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REVIEW ARTICLE

Flood Risk Management in Development Projects: A Review of Malaysian Perspective within the Sendai Framework for Disaster Risk Reduction 2015-2030

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ABSTRACT - This study rigorously assesses Malaysia's development projects' alignment with the Sendai Framework for Disaster Risk Reduction 2015-2030 to identify synergies that can be improved, with a focus on flood risk management challenges and opportunities. The primary goal is to establish a flexible framework that integrates national and grassroots initiatives to advance economic, social, and environmental responsibility in conjunction with development objectives. As Malaysia undergoes rapid development, it is increasingly exposed to flood risks, exacerbated by climate change and urbanization. The Sendai Framework provides guidelines to mitigate these escalating threats. Nonetheless, there is a discernible gap in the existing literature that neither adequately evaluates the development patterns amplifying flood risks nor scrutinizes Malaysia's conformity with the Sendai Framework's objectives. Utilizing a systematic and scoping literature review in conjunction with a qualitative approach. The findings underscore that despite notable progress in Malaysia's flood risk management, significant deficiencies persist in policy execution, financial allocation, and public cognizance. This research refined the flood risk management conceptual framework to adapt to changing environmental contexts. Crucially, the proactive involvement of the federal government, local authorities from various Malaysian states, and the Department of Irrigation and Drainage Malaysia is indispensable in flood risk mitigation. While frameworks like the National Physical Plan 4 (NPP4) have improved, local planning must adapt them to local needs. Every development project should mandatorily embed a comprehensive flood risk assessment, ensuring alignment with national guidelines. This increases compliance and construction sector interest, elevating flood disaster risk reduction. This enables a future where innovation, professionalism, and knowledge improve life quality while prioritizing safety and sustainability.

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1. INTRODUCTION

Integrating Disaster Risk Reduction (DRR) into international development policies is crucial for flood risk management. Climate-induced hazards are increasing, making integration more urgent, a phenomenon well-documented in scholarly literature[1,2]. DRR interventions are bifurcated into two essential categories: structural measures, which incorporate engineering solutions for preventive and protective purposes, and adaptive non-structural measures, which focus on more inclusive and socially oriented strategies to enhance resilience [3]. Different international frameworks have promoted community engagement in DRR. Initially, the Yokohama Strategy pioneered multinational disaster management. However, it is the Hyogo Framework for Action 2005-2015 (HFA) and its successor, the Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR), that have solidified public participation as essential to DRR planning and execution. These frameworks' comprehensiveness and participatory approach have made the global community more resilient to flood risks.

Malaysia is a country that is particularly vulnerable to floods, due to its tropical climate, low-lying terrain, and high rainfall intensity. Floods have caused significant damage to property, infrastructure, and human lives in the country, particularly in the last decade. Development projects are particularly susceptible to flood risk [4], as they involve the modification of the natural environment and often have significant implications for the drainage and water flow patterns of the surrounding area. Malaysia, characterized by its tropical climate, low-lying terrains, and high rainfall intensity, remains highly susceptible to floods [5,6]. In the last decade alone, floods have wreaked havoc, causing devastating damage to property, infrastructure, and human lives [7]. Development projects compound this flood risk as they often involve altering the natural environment, disrupting drainage systems, and modifying water flow patterns in surrounding areas [8]. Given this backdrop, the incorporation of flood risk management in development planning becomes pivotal. The Sendai Framework for Disaster Risk Reduction 2015-2030, established by the United Nations, serves as an excellent guideline for countries like Malaysia [9].

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One of the key principles of the Sendai Framework is to understand disaster risk comprehensively [9]. In the context of Malaysia, this necessitates interdisciplinary assessments that evaluate geological, climatic, and socio-economic conditions [10]. Developers and planners must undertake in-depth hydrological studies, terrain mapping, and risk assessments at the initial planning stages [11]. Simultaneously, engaging with local communities to understand traditional knowledge and practices in flood management can offer valuable insights [12]. Integrating scientific data with indigenous wisdom can help provide a comprehensive understanding of flood patterns [13]. The Sendai Framework prioritizes governance as a cornerstone for effective disaster risk management [9]. Under Malaysia, this implies tightening regulatory frameworks [12,14]. Inter-agency coordination is crucial for harmonizing land use planning, water resource management, and environmental conservation [15].

The economic toll of flood disasters in Malaysia has been alarming, prompting the need for proactive investments in disaster risk reduction (DRR) measures [16]. Investments in flood-resilient infrastructure and the development of green infrastructure can reduce runoff and mitigate flood risks [17]. A critical tenet of the Sendai Framework is the enhancement of disaster preparedness [9]. Development projects in Malaysia should incorporate disaster management methods such as community-based early warning systems and well-defined evacuation strategies. Therefore, it is important to understand the factors that contribute to flood risk in development projects, to mitigate their impact and promote sustainable development. The goal is to establish a flexible framework that integrates national and grassroots initiatives to advance economic, social, and environmental responsibility in conjunction with developmental objectives. The Sendai Framework for Disaster Risk Reduction 2015-2030 serves as a universal blueprint [9], and its application to Malaysia's vulnerabilities is essential for a resilient future. Malaysia can reduce its flood risks by adopting a forward-thinking and interdisciplinary approach to development.

