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Exploring the Cause and Impacts of Flash Floods Vulnerability in Various Areas of Malaysia: A Content Analysis

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Abstract

The rising flash floods disrupt communities, damage infrastructure, and strain economic resources, highlighting the urgent need for effective flood management strategies. This study examines the causes and impact of flash floods in Malaysia to provide a holistic understanding and actionable insights for flood risk management. A comprehensive content analysis was performed from 2013 to 2023, utilizing scholarly articles, governmental reports, and newspaper data. The research identifies key causes contributing to flash flood vulnerability, including inadequate drainage systems, rapid urbaniza-tion, reclamation projects, developer negligence, and insufficient urban planning as specific activities associated with new development projects. These activities disrupt natural water flows, increasing runoff and flood risks. The analysis indicates that flash floods disrupt daily life and economic activities, such as the construction industry, leading to project delays and in-creased costs. This research contributes significantly to flood risk manage-ment by highlighting the importance of integrating resilient design tech-niques, enhanced coordination among local authorities, enforcing stricter regulations, and promoting sustainable development practices. It provides a foundation for future research and policymaking aimed at reducing flash flood vulnerability. The findings recommend future of flood management lies in breaking down silos between engineering, planning, and environmen-tal management, ensuring that guidelines such as MASMA, NPP, and the USMM work in unison toward a common goal of flood resilience.

Keywords: Flash Floods, Vulnerability, Construction Projects, Flood Mitigation

Introduction

Malaysia is prone to floods, with its low-lying coastal areas, concentrated development areas, and mountainous regions. The economic activities of plantations make them vulnerable to flash floods. The country experiences monsoon seasons, with heavy rainfall during the North-East monsoon from

November to March and the South-West monsoon from May to September [1], [2]. In recent years, the frequency and severity of floods in Malaysia have increased, posing serious problems for the country's economic activities and inhibiting gross domestic product (GDP) consequences, particularly in the construction industry.

Flash floods, as defined by the United Nations Office for Disaster Risk Reduction (UNDRR), are sudden and rapid floods that occur within six hours of heavy rainfall or other causative events [3]. These natural calamities inflict significant damage on a global scale, leading to extensive loss of life and property, disruption of infrastructure, and devastating environmental impacts. The ramifications of such incidents are increasingly being acknowledged, not merely as natural phenomena, but as societal concerns that require comprehensive understanding and preventative measures.

According to the [4], flash floods are more frequent and severe due to climate change, urbanization, and land-use changes. Rapid urbanization has further exacerbated Malaysia's struggle against flash flooding, often prioritizing infrastructure development over environmental considerations. Despite the nation's efforts to manage these occurrences, there are recurring instances of damage to property and disruption of livelihoods, underscoring the need for more effective and robust strate-gies.

Development projects, fundamental to Malaysia's socioeconomic advancement, contribute substantially to employment, GDP, infrastructural development, and societal welfare. These projects play an essential role in disaster risk reduction and man-agement. Applying resilient design techniques and materials can considerably mitigate the vulnerability of communities to climate-related disasters such as floods, landslides, and tropical storms [5]. This strategy is increasingly critical for a country like Malaysia, grappling progressively with climate change impacts.

Malaysia's construction industry faces numerous challenges, including the rising cost of materials, labor shortages, and increasing competition from external overseas contractors [6]–[8]. However, the threat of floods is a significant concern for both developers and contractors, as it can delay projects, increase costs, and pose a risk to the safety of workers and the surrounding community. This escalation in flood oc-currences disrupts the construction timeline and forces the industry players to re-think their construction approaches and designs. The study examines the causes and impact of flash floods in Malaysia to provide a holistic understanding and actionable insights for flood risk management. The following research questions prompted the design of this study, which was carried out specifically to answer the questions.

1. What specific activities associated with new development projects cause exacer-bation of flash floods?
2. What impacts of flash floods may arise from new development projects?

This paper is a structured review of the extant literature on flash floods. It explores their causes, impacts, and strategies to combat these disasters. The collected data is synthesized, and recommendations for policy and practice are offered to enhance the management of flash floods in Malaysia.

Literature Review

The term “disaster” has been analyzed through various lenses to capture its multifaceted impact on society. Originating from Latin, the term initially implied events attributed to bad luck or misfortune. It disrupts societal norms and patterns, as noted by [9]. However, these definitions lack a comprehensive understanding of the broader ramifications, a gap filled by the World Health Organization (WHO) by defining disaster as a severe ecological event requiring external aid.

Disasters disrupt society and harm individuals from specific components that consti-tute risk. While the term ‘risk’ varies in interpretation as per [10], it is often under-stood as a blend of hazard and vulnerability in disaster literature. The definition of risk is context-dependent, varying based on the specific conditions and nature of a disaster, as noted by [11]. It is a function influenced by probability and consequence. The [12] emphasizes that disasters result from a mix of factors, cumulatively generating risk [13] highlights that disasters combine natural hazards and human actions, representing extreme events from natural sources or a synergy of natural forces and human involvement. Hazards, vulnerability, and exposure are essential components leading to disaster risk.

Hazards, as defined by [14], are potential threats to communities. They aren’t disasters in isolation but combine with other factors to set the stage for disaster scenarios. The [12] characterizes hazards as dangerous phenomena, substances, or activities that could cause harm, including health impacts, property damage, social disruption, or environmental damage. Hazard hazards include natural events, human activities, or technological sources, such as earthquakes, tsunamis, and wildfires. The key to disaster management is pinpointing these hazards.

Vulnerability refers to a community, system, or asset’s susceptibility to the damaging effects of a hazard. It is shaped by characteristics that decrease the ability to anticipate or respond to threats, such as poverty, inequality, and other socioeconomic factors. [15] and [16] emphasize that it is tied to the resistance and response to disasters. [17] Contrast vulnerability with resilience, highlighting that resilience embodies a system’s capability to absorb, cope with, and adapt post-disaster. Vulnerability extends beyond people and includes communities and can be influenced by particular situational occurrences.

Exposure refers to the potential for people, property, and systems to be affected by natural disasters. [18] contends that without exposure, a hazard is merely an event. The [12] defines exposure as elements in hazard zones susceptible to losses. [19] sees it as the degree of everyday risk from hazard probability to actual event occurrences. Essentially, exposure measures the likelihood of

hazards affecting specific locations. The Intergovernmental Panel on Climate Change [20], [21] suggests that exposure, in interaction with a hazard, prompts vulnerability to emerge as a risk component.

Risk in the context of disasters is a multifaceted concept stemming from the intertwining of hazard, exposure, and vulnerability. While there is no universally agreed-upon definition, risk is generally seen as the product of likelihood and consequence. [14], [22] emphasizes the interrelation between risk and the components of a disaster, associating it with the potential negative outcomes of disaster events. [16] dif-ferentiates risk from vulnerability by combining the latter's potential for loss with the probability of a hazard's occurrence. [23] reinforces this, presenting risk as dependent on hazard, vulnerability, and exposure, with any fluctuation in these elements impacting overall risk. The outcome of disasters can range from physical injuries to significant asset damage. Many countries around the world are vulnerable to flash floods.

In hydrological studies, flood risk is conceptualized as the probabilistic occurrence of flooding events juxtaposed with their ensuing impacts. This risk is predicated upon three salient parameters: the flood's origin, typified by hydrological sources such as fluvial systems; its propagation pathway; and the resultant damages, encompassing infrastructural and economic detriments. A holistic approach to flood risk management requires a nuanced understanding of hydrological disturbance likeli-hood and potential consequences. Existing flood-mitigation infrastructures, notably dams and levees, warrant scrutiny for their operational efficacy. However, nearby areas may be flooded even with strategic flood mitigation systems. This shows the difficulty of completely reducing flood risk, regardless of the countermeasures.

Hydrological studies define flood risk as the probabilistic occurrence and effects of flooding events [24]. Hydrological disturbance likelihood and consequences must be understood to manage flood risk holistically. Dams and levees should be evaluated for efficiency. Even with strategic flood mitigation, nearby areas may flood. This shows that flood risk reduction is difficult regardless of countermeasures.

Flash floods, notable for their abrupt nature and short duration, increased incidence of flash floods in different regions of Malaysia is primarily caused by human activities such as rapid development, land clearance, and poor drainage systems [25], [26] argues that flood risk in Malaysia has increased due to the continued development of densely populated flood plains, encroachment on flood-prone areas, and destruction of forests and hill slope. These devastating occurrences persist as recurring threats worldwide, causing severe disruptions to human lives, infrastructure, and economies. The implications of such incidents, increasingly acknowledged as pressing societal concerns, demand a thorough understanding and pre-emptive measures.

In the Malaysian context, flash floods manifest unique challenges. The country's geographical and climatic characteristics make it highly prone to

such disasters [27], [28]. Rapid urbanization aggravates this predisposition, often focusing more on infrastructure development than environmental considerations. Despite concerted efforts to manage these episodes, recurrent property damage and livelihood disrup-tions highlight the urgent need for more robust and effective strategies.

Methodology

This study is fully based on secondary data. The data sources of this study are mainly online news reports by several mainstream news portals. Previous peer-reviewed publications and Department of Irrigation and Drainage reports were also reviewed to collect data.

