusive, and climate-resilient urban landscape. The study's contribution lies in bridging theory and practice by identifying feasible strategies and spatial planning approaches that can be immediately adapted by city authorities and technical agencies. It reinforces the importance of cross-agency collaboration and localized innovation in climate adaptation planning.

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