2. LITERATURE REVIEW

Floods represent the predominant form of natural disaster in Malaysia, inflicting substantial human and economic losses [18–21]. Although the government has institutionalized a flood disaster management system guided by the National Security Council's Directive No. 20, numerous studies underscore deficiencies in policy implementation, particularly during the post-flood phase [16,18]. This centralized approach primarily emphasizes engineered solutions, such as flood control systems, to the detriment of a comprehensive risk management strategy that incorporates community engagement [22,23]. Experts advocate a multifaceted approach, emphasizing legislative amendments, policy optimization, public engagement, and inter-agency collaboration [16,24–26]. In addition to structural interventions, there is a growing consensus for Malaysia to integrate non-structural measures, leverage cutting-edge technologies, and foster international collaborations [25,27]. The efficacy of these strategies is intrinsically linked to public awareness and preparedness, indicating a need for targeted educational initiatives [14,28].

Malaysia's susceptibility to frequent flooding is exacerbated by its geographic disposition and unchecked urban expansion. Although a structured disaster management cycle comprising prevention/mitigation, preparedness, response, and recovery phases has been established (as depicted in Figure 1), challenges persist in its effective implementation [29]. A focus on prevention and preparedness is particularly critical, as these phases form the foundation for minimizing the impact of the ensuing stages of the disaster.

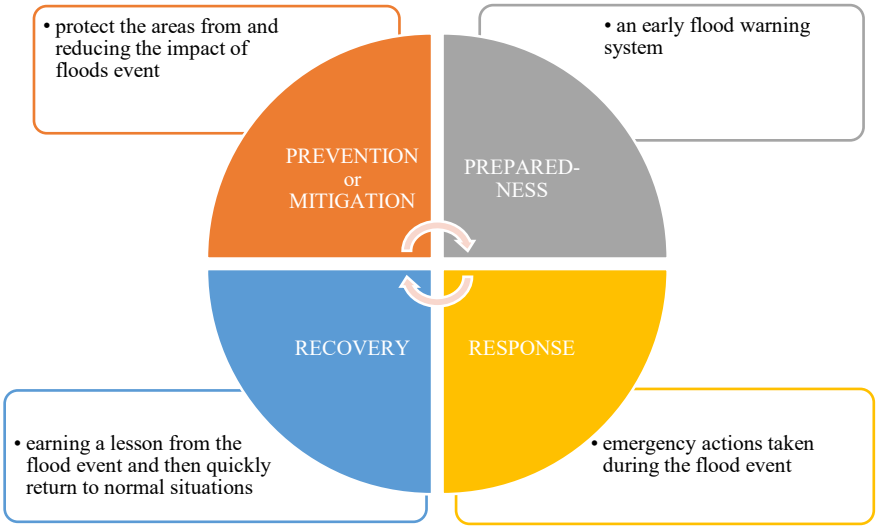

Figure 1. Flood disaster management phases [21]

Among these, the crucible of effective flood management rests on prevention and preparedness, as adept handling of these stages invariably attenuates the strain on subsequent stages. While the National Security Council helms federal flood initiatives, the provincial and municipal tiers are also integral cogs [30]. Yet, an overarching issue is the disjointed coordination across these echelons [19,31,32]. Critics argue that Malaysia's flood directives and operational protocols

lack a panoramic, risk-centric perspective [33]. The clarion call from researchers is to conceptualize a national flood risk framework, oriented around pre-emptive, contemporaneous, and post-event risk considerations [16]. Various academic discourses have proffered novel architectures and methodologies to enhance Malaysia's flood countermeasures, encompassing innovative management cycles [32] depicted in Figure 2, refined models for victim relocation to sanctuaries [19]. The provision of timely and effective relief to flood victims emerges as another challenge. In essence, Malaysia's foundational flood management strategies, while noteworthy, invite further refinement. Scholars advocate for synergized efforts, holistic risk appraisal, policy rejuvenation, and resource optimization models. Such a metamorphosis would synergize Malaysia's flood resilience endeavors with the Sendai Framework's tenets.

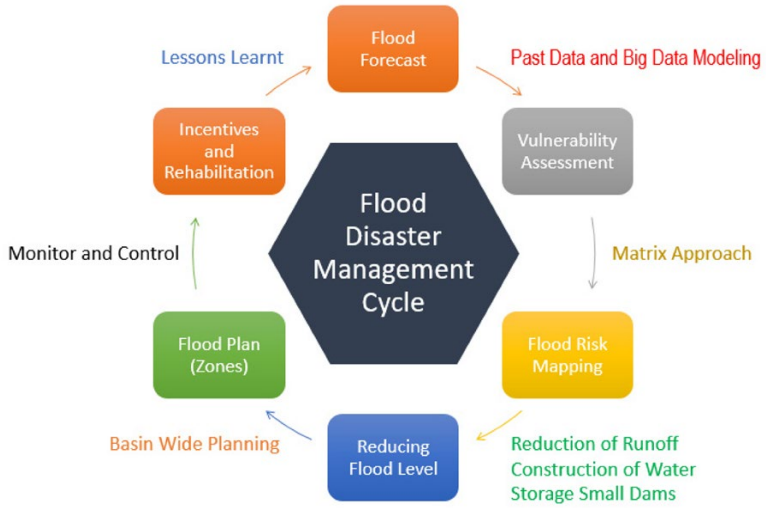

Figure 2. Proposed framework for the flood disaster management cycle [32]