Therefore, to carry out this review, refer to Table 1 and Figure 1 searching protocol; suitable research articles were collected from journal portals such as SCOPUS, MDPI, Google Scholar, and Science Direct. The articles extracted from the journal portals were published between 2013 until 2023, and the keywords used to search the articles were factors, issues, and impact of flash flood, flood vulnerability, and Malaysia. As elucidated in this review, identifying factors contributing to flash flood risk and their implications for local governance can enhance and refine flood risk management strategies. Local governments can adopt a more comprehensive approach to mitigating flash flood impacts by addressing these factors at their origins. This review synthesizes the acquired insights and offers pertinent policy recommendations and practical measures, facilitating more effective management of flash floods in Malaysia.

Table 1. Keyword search strings in the international database (2013-2023)

Sources	String
SCOPUS,MDPI,Google Scholar, Sience Direct	TITLE-ABS-KEY Flood Vulnerability AND, Flash Flood OR Factor of Flash Flood, Causes of Flash Flood, Impact of Flash Flood, Devel-opment Project, Urban Development, Urban Planning, Flood Risk Reduction, Malaysia, Content Analysis

This multifaceted approach to data acquisition was undertaken to ensure a robust and well-rounded dataset that could adequately capture the nuances and dynamics asso-ciated with the subject matter under investigation. Drawing upon these varied sources, the study aimed to attain a holistic perspective on the factors contributing to flash flood risk and their implications, facilitating a more informed analysis and interpretation.

To construct a comprehensive knowledge base, newspapers were examined for their timely and real-time accounts of events and occurrences related to flash floods. Additionally, governmental reports were scrutinized to glean insights from authorita-tive sources that can provide an official and structured overview of the flash flood phenomenon within the study's temporal scope. Furthermore, including academic articles introduced a scholarly dimension, enriching the

analysis with well-researched studies and expert opinions that have evolved over the past decade. By amalgamating these diverse sources, the study aimed to establish a comprehensive and cohesive foundation for investigating the multifaceted dimensions of flash flood risk.

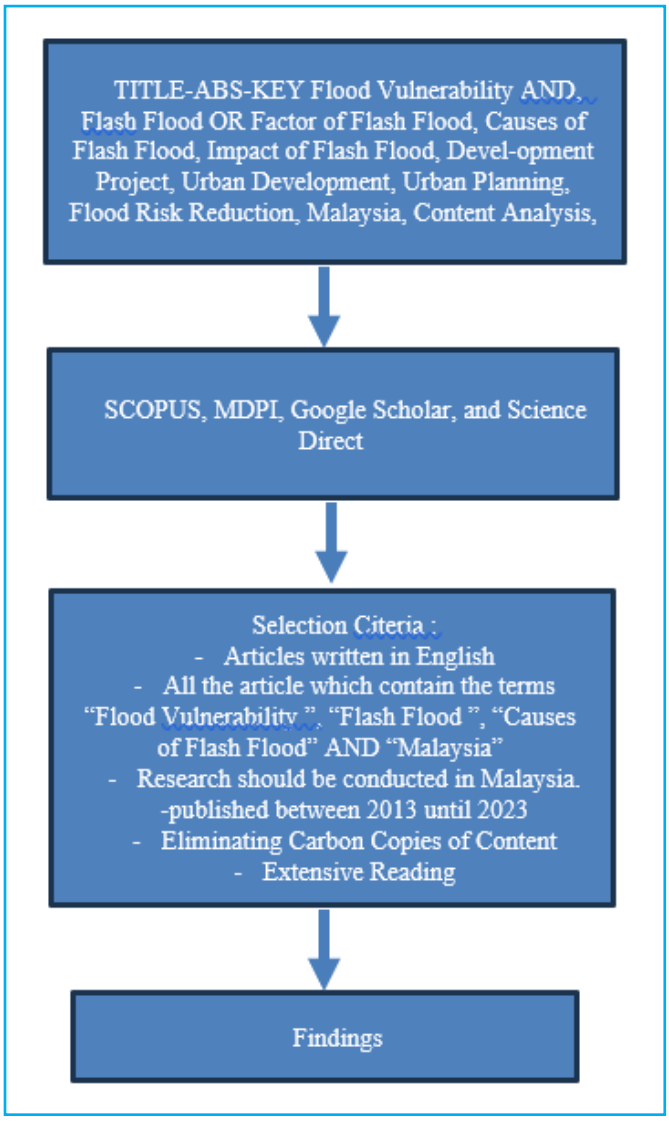

Figure 1. Searching protocol

The chosen timeframe of 2013 to 2023 was guided by the intention to encapsulate the most recent developments and trends in flash flood occurrences and the associated factors. This temporal frame identified patterns and shifts that may have emerged over time, enhancing the study's potential to contribute relevant insights to the con-temporary discourse on flood risk management. The decade-long scope allowed for a retrospective analysis that could uncover long-term trends, abrupt changes, and evolving policy responses to flash floods.

In conclusion, the data collection methodology adopted in this study reflects a deliberate and thorough approach to compiling a comprehensive range of

perspectives and information on flash flood risk. By utilizing newspapers, governmental reports, and academic articles, the study seeks to create a well-informed foundation for the subsequent analysis, interpretation, and recommendations about mitigating and managing flash floods in Malaysia.

Result and Discussion

This section provides an integrative analysis of flash floods in Malaysia, predicated on synthesizing varied data sources. Initially, an assessment of news reports offers a lens into the immediate societal repercussions and prevailing perceptions surrounding these hydrological events. Concurrently, a systematic review of the annual flood reports released by the Department of Irrigation and Drainage (2015-2021) sheds light on institutional responses, trends, and policy implications. It is important to actively involve the existing empirical foundation with current academic literature to enhance the existing empirical foundation. This will ensure that findings are based on thorough study and widely accepted among scholars. Additionally, experts' perspectives on addressing the nation's flash flood issues were incorporated. These interviews, along with recommendations and solutions proposed by community members and policymakers

The culmination of this multifaceted exploration is an in-depth elucidation of flash floods' manifold impacts, encompassing their environmental, socioeconomic, and urban developmental ramifications. Through this consolidated framework, we endeavor to engender a nuanced, academically robust understanding of the challenges and implications of flash floods in Malaysia.

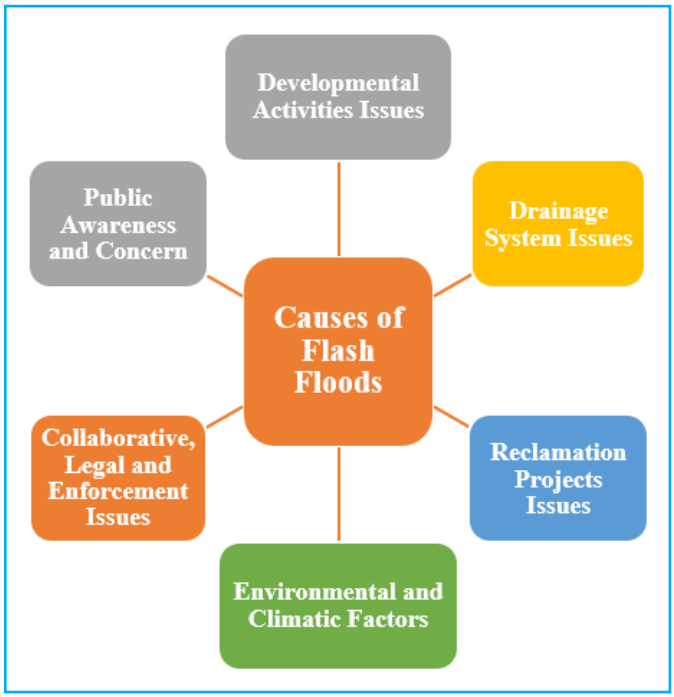

Figure 2. Summarize causes related to flash floods in Malaysia

Causes on flash flood

Recent news reports highlight an emerging concern over the relationship between development projects and the increasing frequency of flash floods in Malaysia, as depicted in Table 2. This summary collates various reports highlighting the relationship between projects and subsequent environmental impacts, spotlighting the significance of proper drainage systems in mitigating these disasters. This review critically analyzes recent news reports highlighting these flood events, pinpointing their causes, and examining measures taken by local authorities. A summary of recurrent themes links these floods to rapid urban development, raising questions about the management of infrastructure projects and their environmental repercussions, as shown in Fig. 2. This synthesis aims to objectively analyze recent reports highlighting the tension between urban development and environmental sustainability.

Table 1. Causes and Factors in Managing Flash Flood in Malaysia

No	Year	Newspaper Tittle	Causes	Factors	Reference Link
1.	2015	Amaran DBKL Buat Pemaju Projek Sebabkan Banjir	Flash floods in the nation's capital	- Construction activities	https://www.bharian.com.my/berita/al/2015/11/95722/amaran-dbkl-buat-pemaju-projek-sebabkan-al/2015/11/95722/amaran-dbkl-buat-pemaju-projek-sebabkan-banjir
2.	2017	DBKL Siasat Kemungkinan Projek Pembangunan Punca Banjir Kilat.	Flash floods on the Federal Highway	- Construction activities, - Inadequate drainage, - Retention systems.	https://www.astroawani.com/berita-malaysia/dbkl-siasat-kemungkinan-projek-pembangunan-punca-banjir-kilat-159336
3.	2017	Banjir SUKE, Amaran Keras Buat Pemaju.	Flooding near Bukit Teratai	-Construction activities.	https://arkib.selangorkini.my/tag/suke/
4.	2017	Banjir Kilat: Pemaju Wajib Tambah Baik Sistem Saliran, Kolam Tahanan.	Flash floods due to blocked drainage systems.	-Construction activities, -Obstructed drainage.	https://www.astroawani.com/berita-malaysia/banjir-kilat-pemaju-wajib-tambah-baik-sistem-saliran-kolam-tahanan-159500
5.	2018	Sampah, sisa projek mega antara punca banjir kilat-Datuk Bandar KL	Flash floods caused by waste and debris blocking drainage pathways	-Waste and debris	https://www.astroawani.com/berita-malaysia/sampah-sisa-projek-mega-antara-punca-banjir-kilat-datuk-bandar-kl-190464
6.	2018	Projek abai alam sekitar undang bencana	Chronic flash flooding in the city	-Inadequate drainage systems -clogged drains -new development projects.	https://www.bharian.com.my/rencana/komentar/2018/11/502917/projek-abai-alam-sekitar-undang-bencana
7.	2019	Pembangunan pesat punca banjir	Flooding in suburban areas due to rapid development.	-Inadequate drainage systems	https://www.sinarharian.com.my/article/57767/suara-sinar/analisis-sinar/pembangunan-pesat-punca-banjir

Table 1. Continued

No	Year	Newspaper Tittle	Causes	Factors	Reference Link
8.	2020	Sistem perparitan tidak sempurna punca banjir	Frequent flooding in Meru, Klang.	- Imperfect drainage systems - Low-lying land - Inconsistent drainage development	https://www.hmetro.com.my/mutakhir/2020/12/648163/sistem-perparitan-tidak-sempurna-punca-banjir
9.	2020	Kerjasama antara agensi elak banjir kilat berulang	Increased flooding severity due to rapid development.	- Uncontrolled development - Obstructed water drainage	https://www.bharian.com.my/rencana/lain-lain/2020/09/732926/kerjasama-antara-agensi-elak-banjir-kilat-berulang#google_vignette
10.	2021	“Isu Banjir Kilat Sebab Projek WCE Diselesaikan,”	Flooding due to construction activities.	- Inadequate retention pond - Drainage systems	https://www.kosmo.com.my/2021/09/24/isu-banjir-kilat-sebab-projek-wce-diselesaikan/
11.	2021	Projek tebus guna mungkin burukkan lagi masalah banjir di Melaka	Flash floods due to sea reclamation projects.	- Disrupted river flow - Large-scale reclamation	https://www.hmetro.com.my/mutakhir/2021/09/752434/syarikat-perumahan-punca-banjir-kilat-dikompaun
12.	2021	Syarikat perumahan punca banjir kilat dikompaun	Flash floods affecting nearby homes.	- Inadequate drainage systems - Failure to adhere to specifications.	https://www.hmetro.com.my/mutakhir/2021/09/752434/syarikat-perumahan-punca-banjir-kilat-dikompaun
13.	2022	Projek pembangunan punca banjir kilat di Pontian	Frequent flash floods in Kampung Parit Pasir Baru	- Development projects causing unchanged drainage systems	https://www.kosmo.com.my/2022/05/11/hujan-30-minit-banjir-akan-berlaku/
14.	2022	Banjir Kilat: MBJB Ambil Tindakan Segera	Mud floods caused by development projects.	- Land work control failure - Debris blocking drainage systems	https://www.malaysiakini.com/news/630624
15.	2022	Projek pembinaan punca banjir kilat di Kampung Budiman	Flash floods affecting homes in Kampung Budiman	- Construction activities nearby	https://www.astroawani.com/berita-malaysia/projek-pembinaan-punca-banjir-kilat-di-kampung-budiman-390889
16.	2022	Projek pembinaan punca banjir kilat di Puchong	Flash floods in Persiaran Saujana Puchong and Kampung Baru Batu 14	- Water overflow from development areas	https://www.sinarharian.com.my/article/191643/edisi/projek-pembinaan-punca-banjir-kilat-di-puchong
17.	2022	Projek infrastruktur perlu titik berat sis-tem saliran, perparitan elak banjir	Flash floods in low-lying areas	- Inadequate drainage - Ditch system infrastrcture development projects.	https://www.bharian.com.my/berita/wilayah/2023/01/1051379/penduduk-kecewa-banjir-akibat-projek-plsb#google_vignette

Table 1. Continued

No	Year	Newspaper Tittle	Causes	Factors	Reference Link
18.	2023	Penduduk kecewa banjir akibat projek PLSB	Severe flooding affecting 62 villages	- Construction of an embankment.	https://www.bharian.com.my/berita/wilayah/2023/01/1051379/penduduk-kecewa-banjir-akibat-projek-plsb#google_vignette
19.	2023	Banjir Melaka: Penambakan dan perubahan iklim antara punca	Frequent flash floods in urban areas of Melaka.	- Climate change, compromised drainage systems due to large-scale reclamation projects.	https://newslab.malaysiakini.com/malacca-floods/ms/
20.	2023	MPKj sita tapak projek di Taman Sri Nanding, didapati punca banjir kilat	Flash floods and mudflow in Taman Sri Nanding	- Absence of proper drainage system and silt trap at construction site	https://selangorkini.my/2023/06/mpkj-sita-tapak-projek-di-taman-sri-nanding-didapati-punca-banjir-kilat/

Developmental activities causes

One of the main causes of flash floods in urban areas is the rapid development in and around cities. These activities include various construction projects that aim to im-prove the infrastructure and provide better facilities for the residents. However, these projects also negatively impact the environment and drainage systems, which can increase the risk of flooding. Developmental activities affect flash floods in three ways: infrastructure development, waste and debris, and negligence.

First, infrastructure development is essential for a city's economic growth and social welfare, but it can also disrupt the natural drainage patterns and alter the hydrologi-cal cycle. For example, developers were cautioned about contributing to flash floods due to construction activities during heavy rains [29]. Investigations from local authorities found flash floods on Federal Highways were potentially linked to developmental projects. Kuala Lumpur Mayor mentioned issuing stop work orders until developers incorporated flash flood mitigation measures [30]. The Sungai Besi-Ulu Kelang Elevated Highway (SUKE) flooding resulted in warnings to developers, urg-ing compliance with mega project requirements [31]. Flash floods were linked to developmental activities obstructing existing drainage systems, with subsequent directives to upgrade and maintain these systems [32]. Moreover, these structures can obstruct water flow and create bottlenecks that cause water to accumulate in certain areas. Therefore, infrastructure development can increase the intensity and frequency of flash floods, especially during heavy rainfall events.

Second, waste and debris are another by-product of developmental activities that can aggravate flash floods. Construction projects often generate a lot of waste and de-bris, such as concrete, metal, wood, and plastic, which must be appropriately disposed of or recycled. In 2018, Kuala Lumpur's Mayor identified waste from major developments and plastics obstructing drains as significant factors for flash floods in specific city regions [33]. Furthermore, waste and

debris can also act as floating objects that can damage the infrastructure and cause more flooding [34]. Therefore, managing waste and debris is essential in exacerbated flash floods.

Third, negligence is a human factor that can exacerbate flash floods caused by de-velopmental activities. Some developers undertake construction projects without considering the impact on the drainage systems or following the regulations and guidelines. For instance, some developers encroach on the floodplains or wetlands that act as natural buffers for floodwater [35]. Some developers also ignore the design standards or maintenance requirements for the drainage systems, which can lead to their deterioration or failure [36]–[38]. Therefore, negligence can lead to inadequate planning and execution of developmental activities, exacerbating flash flooding.

In conclusion, urban development activities have positive and negative effects on flash floods. On the one hand, they improve the city dwellers' infrastructure and quality of life. On the other hand, they disrupt the drainage systems and increase the vulnerability of the urban areas to flooding. Therefore, it is important to balance the benefits and costs of development activities and adopt measures to mitigate their impacts on flash floods.

Drainage system causes

One of the main challenges faced by urban areas in Malaysia is the frequent occur-rence of flash floods that disrupt residents' social and economic activities. A combi-nation of factors, such as heavy rainfall, land use changes, and drainage system is-sues often causes flash floods. Drainage system causes can be classified into three main categories: inadequate drainage, clogged drains, and unchanged systems.

Inadequate drainage refers to the situation where the existing drainage system cannot cope with the volume and intensity of rainfall, resulting in water accumulation and overflow. For instance, inadequate drainage in construction sites, as seen with the Alam Sari housing project, has been linked to flash floods [39]. This can be due to poor design, lack of maintenance, or insufficient drainage system capacity. For example, the Kajang Municipal Council (MPKj) took action against a developer in Taman Sri Nanding, Semenyih, due to inadequate drainage and silt traps causing mud floods [40].

Clogged drains are another common problem that hinders the adequate drainage of stormwater. Drains can be blocked by various types of waste, such as plastic bags, bottles, leaves, branches, and construction materials. Additionally, specific projects overlook environmental concerns, leading to flash floods as a result of smaller drainage systems, clogged drains, or proximity to new developments [41]. These wastes not only reduce the cross-sectional area of the drains but also create obstructions that impede the water flow. Kampung Parit Pasir Baru residents attribute the frequent flash floods since 2018 to ongoing development projects in Pekan Nanas. They opine that these projects have not

incorporated improved drainage systems, causing drainage congestion during rains. Past solutions like U-shaped concrete drains have not yielded the desired results [42].