The Sendai Framework for Disaster Risk Reduction (SFDRR) (2015-2030) serves as a cornerstone for global disaster management strategies, setting the standard for the practices discussed herein. Ratified by the United Nations General Assembly during the Third UN World Conference on Disaster Risk Reduction in 2015, the Framework is the most contemporary international blueprint aimed at the reduction of disaster risks [34]. The SFDRR aspires to proactively mitigate both emergent and established risks by coherently integrating diverse facets including economic, social, health, educational, cultural, environmental, legal, technological, and political considerations [34]. It aims to minimize hazard exposure and vulnerabilities, while simultaneously enhancing preparedness to enable effective disaster response and recovery [35]. Applicability extends to a myriad of risks, varying in scale, frequency, and onset dynamics [36].

The Framework outlines four core priorities applicable at multiple scales of governance local, national, regional, and global [34]. These encompass an in-depth understanding of disaster risks and fortifying risk governance, which precede a third priority that encourages strategic investment in risk reduction to enhance resilience. The concluding priority accentuates the need for robust preparedness measures and underscores the concept of "Building Back Better" post-disaster. The SFDRR also guides disaster risk management in Malaysia, including its flood risk management efforts. [36] clarifies that the Framework aims for a substantial reduction in disaster risk and associated losses within a 15-year timeline, considering both natural and anthropogenic hazards such as floods. [37] affirm that the SFDRR's four priorities are highly relevant to Malaysia's disaster management landscape. However, challenges in actualizing these priorities persist, as highlighted by [38], who found deficiencies in flood preparedness within local development plans. [39] also contend that Malaysia's existing governance structure in flood management requires comprehensive improvement.

Studies suggest an array of improvements under the SFDRR guidelines, addressing issues like authority, enforcement, funding, and asset availability in Malaysian flood-related agencies [40]. [35] exemplify the Paris region's adherence to the SFDRR, recommending that Malaysia should similarly focus on enhancing public awareness, augmenting preparedness, and reconstructing post-flood landscapes effectively. In summary, while the SFDRR sets a foundational framework for flood risk management in Malaysia, actual implementation confronts substantial challenges. To align with the SFDRR's objectives, Malaysia should focus on strengthening governance mechanisms, promoting resilience investments, and enhancing both preparedness and community involvement. This will facilitate a marked reduction in flood-related risks and losses, by the SFDRR's vision.

The notion of "risk" is contextually variable, and subject to the field of consideration. As articulated by [41], risk is commonly delineated as "the amalgamation of an event's probability and its negative repercussions." The pivot of the proposed framework for a contemporary flood management strategy orbits around this risk management paradigm. Although variations in flood risk definitions prevail, it is commonly perceived as the product of a flood event's likelihood and its potential outcomes, which may span infrastructural damages, environmental degradation, and loss of life or injury. Conceptually, flood risk is encapsulated as:

$$\text{Risk} = \text{Hazard} \times \text{Exposure} \times \text{Vulnerability} \quad (1)$$

Hazard, as delineated by [41], represents "a perilous phenomenon or human activity with the potential to inflict death, injury, property damage, or environmental degradation." Specifically, in the realm of floods, hazards connote regions predisposed to inundation, inherently fraught with tangible risks. The gravity of such hazards is intertwined with the flood's characteristics its depth, velocity, and persistence. Areas with analogous flood probabilities but differing flood characteristics showcase variances in hazard magnitudes. Extended inundation, for instance, can intensify agricultural perturbations and imperil infrastructural solidity [42]. Although hazards are foundational to risk, their mere existence doesn't invariably equate to manifest risk. It's the intertwining of hazards with vulnerable elements that births risk. Flooding presents real dangers when the property is threatened., or when human activities be it habitation, work, or transit traverse flood-prone locales. Simply, risk burgeons when entities are exposed to flood hazards. This risk magnitude is proportionate to exposure levels, amplifying with intensified land use, escalated asset values in flood zones, or heightened population densities [43].

Vulnerability, as elucidated by [41], embodies a set of attributes that predispose communities or assets to hazard-induced damages. Within flood risk contours, vulnerability delves into the receptiveness of people and assets to flood perils. Despite pronounced exposures, eventual impacts significantly orbit around entities' inherent vulnerabilities. This differential between potential and actual damages marks a cornerstone in flood damage appraisals. Mitigating vulnerability involves:

i. Fortifying asset resilience against flood damages, and

ii. Augmenting community flood-risk cognizance, ensuring both a comprehensive flood emergency grasp and seamless access to emergency response and post-catastrophe support [44].

Flood Risk Management (FRM) adopts a multi-dimensional strategy that acknowledges the impracticality of completely eradicating flood risks, due in part to the potential detriment of other societal imperatives [45], as delineated in Figure 3. The ultimate goal of FRM is to mitigate flood-induced damage while simultaneously optimizing other societal benefits. The FRM cycle is an intricate, multi-faceted mechanism composed of five pivotal stages: 1) risk assessment, 2) risk treatment/strategy formulation, 3) strategy implementation, 4) strategy monitoring and evaluation, and 5) policy development and adjustment. Risk communication acts as a vital thread woven through each phase, ensuring a transparent exchange of information among all stakeholders from policymakers to the general populace [14].