Unchanged systems have not been upgraded or modified to suit the changing land use patterns and urban development. As urban areas expand and densify, more impervious surfaces are created, such as roads, buildings, and parking lots. As reported, developments around the Setiawangsa-Pantai Expressway (SPE DUKE 3) were directed to improve drainage systems following an investigation linking them to flooding [30]. These surfaces increase the runoff coefficient and decrease the rainfall infiltration rate, leading to higher peak flows and shorter concentration times. However, if the drainage system remains unchanged, it will not be able to accom-modate the increased runoff and may cause flooding.

Reclamation project causes

One of the challenges coastal development faces is the impact of reclamation projects on the hydrological cycle. Reclamation projects involve filling up parts of the sea with soil or other materials to create new land for various purposes. However, this can alter the natural flow of river water to the ocean, which is essential for maintaining the balance of freshwater and saltwater in the coastal ecosystem.

Moreover, reclamation projects can reduce the capacity of the coastal zone to absorb excess rainwater, increasing the risk of flash floods during heavy rainfall events. Beyond construction, large-scale reclamation projects have compromised drainage efficiency, leading to increased flooding, especially in heritage areas like Melaka. Further, climatic changes exacerbating weather shifts compound this problem, em-phasizing the need for improved drainage systems [43], [44]. Therefore, it is important to critically examine the potential consequences of reclamation projects on the hydrological cycle and the coastal environment and propose alternative solutions that can minimize the negative impacts.

Environmental and climatic causes

One of the main challenges urban planners face today is coping with the increasing threat of flash floods. Flash floods are sudden and destructive events that can cause severe damage to infrastructure, property, and lives. Various factors influence flash floods, but two of the most significant ones are environmental and climatic factors.

Environmental and climatic factors refer to the natural conditions that affect the occurrence and severity of flash floods. One of these factors is climate change, which has been linked to rising global temperatures and changes in weather patterns. According to [44] and [45] flash floods in Melaka were attributed to climate change and large-scale coastal reclamation projects that hindered efficient drainage. This means that more Water is accumulated in a shorter period, exceeding the capacity of the drainage systems and resulting in flash floods.

Another environmental and climatic factor is the natural topography of the land. Low-lying areas are more vulnerable to flooding because they have less elevation and slope to facilitate water runoff. However, many urban areas are low-lying for historical, economic, or social reasons. Without proper planning and precautions, urban development in these areas can exacerbate the risk of flash floods by reducing the natural vegetation, increasing impervious surfaces, and altering the hydrological cycle. For example, the suburban areas in the Kuala Selangor district of Selangor, such as Puncak Alam and Desa Coalfields, have seen a surge in housing projects, increasing flood risks for traditional villages in lower regions [45].

Therefore, urban planners must consider the environmental and climatic factors when designing and implementing strategies to mitigate flash floods. By understanding the causes and effects of these factors, urban planners can adopt more effective and sustainable measures to reduce the impacts of flash floods on urban areas.

Collaborative, legal and enforcement causes

One of the challenges the construction industry faces is the legal and enforcement issues related to compliance with construction specifications. Some developers are non-compliant with the standards and regulations, resulting in problems such as poor drainage at construction sites. This can cause increased runoff, erosion, sedimentation, and pollution of the waterways, affecting the ecosystem and public health.

Local councils have issued warnings, directives, and penalties against negligent developers. For instance, penalties and stop work orders, as instituted by councils like MBJB and MPKj, indicate the enforcement of legal measures against erring developers, but these might be reactive rather than preventive [43][40]. However, there is a need for stricter enforcement and compliance checks to ensure that the construction standards are met, and the environmental regulations are followed. In response to these challenges, regulatory bodies like the Johor Bahru City Council (MBJB) and Subang Jaya City Council (MBSJ) have issued notices and warnings to developers, emphasizing the importance of land work controls to prevent sediment from entering the main drainage systems [43], [46]. suggest that developers and contractors need more awareness, education, and training to improve their compliance level.

One key challenge in river and drainage management is the lack of coordination and cooperation among the local authorities responsible for different areas and jurisdictions. Local authorities must collaborate and share information to effectively manage and maintain rivers and drainage systems. This is crucial to prevent flooding, pollution, erosion, and other environmental and social problems affecting residents' quality of life and well-being. [47] highlighted the complications from the Klang River traversing multiple administrative regions, necessitating coordinated river management. Local authorities, including councils like Dewan Bandaraya Kuala Lumpur (DBKL), Majlis Bandaraya Shah

Alam (MBSA), Majlis Bandaraya Subang Jaya (MPSJ), Majlis Bandaraya Petaling Jaya (MBPJ), and Majlis Perbandaran Klang (MPK), must collaborate and share information to manage and maintain the rivers and drainage systems effectively. A call was made to enhance information sharing and collaboration among local authorities and agencies, emphasizing the use of topographical data for flood prediction [47]. Furthermore, collaboration can foster a sense of ownership and responsibility among the stakeholders and promote public awareness and participation in river conservation.

Therefore, local authorities should establish a clear communication, coordination, cooperation, and enforcement mechanism to address the common challenges and issues related to river and drainage management. In addition to collaborative efforts, another important aspect that needs to be considered is the legal and enforcement issues affecting river and drainage management policies and practices.

Urban expansion, waterways, and drainage systems are all confronted with collaboration, legal issues, and enforcement obstacles. These problems impact the quality and safety of buildings, and solutions have been provided. Additional study and immediate action are necessary to address these difficulties and ensure developers adhere to the construction specifications.

Public awareness and concern

One of the main challenges in addressing urban flooding is the lack of public awareness and concern about the causes and consequences of this phenomenon. Many affected residents have expressed dissatisfaction and opposition to development projects that they perceive as contributing to the worsening of flood risks. In May 2022 as reported in Kosmos, residents of Kampung Parit Pasir Baru in Pontian reported that the development projects, especially housing, in Pekan Nanas were the leading cause of recurrent flash floods since 2018. The unchanged and unimproved drainage system was cited as a primary reason for these flooding incidents [42].

However, these voices are often ignored or dismissed by the developers and authorities who are responsible for ensuring the safety and sustainability of urban planning. For example, residents affected by these floods have expressed increasing concerns over property damage and potential loss of life. Demonstrations and peaceful protests have emerged as channels for communities to voice their grievances and urge the implementation of effective solutions [48]. Therefore, raising public awareness and fostering active participation among the stakeholders involved in urban flood management is essential. By doing so, the public can pressure the decision-makers and demand more accountability and transparency in implementing flood mitigation measures. Moreover, public awareness and participation can also enhance the resilience and adaptation capacity of the communities affected by flooding, as they can learn from their experiences and share their knowledge and best practices with others.

While development projects undeniably fuel economic growth and urbanization, they concurrently elicit significant environmental and public safety concerns. Without proper drainage systems, disasters can occur, invalidating any economic benefits. The repetitiveness of these flash flood events underscores the exigency for a thorough reconsideration of land use and urban planning policies.

In summation, the exacerbation of flash flood issues in Malaysia's expanding urban and suburban landscapes stems from inadequate planning, insufficient drainage systems, and a lack of developer accountability. Addressing these challenges mandates a comprehensive strategy that includes enhanced coordination among local governing bodies, strict compliance with building codes, and robust community engagement. Rigorous oversight, reinforced regulatory frameworks, and public participation remain pivotal in averting future calamities.

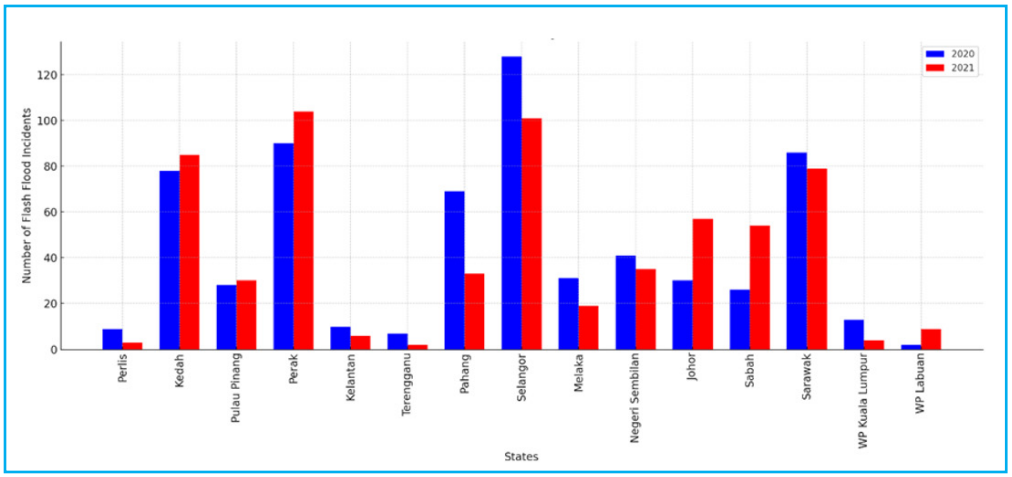

Figure 3. Numbers of Flash Flood Incidents by States for 2020 and 2021 [49]

Annual flood reports published by the Department of Irrigation and Drainage: 2015-2021

Flash floods have long posed a threat to many regions across the globe, with Malaysia being no exception. The consequences of these sudden water surges are often catastrophic, affecting life, property, and the environment. The Department of Irrigation and Drainage Malaysia (DID) has been actively documenting these incidents to gain a comprehensive understanding of their occurrence and potential causes. This research delves into the data provided by the DID, focusing on the variation in flash flood incidents between 2015 and 2021, and aims to shed light on the causes and impacts of these floods across various Malaysian states.

In recent years, Malaysia has seen many flash flood incidents. In 2020 alone, the country experienced 648 flash floods across all its states. While there was a marginal decline in 2021, with 621 incidents reported, the numbers remain alarmingly high. Selangor, the country's most developed state, bore the brunt of these incidents. It consistently ranked the highest with 128 incidents in 2020 and

101 in 2021. Other states like Perak and Sarawak also faced many flash floods, indicating a widespread issue nationwide. Flash flood incidents in Malaysian states are depicted graphically in Fig. 3, with data from the Department of Irrigation and Drainage for 2020 and 2021 (DID).

The Department of Irrigation and Drainage (DID), has published in its yearly report the causes of flash floods between 2015 and 2021; Malaysia has encountered con-sistent flood-related challenges. The factors causing these floods share common themes across these years. and outlined several salient points fully integrated, as shown in Fig. 4. A primary concern was the inability of the extant drainage systems to accommodate increased surface runoff, particularly during periods of intensive rainfall. The problem was aggravated by the clogging of drainage systems due to waste materials and construction debris.

Figure 4. Causes of flash flood

Another contributing factor to the flood events was the impact of development projects. The reports underscored that these projects, often executed rapidly, have sig-nificantly altered the land use patterns, consequently diminishing the capacity of these areas to absorb water. This has led to increased surface water runoff and a higher flood risk. Moreover, construction activities in river reserves disrupt the natural water flow, contributing to flooding during periods of heavy rainfall.

In addition to these man-made factors, natural occurrences such as consistent, wide-spread rainfall and reservoir water releases have also contributed to river overflow. Sediment accumulation in riverbeds, causing them to become shallower

and narrower, further compounded these issues by obstructing efficient water drainage. Tidal influences have also played a significant role, particularly during simultaneous high tide and heavy rainfall. Such events have delayed water drainage from both natural and artificial systems. Moreover, low-lying areas have been identified as particularly vulnerable, being naturally predisposed to flooding.

From this assessment, it becomes clear that while natural factors play a significant role in flood risk, it is the influence of developmental projects that is the most controllable variable. Therefore, sustainable development, robust waste management, and thoughtful urban planning become critical components of flood risk management strategies. The ongoing challenge for Malaysia lies in striking a balance between economic development and environmental conservation to prevent future flooding disasters.

The factors above were consistently reported as causes of flooding incidents for each year between 2015 and 2021. Their recurrent nature over multiple years indicates their enduring significance in the context of flood causation and underscores the need for effective mitigation and management strategies.

Previous literature review about flash flood

One major challenge many Southeast Asian countries face is flash flood severity, which can cause significant economic and social losses. Flash floods are sudden and intense floods that occur within a few hours of heavy rainfall, and various factors influence them. This research discusses the factors influencing flash flood severity in Malaysia, which experiences frequent and devastating flash floods. The main factors that will be discussed are topography, land use, climate change, and urbani-zation [50]–[53].

New development projects in Malaysia have significantly contributed to increased flood risk over time [26], [54]. Rapid urban development and environmental degra-dation in Malaysia have led to increased flash flooding over time [55]. Uncontrolled development in floodplains, pocket development and on hill slopes, deforestation, and encroachment into flood-prone areas have changed the physical characteristics of water systems and increased flood risks [56]. Despite the increasing risks, policymakers and the public prioritize economic gains over flood control. Engineering solutions have failed to address the root causes of increased flooding from development.

Flood risks, exposure, and damages are rising in Malaysia due to urbanization and poverty in floodplains. While indigenous communities have adapted to floods through stilt houses, modernization threatens these adaptations. Environmental im-pact assessments (EIAs) aim to curb the adverse effects of development but have failed to do so for landslides and flash floods in Malaysia [57], [58]. Despite EIAs and laws, landslides and flash floods continue frequently, showing the need to revise EIAs to consider disaster risks and effectiveness. Kuala Lumpur, Malaysia’s capital, faces frequent flash floods due to expanding development and

intense rainfall [3], [59], [60]. The city center and Damansara-Penchala areas are most at risk, accounting for 39% and 20% of flash floods respectively [60].

Affected people face roadblocks, traffic, and damage. Structural approaches like smart tunnels and drainage have failed to solve the problem, showing the need for non-structural approaches [61]–[63]. Conventional drainage systems in Malaysia aim to remove runoff quickly but have worsened flash floods and water quality. New guidelines since 2001 require best management practices (BMPs) that control runoff quantity and quality to prevent development impacts [64], [65]. Natural river capacities can be preserved using BMPs. Vulnerability reduction and emergency prepared-ness can decrease flood damages and deaths. Innovative technologies should reduce vulnerability and increase resilience. Guidelines for floodplain development in Malaysia should recognize that uncontrolled development increases flood risks [66], [67]. All stakeholders from the public and private sectors share the responsibility to provide guidelines, assess development applications, and ensure suitable construction. Structural approaches have limited benefits without planning. Improved planning can achieve greater cost-benefit than structures alone.

Urban development and expansion in Malaysia have significantly increased the risk of flooding over time. [57] land clearance and construction in hilly areas have caused soil erosion and slope failure, leading to more landslides and flash floods, especially during the rainy season. [3] and [68] also found that anticipated urban expansion will moderately increase flooding, while climate change may increase flood-prone areas in Segamat by up to 16.64% for major storms. Deforestation and changing land use have reduced the land's ability to absorb rainwater, according to [69], [70]. [71] and [72] surveyed flood-affected communities in Temerloh and found that while they experienced frequent floods and damage, they primarily blamed natural causes rather than human activity, like deforestation.

However, analysis of land use changes showed significant forest and agricultural land conversion that could worsen future flood risks. Inadequate infrastructure and poor urban planning also exacerbate floods, according to [73]–[75] argues that infrastructure projects like Kuala Lumpur's SMART Tunnel aim to mitigate floods but do not adequately consider future climate and socioeconomic scenarios. [50] heavy rainfall, steep slopes, low drainage density, and high flow accumulation were the main factors causing catastrophic floods in Kg. Kolopis, indicating a need for better infrastructure and land use planning. Socioeconomic factors like population growth, urbanization, and economic development also drive flood risk, according to [76], [77]. [78] demonstrated that the magnitude of floods and resulting damage significantly affected the short-term and long-term growth of Malaysia's construction sector GDP. This highlights the necessity for stronger infrastructure and better disaster readiness.

The challenges associated with flash floods in Malaysia require more than isolated policy solutions; they demand a multi-sectoral, integrated approach

that aligns national strategies with local realities. While Manual Saliran Mesra Alam (MASMA), the National Physical Plan (NPP), and the Urban Stormwater Management Manual (USMM) provide crucial guidance for managing flood risks, their full potential can only be realized through coordinated efforts among government bodies, developers, and local communities[65], [79], [80]. As Malaysia continues to urbanize and climate risks intensify, it is imperative to embed resilience into every stage of devel-opment, ensuring that infrastructure, policies, and urban planning work harmoniously to safeguard people and property from future flood events.

By building on the strengths of these existing frameworks and addressing their limi-tations, Malaysia can move towards a future where sustainable development and flood resilience go hand in hand. Policymakers and practitioners must embrace technical solutions and ecological approaches, recognizing that the path to flood resilience lies in the convergence of innovative design, strategic planning, and collective action.

Impact of flash flood

The urban development landscape, particularly in Malaysia, is interspersed with the growing challenge of flash floods. Numerous reports and studies have highlighted the correlation between intensifying urban developmental activities and the rising frequency of flash floods.

Proactive measures such as warnings and stop-work orders, along with a focus on upgrading infrastructure, represent positive steps by authorities [81]. However, rapid development and insufficient oversight remain formidable challenges [82]. The importance of multi-sectoral collaboration, effective project planning, and robust environmental considerations cannot be overstated in the context of sustainable urban development. The evidence compellingly implicates developmental activities as a contributing factor to flash floods [29], [30], [46], [83]. This relationship necessitates an urgent review of planning strategies, improved coordination among municipal authorities, and stricter compliance with construction guidelines. Failure to address these elements could aggravate flood conditions and obstruct sustainable urban development.

Although media reports commonly emphasize the correlation between rapid development and flash floods, concrete causative evidence remains elusive and warrants further scientific inquiry. One of the primary limitations is the absence of compre-hensive evaluations coupled with a dearth of strict regulatory enforcement [31], [40], [48], [84]. While developmental projects yield significant economic benefits, their potentially adverse environmental impacts cannot be dismissed [41], [44]. The recurring concerns regarding inadequate drainage systems and blockage of natural water pathways necessitate an integrated approach to planning, stringent monitoring procedures, and effective inter-agency collaboration [32], [43], [85].

Although urban development projects offer significant economic boosts, they simultaneously raise issues of environmental integrity and resident safety [41], [43], [58], [60]. A lack of attention to drainage systems can precipitate catastrophic consequences, offsetting the benefits of development. The recurrent flash floods reinforce the need for a comprehensive review of land use policies and urban planning strate-gies [81], [86]. The consistent association of flash floods with construction activities flags potential gaps in urban planning and environmental assessments [3], [78]. While public sentiment often focuses on immediate concerns, these must be rigorously validated through comprehensive scientific evaluations.