Figure 3. Flood risk management [46]

Empirical studies underscore the necessity of a well-coordinated sequence of actions assessment, planning, implementation, and evaluation for effective FRM. [38] argues for the dire need for a cohesive national FRM policy in Malaysia, citing the current over-reliance on structural and technological measures. [47] and [14] both identify issues related to coordination, communication, manpower, public awareness, and power and authority among local authorities. [48] highlights the lack of an effective legal mechanism for integrating policies and mechanisms in flood management in Malaysia and suggests that the English Flood and Water Management Act 2010 could serve as a benchmark for potential Malaysian legal counterparts Collectively, the literature indicates that a more synergistic approach to FRM in Malaysia could benefit from multi-sectoral collaboration, including the incorporation of traditional systems. The significance of Flood Risk Assessment (FRA) is paramount. It serves not only to improve disaster management protocols but also to curtail the adverse socio-economic consequences of flooding, and to steer urban planning toward less flood-prone zones. FRA employs a triadic model encompassing hazard (the flood event), exposure (vulnerable elements), and vulnerability (susceptibility to harm).

Several academic inquiries provide an illuminating perspective on Malaysia's FRA methodologies. For instance, [49,50] focus on damage estimation and assessment frameworks, whereas [11] explore hydrological parameters influencing the Muda River Basin. [51] introduces Geographic Information System (GIS)-enabled mapping to assess flood vulnerability. These studies demonstrate the indelible role of FRA in shaping public policy, land-use planning, and disaster preparedness. Nevertheless, a glaring gap persists in community-level FRA research, hampering the development of finely tuned-mitigation strategies. After risk assessment, the next imperative is to articulate a coherent strategy to alleviate both immediate and future flood impacts. This strategy should meticulously delineate proposed actions and offer a transparent cost-benefit analysis. A prominent issue at this juncture is the widespread governmental dependency on structural interventions such as dams, levees, and floodwalls [25,51,52]. Emerging evidence advocates for the efficacy of non-structural measures like land-use planning and public education programs [24, 53–55]. However, these non-structural measures are conspicuously under-implemented, particularly in arid and semi-arid regions, due to factors ranging from lack of awareness and inadequate funding to a scarcity of specialized expertise.

Collectively, scholarly contributions highlight several challenges plaguing Malaysia's FRM efforts. These encompass limited authority, financial constraints, and coordination issues among governmental agencies, as noted by [40,47,57,58] underscore the need for a more comprehensive and proactive strategy, inclusive of stakeholder engagement and non-structural measures. [59] critiques the absence of effective legal frameworks in Malaysia and suggests emulating legislation from countries like England and Wales. Overall, there is a consensual call for enhanced collaboration, resource allocation, stakeholder engagement, and legal provisions to fortify flood risk management in Malaysia.

3. METHODOLOGY

Thus, following the guidance of reference [60], chose to conduct a scoping review as a suitable option. A scoping review serves to outline the current landscape of flood disaster management and flood risk management research in Malaysia, identify existing gaps in scholarly analysis, and lay the groundwork for more targeted future systematic reviews. According to the [61], the principal aim of a scoping review is to map the existing body of literature to inform subsequent, more focused systematic reviews. To achieve the objectives of this scoping review, a comprehensive literature search was undertaken to identify peer-reviewed articles relevant to flood disaster management and flood risk management in Malaysia. The initial approach involved the collection of a random assortment of pertinent studies. Keywords such as "flood disaster management," "flood risk management," and "Malaysia" were prevalent in the metadata of these works. The search strategy used a simple query with these key terms: ("Flood Disaster Management" AND "Malaysia"), ("Flood Risk Management" AND "Malaysia"), and also ("Disaster Risk Reduction" AND "Malaysia"). This query was executed across leading academic databases, specifically Scopus and ScienceDirect. The selection is determined by several crucial parameters that enhance the robustness and comprehensiveness of the literature evaluation.

Firstly, Scopus stands as one of the largest abstract and citation databases of peer-reviewed literature, encompassing a vast array of journals in the fields of science, technology, medicine, social sciences, and more [62], [63]. Its broad coverage ensures a multifaceted exploration of flood risk management, enabling access to a diversity of perspectives, methodologies, and findings that are essential for a holistic understanding of the subject matter. Furthermore, Scopus's sophisticated search functionality and citation analysis tools facilitate an efficient and in-depth examination of the existing body of knowledge, ensuring that critical insights and trends are not overlooked [62,64]. ScienceDirect, on the other hand, is renowned for its high-quality, full-text journal articles and book chapters from leading publications in the field [65]. It emphasizes scientific and technical research, which is consistent in investigating flood risk management techniques, policies, and development in Malaysia that are technically rigorous and empirically rich. By utilizing both databases, research has an advantage from a combination of the comprehensive and interdisciplinary coverage provided by Scopus and the specialized and thorough access to reliable sources afforded by ScienceDirect. This dual-database approach enables a comprehensive and nuanced exploration of the intersecting domains relevant to our study. Additionally, reports from the Disaster Risk Reduction in Malaysia Status Report 2020 and Malaysia Water Partnership served as valuable data sources for this study [66,67]. The review covered materials published until 2023 and established alerts to promptly notify of new, relevant articles upon their release.

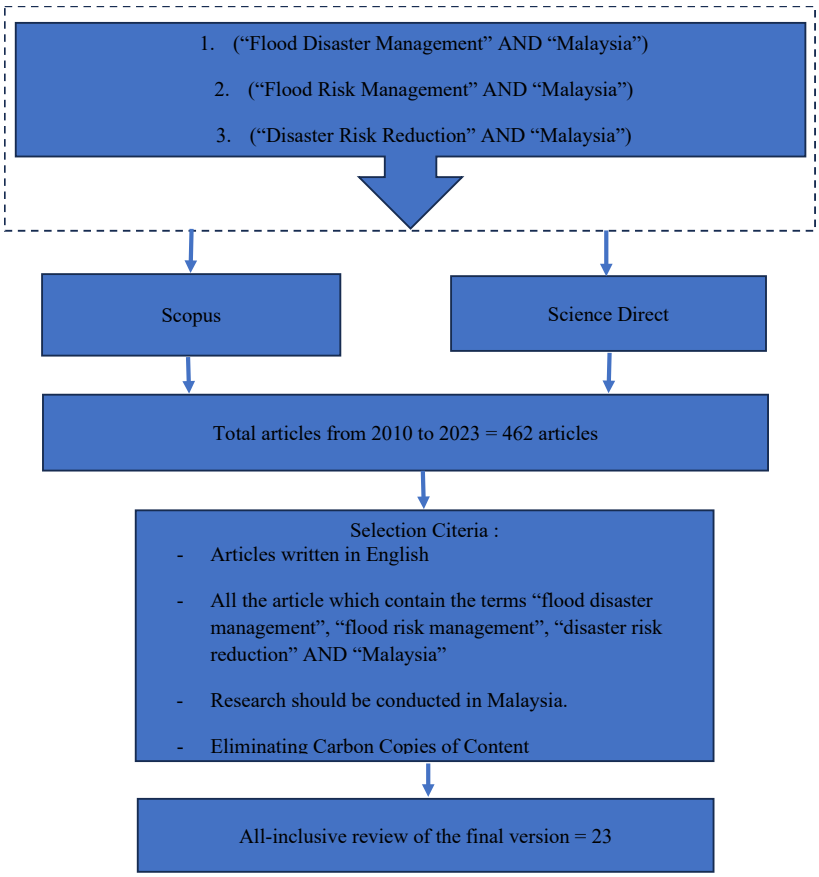

Figure 4. Searching protocol (Scopus and Science Direct)

4. RESULTS AND DISCUSSION

The findings indicate that the Sendai Framework for Disaster Risk Reduction 2015-2030 plays a crucial role in emphasizing the need for comprehensive risk management across multiple dimensions, including natural hazards and socio-economic vulnerabilities. The framework aims to significantly reduce disaster risk and losses in various sectors, including lives, livelihoods, health, and assets such as economic, physical, social, cultural, and environmental resources. The analysis reveals that while Malaysia has made progress in aligning its developmental projects with the Sendai Framework's guidelines, challenges remain in fully integrating these principles into national and local policies. The evaluation highlights specific areas where improvements are needed, particularly in policy execution, financial allocation, and public awareness, to achieve the framework's objectives effectively.

In the context of Malaysia, the Sendai Framework brings forth priority pointers for addressing flood risk in disaster risk reduction [66,67] as illustrated in Figure 5. The Framework underscores four priority actions that, when applied judiciously, can steer Malaysia toward a sustainable development trajectory while minimizing flood vulnerabilities:

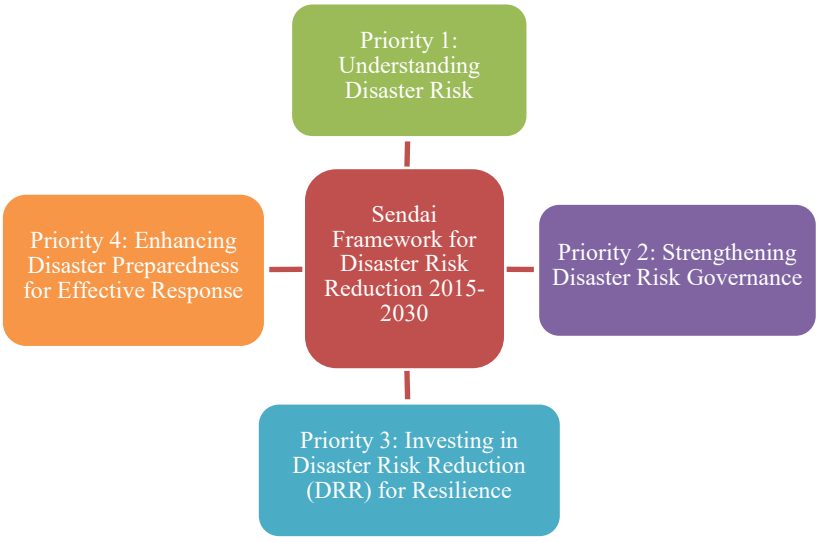

Figure 5. Four priority Sendai frameworks for disaster risk reduction

Priority 1: Understanding Disaster Risk

Comprehensive flood risk assessments should be integral to any development initiative. Malaysia, with its unique geophysical and climatic attributes, needs context-specific data and studies. These can provide invaluable insights for builders, urban planners, and policy-makers, enabling them to anticipate potential flood hazards and design resilient structures. During the periods of the Tenth and Eleventh Malaysia Plans (2011–2015 and 2016–2020, respectively), commendable strides have been made in flood risk management. A total of 194 flood mitigation projects were implemented and 34 local scale flood hazard maps were formulated during the Tenth Plan, with a commitment to develop six more river-basin level maps in the subsequent plan. Notwithstanding these achievements, several critical gaps persist. Principally, the data and findings such as detailed flood risk maps and climate change impacts modeled by NAHRIM remain largely inaccessible to the general populace. These omissions are primarily ascribable to the absence of a formal policy for public dissemination of flood-related data, rooted in concerns over security, land-use planning, and the potential socio-political ramifications tied to historical flood data. Additionally, the persistence of unpredictable flood events signals a lacuna in current management strategies, particularly owing to their reliance on hydro-climatic data spanning the last half-century, a timeframe increasingly rendered obsolete by rapid urbanization and climate change.

To rectify these deficiencies, a multipronged approach is imperative. First, policies should be developed for transparent and nuanced dissemination of historical and prospective flood data. Concurrently, guidelines should be established to sift through data that is non-sensitive and thus can be shared with the public without jeopardizing security or stoking socio-political tensions. Finally, a dedicated budget allocation and scholarly encouragement are warranted to facilitate cutting-edge research in flood disaster risk management. Such an approach would not only plug the existing informational gaps but also arm stakeholders both governmental and civilian with the tools and information essential for proactive and informed participation in flood risk mitigation. The findings for priority 1, as depicted in the figure below (Figure 6).

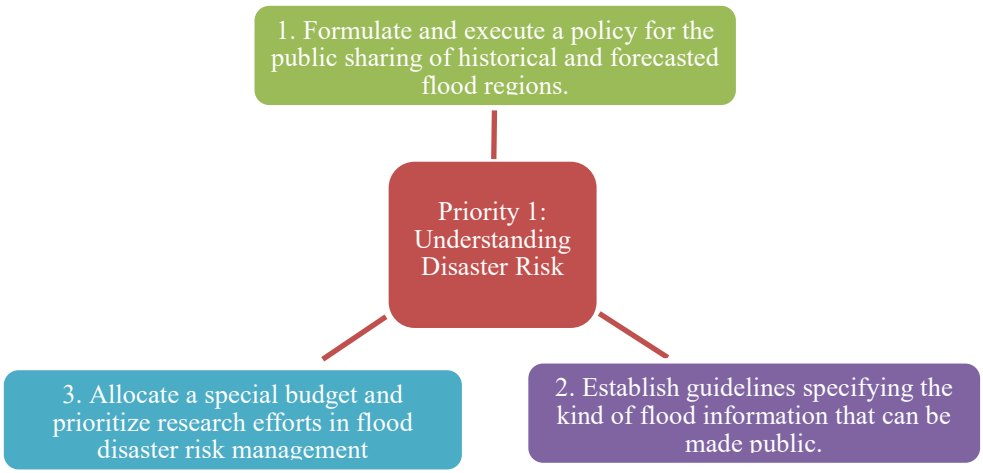

Figure 6. Finding for Priority 1

In Malaysia, the Tenth (2011–2015) and Eleventh (2016–2020) Plans saw the implementation of significant flood mitigation projects and the development of flood hazard maps. However, despite these advances, there's a notable gap in public accessibility to detailed flood risk data and climate change impact models, with much of the information retained for internal use. This limited dissemination can be traced back to the lack of a formal public disclosure policy, driven by concerns over security, land-use implications, and potential socio-political repercussions. Furthermore, the current flood management strategies, while comprehensive, are faced with challenges due to unpredictable flood events, which are possibly a result of changing hydro-climatic conditions influenced by urbanization and climate shifts. Addressing these gaps necessitates the formation of transparent dissemination policies, the creation of public information-sharing guidelines, and an increased budget allocation for contemporary flood disaster risk management research.

Priority 2: Strengthening Disaster Risk Governance

Ensuring that clear regulatory frameworks and standardized guidelines are in place for development projects can curb haphazard constructions in flood-prone areas. Collaborative efforts between local authorities, national governments, and other stakeholders can lead to informed decision-making, taking flood considerations into account. In the landscape of Malaysian flood risk management, substantial strides have been made since 1971, notably the establishment of the Permanent Flood Control Commission, flood disaster relief mechanisms, river basin studies, and an intricate network of hydrological and flood data collection stations. Additionally, the institutionalization of national directives and the advent of specialized agencies like the National Disaster Management Agency (NADMA) in 2015 underscore the multi-pronged approach undertaken by the government. Yet, there remain significant gaps in the system that necessitate rigorous scrutiny. For instance, despite the various structural and non-structural measures implemented, extreme flood events and uncoordinated land use continue to pose challenges. Disparities in disaster relief distribution and inadequacies in trained manpower further compound these issues. Notably, the absence of a coherent policy framework for public dissemination

of flood risk information and a lack of coordination among different managing bodies are obstacles to achieving a truly integrated flood management system.