Given the recurrent incidents of flooding connected to development projects, it is evident that there exists a significant gap in urban planning and infrastructural evolution in Malaysia. Legal measures, such as penalties and stop-work orders imposed by councils like MBJB and MPKj, may signify attempts at enforcement but appear to be more reactive than preventive in nature [31], [43], [44], [81], [84]. Civil unrest and peaceful protests signal the societal consequences and eroding public trust in infrastructure projects [42], [48]. These manifestations necessitate greater transparency and accountability from both developers and governing bodies refer Fig.5.

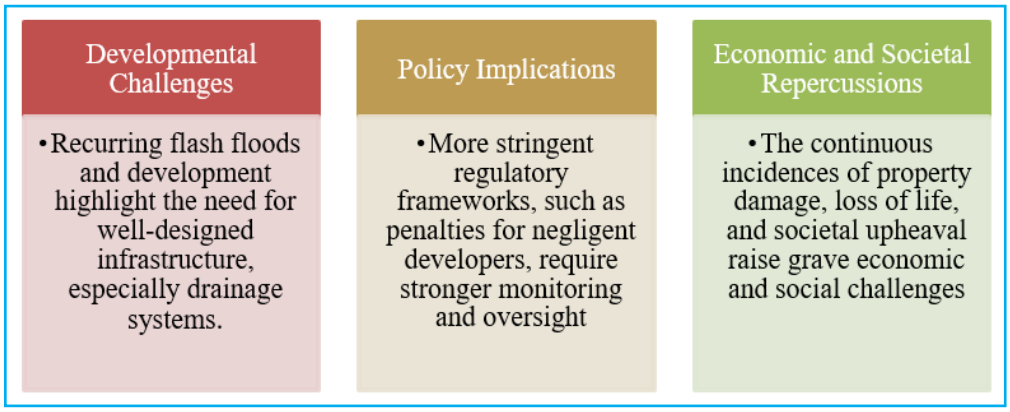

Figure 5. Developer and Governing Bodies

Finally, the linkage between development projects and flood incidents highlights the urgency of revisiting urban planning and policy frameworks. While development is a prominent factor, the role of climate change and geological conditions suggests a multifaceted issue that warrants a comprehensive approach.

In summary, the literature indicates a relationship between Malaysia's development trajectory and increased flash flooding events. Current infrastructural solutions and policies have proven to be insufficient, especially considering the looming threat of climate change. A multifaceted, comprehensive solution is essential to mitigate these floods' severe and increasingly frequent impacts [87].

Conclusion

The study identified several key vulnerabilities contributing to flash floods, including developmental activities, unchanged drainage systems, urban expansion and densification, impervious surfaces, hydrological cycle, coastal environment, environmental and climatic factors, collaboration and coordination, legal and enforce-ment issues, construction standards and guidelines and developer negligence. The investigation revealed that developmental activities often disrupt natural water flow and increase surface runoff, exacerbating flood risks. Additionally, the study highlighted the critical role of effective drainage systems and the need for integrated planning and robust environmental considerations in mitigating flood impacts.

This research examines the relationship between urban expansion and flood susceptibility in Malaysia, providing valuable insights into flash flood dynamics. It pin-points specific developmental endeavors and infrastructural deficiencies that amplify flash flood risks, providing a well-defined structure for addressing these concerns. The study stresses the significance of sustainable development practices and im-proved coordination among local authorities. Moreover, it provides practical policy suggestions, such as enforcing stricter adherence to construction regulations, enhancing public awareness, and encouraging interagency cooperation.

Moreover, the MASMA, NPP, and USMM, though distinct in their scope, comple-ment one another and could together form the foundation for a more holistic flood management framework in Malaysia. However, policy fragmentation remains a major barrier to achieving this integration. For example, while the NPP offers strategic direction for sustainable urban growth, the effectiveness of these strategies depends on local-level implementation and adherence to MASMA's drainage guidelines and USMM's stormwater management standard. Improved coordination between federal, state, and local governments to align development goals with flood risk considerations. Regular monitoring and updates of these policy frameworks to reflect changing climate patterns and urban dynamics. Stakeholder engagement, involving developers, engineers, policymakers, and civil society, to ensure that flood risk management becomes a shared responsibility.

In conclusion, this study not only illuminates the root causes and repercussions of flash floods in Malaysia but also promotes a holistic approach to urban design and disaster risk reduction. By addressing the identified risk elements and implementing the proposed suggestions, such as sustainable land management, policy implications, prioritized land use planning, and disaster risk reduction, Malaysia can more effectively handle flash flood risks and boost the resilience of its urban settings. This research is a major step toward sustainable development and flash flood protection.

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Conflicts of Interest

The authors declare no competing interest.

Author Contributions

Mohammad Syamsyul Hairi Saad: writing, original draft preparation. **Mohamad Idris Ali:** writing, reviewing and editing. **Putri Zulaiha Razi:** reviewing and editing. **Noram Irwan Ramli:** reviewing and editing. **Ramadhansyah Putra Jaya:** reviewing and editing.

Data Availability Statement

The data used to support the findings of this study are included within the article.

References

[1] J. Jaafar, A. N. B. Ishak, S. Hassan, K. F. Bin, Adrutdin, and M. I. Qureshi, "A Study of Customer Satisfaction with Planning Movement of Goods during Disaster Aid Programs: A Case Study of Flood Hit in Segamat, Johor," 2020, [Online]. Available: https://www.semanticscholar.org/paper/6065a7e4f80206082ddec59305824069e7f84e7e

[2] U. H. M. Asri and M. R. Mahmud, "44% of the flash flood in Klang Valley occurred coincidentally during the typhoon period: A review on 2015," IOP Conf. Ser. Earth Environ. Sci., vol. 1135, no. 1, p. 012016, 2023, doi: http://dx.doi.org/10.1088/1755-1315/1135/1/012016

[3] N. Samsuri, R. A. Bakar, and T. Unjah, "Flash Flood Impact in Kuala Lumpur – Approach Review and Way Forward," Int. J. Malay World Civilis. 6, vol. 6, no. 1, pp. 69–76, 2018.

[4] DID, "Annual flood report 2020," Dep. Irrig. Drain. Malaysia, pp. 1–240, 2020.

[5] A. Mustafa et al., "Effects of spatial planning on future flood risks in urban environments," J. Environ. Manage., vol. 225, no. July, pp. 193–204, 2018, doi: http://dx.doi.org/10.1016/j.jenvman.2018.07.090

[6] W. Alaghbari, A. K. Mohd. Razali, S. Azizah, and Ernawati, "The significant factors causing delay of building construction projects in Malaysia," Eng. Constr. Archit. Manag., vol. 14, no. 2, pp. 192–206, 2007.

[7] G. Dehdasht, M. S. Ferwati, N. Z. Abidin, and M. O. Oyedeji, "Trends of construction industry in Malaysia and its emerging challenges," J. Financ. Manag. Prop. Constr., vol. 27, no. 2, pp. 161–178, 2022, doi: http://dx.doi.org/10.1108/JFMPC-08-2020-0054

[8] M. A. N. Masrom, M. H. I. A. Rahim, S. Mohamed, G. K. Chen, and R. Yunus, "Successful criteria for large infrastructure projects in Malaysia," Procedia Eng., vol. 125, pp. 143–149, 2015, doi: http://dx.doi.org/10.1016/j.proeng.2015.11.021

[9] L. M. Killian, "Some Accomplishments and Some Needs in Disaster Study," J. Soc. Issues, vol. 10, no. 3, pp. 66–72, 1954, doi: http://dx.doi.org/10.1111/j.1540-4560.1954.tb02000.x

[10] W. Kron, “Flood risk = hazard • values • vulnerability,” Water Int., vol. 30, no. 1, pp. 58–68, 2005, doi: http://dx.doi.org/10.1080/02508060508691837

[11] B. Gouldby and P. G. Samuels, “and Management Methodologies Language of Risk,” no. April, 2005.

[12] UNISDR, “Sendai Framework for Disaster Risk Reduction 2015 - 2030,” 2015. [Online]. Available: http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

[13] B. Wisner, P. Blaikie, T. Cannon, and I. Davis, “At risk: natural hazards, peoples vulnerability and disasters,” Risk Nat. Hazards Peoples Vulnerability Disasters, pp. 1–471, 2014, doi: http://dx.doi.org/10.4324/9780203714775.

[14] D. P. Coppola, The Management of Disasters. 2015. doi: http://dx.doi.org/10.1016/b978-0-12-801477-6.00001-0.

[15] P. Timmerman, “Vulnerability. Resilience and the collapse of society: a review of models and possible climatic applications. Environmental Monograph No. 1,” Institute for Environmental Studies, Univ. of Toronto. pp. 1–41, 1981. [Online]. Available: https://www.ilankelman.org/miscellany/Timmerman1981.pdf

[16] P. Blaike, T. Cannon, I. Davis, and B. Wisner, “At Risk: Natural Hazards,” People’s Vulnerability and Disasters, no. January, 1994.