The underlying causes of these shortcomings range from climatic variability exacerbated by climate change to socio-political limitations, such as sensitivities around land use and ownership. Importantly, the absence of a centralized policy or agency that coordinates the gamut of flood management laws and regulations has resulted in ambiguous legal jurisdictions and fragmented enforcement. Lack of technical capacity, insufficient budgeting, and complexities introduced by the interplay of federal, state, and local authorities have further hampered progress. Addressing these gaps necessitates a multifaceted solution. Primarily, a holistic and integrated policy framework should be instituted to guide flood management practices, one that amalgamates structural measures, such as flood control dams, with non-structural ones, like urban planning. These should be informed by contemporary hydro-meteorological data to adapt to changing climatic conditions. A formalized communication strategy that disseminates non-sensitive flood risk information to the public could play an educative role and enhance community preparedness. Furthermore, capacity building across federal, state, and local levels is critical, which includes technical training and the establishment of specialized agencies. For the financial aspects, innovative cross-sector financing models and legislative frameworks, such as a proposed National Water Resources Act, could provide the structural underpinning for long-term flood management. These proposals, if realized in concert, have the potential to substantially ameliorate the existing gaps in Malaysia's flood risk management infrastructure. The findings for priority 2, as depicted in the figure below (Figure 7).

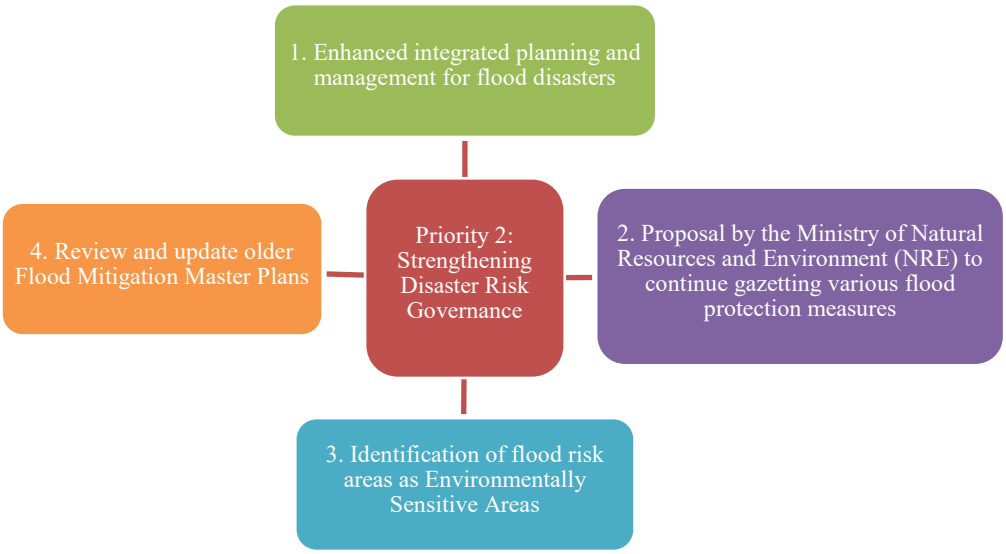

Figure 7. Finding for Priority 2

In summary, Malaysia has made significant progress in flood risk management since 1971 through the establishment of various institutions, policies, and technical measures. Despite these advancements, critical gaps exist in the country's flood management system, most notably in dealing with extreme flood events, uncoordinated land use, and inconsistencies in disaster relief distribution. The root causes of these issues are multifaceted, ranging from climatic changes to socio-political complexities, including fragmented jurisdiction and limited technical and financial capacities. To bridge these gaps, a holistic and integrated approach to flood management is essential. This involves creating a unified policy framework, enhancing technical capacities at all levels of governance, establishing a clear legal structure, and innovating in financial mechanisms. Such a multi-pronged approach would strengthen Malaysia's resilience against both regular and extreme flood events.

Priority 3: Investing in Disaster Risk Reduction (DRR) for Resilience

Infrastructure projects in Malaysia, be it housing colonies, roadways, or industrial setups, need to integrate DRR principles. These might include constructing elevated structures, developing efficient drainage systems, or preserving natural buffers like mangroves that absorb excess water. Importantly, financial investments must be paired with community education, making citizens aware of the risks and best practices to mitigate them. In the evolving landscape of flood risk management, the deployment of public funds for flood mitigation in urban areas, the MSMA guidelines that regulate private developers, and the 2017 governmental initiative on flood insurance, represent seminal achievements. However, the system grapples with financial shortcomings for a comprehensive approach to flood risk, partly because societal perceptions often relegate flood events as isolated natural phenomena. Against this backdrop, one document demands special attention: The National Physical Plan-4 (NPP4). Prepared by the Federal Department of Town and Country Planning, under the aegis of the Ministry of Housing and Local Government in 2022, the NPP4 lays the groundwork for sustainable land use, with an implicit recognition of climate change impacts.