[17] S. L. Cutter et al., “A place-based model for understanding community resilience to natural disasters,” Glob. Environ. Chang., vol. 18, no. 4, pp. 598–606, 2008, doi: http://dx.doi.org/10.1016/j.gloenvcha.2008.07.013

[18] P. J. Ward et al., “The need to integrate flood and drought disaster risk reduction strategies,” Water Secur., vol. 11, no. 2020, 2020, doi: http://dx.doi.org/10.1016/j.wasec.2020.100070

[19] E. Lechowska, Approaches in research on flood risk perception and their importance in flood risk management: a review, vol. 111, no. 3. Springer Netherlands, 2022. doi: http://dx.doi.org/10.1007/s11069-021-05140-7

[20] IPCC, Climate Change 2022 Mitigation of Climate Change Summary for Policymakers, no. 1. 2022. [Online]. Available: https://www.ipcc.ch/report/ar6/wg2/

[21] E. T. Busayo, A. M. Kalumba, G. A. Afuye, A. O. Olusola, O. O. Ololade, and I. R. Orimoloye, “Rediscovering South Africa: Flood disaster risk management through ecosystem-based adaptation,” Environ. Sustain. Indic., vol. 14, no. October 2021, p. 100175, Jun. 2022, doi: http://dx.doi.org/10.1016/j.indic.2022.100175

[22] S. Huang, H. Wang, Y. Xu, J. She, and J. Huang, “Key disaster-causing factors chains on urban flood risk based on bayesian network,” Land, vol. 10, no. 2, pp. 1–21, Feb. 2021, doi: http://dx.doi.org/10.3390/land10020210

[23] O. M. Nofal and J. W. van de Lindt, “Understanding flood risk in the context of community resilience modeling for the built environment: research needs and trends,” Sustain. Resilient Infrastruct., vol. 7, no. 3, pp. 171–187, 2022, doi: http://dx.doi.org/10.1080/23789689.2020.1722546

[24] D. D’Ayala et al., “Flood vulnerability and risk assessment of urban traditional buildings in a heritage district of Kuala Lumpur, Malaysia,” Apr. 2020, doi: http://dx.doi.org/10.5194/nhess-2020-96

[25] T. K. Karki, “Flood resilience in Malaysian cities: a case study of two towns in Johor state,” Int. J. Disaster Resil. Built Environ., vol. 11, no. 3, pp. 329–342, Dec. 2020, doi: http://dx.doi.org/10.1108/IJDRBE-06-2019-0037

[26] N. W. Chan, A. A. Ghani, N. Samat, N. N. N. Hasan, and M. L. Tan, “Integrating Structural and Non-structural Flood Management Measures for Greater Effectiveness in Flood Loss Reduction in the Kelantan River Basin, Malaysia,” Lect. Notes Civ. Eng., vol. 53, pp. 1151–1162, 2020, doi: http://dx.doi.org/10.1007/978-3-030-32816-0_87

[27] A. A. Latif and N. H. Arshad, “A review of flood management governance framework in Malaysia and selected countries,” Conf. Proc. - 6th Int. Conf. Inf. Technol. Multimed. UNITEN Cultiv. Creat. Enabling Technol. Through Internet Things, ICIMU 2014, pp. 178–183, 2015, doi: http://dx.doi.org/10.1109/ICIMU.2014.7066626

[28] I. Sufiyan, J. I. Magaji, A. T. Oga, and I. Zaharaddeen, “Analysis of Hydrologic Response Units and Impact of Flooding in Kuala Terengganu Sub-basins River Catchment in Malaysia,” Asian J. Geogr. Res., vol. 2, no. 1, pp. 1–16, 2019, doi: http://dx.doi.org/10.9734/ajgr/2019/v2i129631

[29] BERNAMA, “Amaran DBKL buat pemaju projek sebabkan banjir,” Berita Harian, pp. 1–7, 2015.

[30] BERNAMA, “DBKL siasat kemungkinan projek pembangunan punca banjir kilat,” Astroawani.com, pp. 1–7, 2017.

[31] Nurul Farina Nazlan, “Banjir SUKE, amaran keras buat pemaju,” Selangorkini, pp. 1–20, 2017.

[32] H. A. Hasnan, “Banjir kilat : Pemaju wajib tambah baik sistem saliran , kolam tahanan,” Astroawani.com, 2017.

[33] Firdaus Alauddin, “Sampah, sisa projek mega antara punca banjir kilat - Datuk Bandar KL | Astro Awani,” Astroawani.com, pp. 1–6, 2018. [Online]. Available: https://www.astroawani.com/berita-malaysia/sampah-sisa-projek-mega-antara-punca-banjir-kilat-datuk-bandar-kl-190464

[34] M. Luqman Ismail, S. Meryam, S. Musa, F. P. Teknologi, and D. Perniagaan, “Study on the Implementation of Drainage System at Universiti Tun Hussein Onn Malaysia (UTHM) Kajian Perlaksanaan Sistem Saliran di Universiti Tun Hussein Onn Malaysia (UTHM),” J. Techno Soc., vol. 12, no. 2, pp. 12–20, 2020, [Online]. Available: http://penerbit.uthm.edu.my/ojs/index.php/jts

[35] I. Noor Syamimi, M. D. Azharudin, and A. R. Mohamad Rodzi, “Sejarah Banjir Besar di Semenanjung Malaysia , 1926- – 1971,” J. Perspekt., vol. 6, no. 3, pp. 54–67, 2014.

[36] P. Hudson, P. Raška, J. Macháč, and L. Slavíková, “Balancing the interaction between urban regeneration and flood risk management – A cost benefit approach in Ústí nad Labem,” Land use policy, vol. 120, no. July, 2022, doi: http://dx.doi.org/10.1016/j.landusepol.2022.106276

[37] A. R. Nuruddin, S. P. S. Abu Bakar, and M. Jaafar, “Unveiling the challenges faced by Malaysian housing developers through government policy changes,” J. Constr. Dev. Ctries., vol. 20, no. 2, pp. 37–52, 2015.

[38] N. A. Mohd Sofberi and R. Zainal, “Decision Making Process Practised At Planning Phase in Malaysia,” Malaysian J. Sustain. Environ., vol. 7, no. 2, p. 107, 2020, doi: http://dx.doi.org/10.24191/myse.v7i2.10267

[39] E. H. F. Haque, “Syarikat perumahan punca banjir kilat dikompaun,” hmetro.com.my, pp. 1–10, 2021.

[40] F. Zakinan, “MPKj sita tapak projek di Taman Sri Nanding , didapati punca banjir kilat,” selangorkini.my, pp. 1–5, 2023.

[41] Bernama, “Projek abai alam sekitar undang bencana,” bharian.com.my, pp. 1–9, 2018.

[42] M. Zikri, “Projek pembangunan punca banjir kilat di Pontian,” kosmo.com.my, pp. 1–9, 2022.

[43] Bernama, “Projek tebus guna mungkin burukkan lagi masalah banjir di Melaka,” malaysiakini.com, pp. 23–25, 2021.

[44] L. C. Chyuan, “Banjir Melaka : kilat yang lebih kerap di Melaka , dengan sistem Melaka dengan cekap . Memburukkan lagi keadaan , projek penambakan berskala besar di persisiran pantai Melaka telah mengganggu sistem perparitan .,” newslab.malaysiakini.com, 2023.

[45] M. I. Izuan Tahir, “Pembangunan Pesat Punca Banjir,” Suara Sinar, no. November 2019, 2019. [Online]. Available: https://www.sinarharian.com.my/article/57767/Suara-sinar/analisis-sinar/pembangunan-pesat-punca-banjir

[46] M. A. Zainury, “Projek pembinaan punca banjir kilat di Puchong,” sinarharian.com.my, pp. 1–15, 2022.

[47] D. H. A. Rahman, “Kerjasama antara agensi elak banjir kilat berulang,” bharian.com.my, pp. 1–10, 2020.

[48] S. Mustafa, “Penduduk kecewa banjir akibat projek PLSB,” bharian.com.my, pp. 1–9, 2023.

[49] DID, “Laporan Banjir 2020,” Dep. Irrig. Drain. Malaysia, pp. 1–240, 2020.

[50] K. Sharir, G. T. Lai, N. Simon, L. K. Ern, M. A. Talip, and R. Roslee, “Assessment of Flood Susceptibility Analysis Using Analytical Hierarchy Process (AHP) in Kota Belud Area, Sabah, Malaysia,” IOP Conf. Ser. Earth Environ. Sci., vol. 1103, no. 1, 2022, doi: http://dx.doi.org/10.1088/1755-1315/1103/1/012005

[51] A. K. B. de Oliveira et al., “Evaluating the Role of Urban Drainage Flaws in Triggering Cascading Effects on Critical Infrastructure, Affecting Urban Resilience,” Infrastructures, vol. null, p. null, 2022, doi: http://dx.doi.org/10.3390/infrastructures7110153

[52] G. O. Abah and S. O. Onah, “Striking an Interactive Balance Between Nature and Culture in Human Developmental Exploits for Sustainable Environmental Protection and Management,” Glob. J. Health Sci., vol. 12, no. 5, p. 110, 2020, doi: http://dx.doi.org/10.5539/gjhs.v12n5p110

[53] K. I. Abdrabo et al., “The Role of Urban Planning and Landscape Tools Concerning Flash Flood Risk Reduction Within Arid and Semiarid Regions,” no. September, pp. 283–316, 2022, doi: http://dx.doi.org/10.1007/978-981-16-2904-4_11

[54] N. Weng Chan, “Increasing flood risk in Malaysia: Causes and solutions,” Disaster Prev. Manag. An Int. J., vol. 6, no. 2, pp. 72–86, 1997, doi: http://dx.doi.org/10.1108/09653569710164035

[55] N. W. Chan, “Impacts of Disasters and Disaster Risk Management in Malaysia: The Case of Floods,” in Resilience and Recovery in Asian Disasters, Springer Japan, 2015, pp. 239–265. doi: http://dx.doi.org/10.1007/978-4-431-55022-8_12

[56] Hanis Syazwani Ramli1, H. Shafii, H. Masram, S. T. Wee, N. Sarpin, and Mohd Hairy Ibrahim, “Isu ‘Poket Development’ Membawa kepada,” Res. Manag. Technol. Bus., vol. 4, no. 1, pp. 1185–1202, 2023, [Online]. Available: http://publisher.uthm.edu.my/periodicals/index.php/rmtb

[57] Alya Batrisyia Hipeny, Nor Azam Ramli, and Nur Baitul Izati Rasli, “Procedural Effects on Controlling Natural Disasters (Landslides and Flash Floods) Based on Environmental Degradation from Development in Malaysia,” Int. J. Eng. Manag. Res., vol. 12, no. 5, pp. 189–196, 2022, doi: http://dx.doi.org/10.31033/ijemr.12.5.23

[58] I. Sufiyan et al., “44% of the flash flood in Klang Valley occurred coincidentally during the typhoon period: A review on 2015,” IOP Conf. Ser. Earth Environ. Sci., vol. 7, no. 1, pp. 583–595, 2021, doi: http://dx.doi.org/10.1088/1755-1315/1135/1/012016

[59] M. A. Bari, L. Alam, M. M. Alam, L. F. Rahman, and J. Pereira, “Estimation of losses and damages caused by flash floods in the commercial area of Kajang, Selangor, Malaysia,” Arab. J. Geosci., vol. 14, p. null, 2021, doi: http://dx.doi.org/10.1007/s12517-021-06503-x

[60] T. R. Bhuiyan, M. I. H. Reza, E. A. Choy, and J. J. Pereira, “Facts and trends of urban exposure to flash flood: A case of kuala lumpur city,” Community, Environ. Disaster Risk Manag., vol. 20, pp. 79–90, 2018, doi: http://dx.doi.org/10.1108/S2040-726220180000020016

[61] H. S. Rosmadi, M. F. Ahmed, M. Bin Mokhtar, and C. K. Lim, “Reviewing Challenges of Flood Risk Management in Malaysia,” Water, vol. 15, no. 13, p. 2390, 2023, doi: http://dx.doi.org/10.3390/w15132390

[62] I. Usman Kaoje et al., “Physical flood vulnerability assessment using geospatial indicator-based approach and participatory analytical hierarchy process: A case study in Kota Bharu, Malaysia,” Water (Switzerland), vol. 13, no. 13, 2021, doi: http://dx.doi.org/10.3390/w13131786

[63] N. Shifulah and N. Zakaria, “Knowledge transfer existence for flood forecasting in higher education community: internet of things solution,” 2017, [Online]. Available: https://www.semanticscholar.org/paper/06c077da2ba78ad272c4508cc613e94b1dfeac18

[64] L. M. Sidek et al., “Stormwater and Drainage Master Plan and Formulation of Best Management Practices for Cameron Highlands,” Int. J. Recent Technol. Eng., vol. 8, no. 4, pp. 6468–6473, 2019, doi: http://dx.doi.org/10.35940/ijrte.d5159.118419

[65] N. A. Zakaria et al., “MSMA- A New Urban Stormwater Management Manual for Malaysia,” Adv. Hydro-Science - Eng., vol. VI, no. February 2014, pp. 1–10, 2014.

[66] L. Bertilsson, K. Wiklund, I. de Moura Tebaldi, O. M. Rezende, A. P. Veról, and M. G. Miguez, “Urban flood resilience – A multi-criteria index to integrate flood resilience into urban planning,” J. Hydrol., vol. 573, pp. 970–982, Jun. 2019, doi: http://dx.doi.org/10.1016/J.JHYDROL.2018.06.052

[67] F. K. S. Chan, C. J. Chuah, A. D. Ziegler, M. Dąbrowski, and O. Varis, “Towards resilient flood risk management for Asian coastal cities: Lessons learned from Hong Kong and Singapore,” J. Clean. Prod., vol. 187, pp. 576–589, 2018, doi: http://dx.doi.org/10.1016/j.jclepro.2018.03.217

[68] N. H. Ab Razak, A. Z. Aris, M. F. Ramli, L. J. Looi, and H. Juahir, “Temporal flood incidence forecasting for Segamat River (Malaysia) using autoregressive integrated moving average modelling,” J. Flood Risk Manag., vol. 11, pp. S794–S804, Aug. 2018, doi: http://dx.doi.org/10.1111/jfr3.12258

[69] S. K. Abid, N. Sulaiman, C. S. Wei, and U. Nazir, “Flood vulnerability and resilience: Exploring the factors that influence flooding in Sarawak,” IOP Conf. Ser. Earth Environ. Sci., vol. 802, no. 1, 2021, doi: http://dx.doi.org/10.1088/1755-1315/802/1/012059

[70] United Nations Office for Disaster Risk Reduction, Global Assessment Report on Disaster Risk Reduction 2022: Our World at Risk: Transforming Governance for a Resilient Future. 2022.

[71] N. A. Alias, C. Siwar, M. K. Ismail, and N. D. M. Idris, “Flood disaster management in sungai pahang basin: Case of temerloh,” in Community, Environment and Disaster Risk Management, vol. 20, Emerald Publishing Limited, 2018, pp. 91–102. doi: http://dx.doi.org/10.1108/S2040-726220180000020017

[72] A. Nurul Ashikin, M. I. Nor Diana, C. Siwar, M. M. Alam, and M. Yasar, “Community preparation and vulnerability indices for floods in Pahang State of Malaysia,” Land, vol. 10, no. 2, pp. 1–23, Feb. 2021, doi: http://dx.doi.org/10.3390/land10020198

[73] V. Bell et al., “Flood Impacts across Scales: towards an integrated multi-scale approach for Malaysia,” p. null-null, 2021, doi: http://dx.doi.org/10.3311/floodrisk2020.9.6

[74] R. Roslee and K. Sharir, “Integration of GIS-Based RUSLE model for land planning and environmental management in Ranau area, Sabah, Malaysia,” ASM Sci. J., vol. 12, no. Special Issue 3, pp. 60–69, 2019.

[75] S. H. Muhammad Arshad et al., “Penilaian keberkesanan terowong SMART Kuala Lumpur dalam menghalang banjir kilat,” Malaysian J. Soc. Sp., vol. 16, no. 3, pp. 184–200, 2020, doi: http://dx.doi.org/10.17576/geo-2020-1603-14

[76] N. Shuhada, A. Malek, S. Zayid, Z. Ahmad, S. Ya’acob, and A. A. Bakar, “Data Understanding for Flash Flood Prediction in Urban Areas,” 2020, [Online]. Available: https://www.semanticscholar.org/paper/438c042acab6345725135557e23205a97f73255f

[77] P. N. Duy, L. Chapman, M. Tight, P. N. Linh, and L. V. Thuong, “Increasing vulnerability to floods in new development areas: evidence from Ho Chi Minh City,” Int. J. Clim. Chang. Strateg. Manag., vol. 10, no. 1, pp. 197–212, 2018,
doi: http://dx.doi.org/10.1108/IJCCSM-12-2016-0169

[78] N. Z. A. Norizan, N. Hassan, and M. M. Yusoff, “Strengthening flood resilient development in malaysia through integration of flood risk reduction measures in local plans,” Land use policy, vol. 102, no. May 2019, p. 105178, 2021,
doi: http://dx.doi.org/10.1016/j.landusepol.2020.105178

[79] F. K. S. Chan et al., “Comparison of sustainable flood risk management by four countries - the United Kingdom, the Netherlands, the United States, and Japan - and the implications for Asian coastal megacities,” Nat. Hazards Earth Syst. Sci., vol. 22, no. 8, pp. 2567–2588, 2022, doi: http://dx.doi.org/10.5194/nhess-22-2567-2022

[80] Department of Irrigation and Drainage Malaysia, Guideline for erosion and sediment control. 2010.

[81] M. A. R. Shah, A. Rahman, and S. H. Chowdhury, “Assessing sustainable development of flood mitigation projects using an innovative sustainability assessment framework,” Sustain. Dev., vol. 28, no. 5, pp. 1404–1417, 2020, doi: http://dx.doi.org/10.1002/sd.2094

[82] M. I. Izuan Tahir, “Pembangunan Pesat Punca Banjir,” Suara Sinar, no. November 2019, 2019.

[83] Bernama, “Banjir kilat: MBJB ambil tindakan segera,” malaysiakini.com, pp. 6–8, 2022.

[84] Z. SALLEH, “Isu banjir kilat sebab projek WCE diselesaikan,” kosmo.com.my, pp. 1–7, 2021.

[85] Firdaus Alauddin, “Sampah, sisa projek mega antara punca banjir kilat - Datuk Bandar KL | Astro Awani,” Astroawani.com, pp. 1–6, 2018.

[86] K. Zanudin, I. Ngah, and S. H. Misnan, “Public planner’s perception of the community participation in planning and operational decision-making in Iskandar Malaysia,” Eng. J., vol. 25, no. 1, pp. 275–285, 2021, doi: http://dx.doi.org/10.4186/ej.2021.25.1.275

[87] P. Raška et al., “Identifying barriers for nature-based solutions in flood risk management: An interdisciplinary overview using expert community approach,” J. Environ. Manage., vol. 310, no. December 2021, 2022, doi: http://dx.doi.org/10.1016/j.jenvman.2022.114725