The NPP4 is unique in its synthesis of interdisciplinary concerns, providing a strategic vision that, theoretically, incorporates flood risk in a broader context of sustainable development and climate adaptation. However, its last review

two years ago appears to have missed the newer variables of extreme weather events that were palpably manifest in the catastrophic floods of 2014-2015. The absence of timely revisions indicates that while the NPP4 is forward-thinking, it may not be agile enough to adapt to rapidly emerging challenges. This is concerning for ongoing and future development projects, which should ideally be conceptualized and executed in alignment with the most up-to-date risk assessment metrics and climate data. Consequently, the development projects that proceed under the older NPP4 framework may inadvertently perpetuate the vulnerabilities they were intended to mitigate. Moreover, the challenges presented by climatic shifts necessitate that the NPP4 be continually updated and that its recommendations be swiftly translated into actionable strategies. Here, development projects can play a transformative role. They offer the operational terrain where NPP4 guidelines can be tested, adjusted, and eventually standardized. In essence, each new development project can function as a real-world laboratory for fine-tuning the NPP4's guidelines. This will not only aid in achieving NPP4's aims but also contribute substantively to our body of knowledge on effective flood management in the face of climate uncertainties.

To supplement this, enhancing public awareness about the hydro-meteorological changes is vital. This education must also encompass development stakeholders, for whom understanding the shifting dynamics could prove crucial in financial decision-making and risk mitigation. Similarly, while general building codes do serve a purpose, there's a compelling need to incorporate flood-specific provisions, possibly inspired by international best practices such as FEMA's guidelines. These could serve as supplementary modules within the broader NPP4 framework, thereby providing a comprehensive, nuanced guideline for future development projects. The findings for priority 3, as depicted in the figure below (Figure 8).

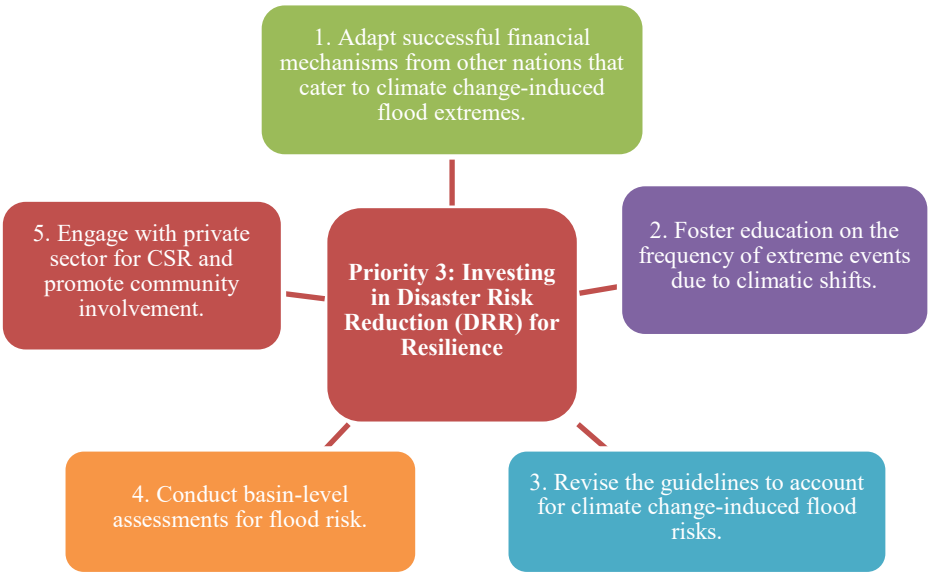

Figure 8. Finding for Priority 3

In summary, Malaysia has made strides in flood risk management through public funding, MSMA guidelines, and a subsidized flood insurance scheme. However, gaps exist in financial preparedness, stakeholder involvement, and public awareness. Additionally, existing regulations are not adequately geared toward mitigating climate change-induced flood extremes. Recommendations include the adoption of international best practices, revising planning documents like the National Physical Plan-4 to consider climate change impacts, and implementing the findings of academic studies into actionable policies. Challenges such as financial limitations and public perception need to be addressed through enhanced education, private sector involvement, and updated policy frameworks. Therefore, a multi-pronged approach involving financial investment, public awareness campaigns, policy updates, and stakeholder engagement is essential for robust flood risk management in Malaysia.

Priority 4: Enhancing Disaster Preparedness for Effective Response

Despite the best prevention measures, the unpredictability of natural disasters remains. Hence, having a robust response mechanism is paramount. Development projects should not only be built with resilience but should also have evacuation plans, safe zones, and emergency provisions. Regular drills, community engagement, and continuous feedback loops can ensure that when floods strike, the damage is minimized. Malaysia's commitment to flood risk management in the face of rapid urbanization and development is evident through the establishment of the National Flood Forecasting and Warning System (NaFFWS) and the integrated flood forecasting and river monitoring system (iFFRM). Public engagement tools, such as mobile applications and flood warning board practices initiated as early as 1980 seek to enhance community preparedness. Furthermore, the collaborative endeavor between Malaysia and the UK, specifically the Earth and Sea Observation System (EASOS), seeks to intertwine satellite technology with development projects, aiming for safer urban spaces.

However, as development projects continue to burgeon, challenges in flood management are becoming more apparent. Flash floods, often exacerbated by unplanned development and inadequate drainage systems, provide minimal warning.

Historically, stakeholder engagement in development projects remained limited, leading to flood warning systems that predominantly leaned towards technical solutions, occasionally facing issues such as community indifference or vandalism.

The underlying perception of treating floods merely as post-development engineering challenges, rather than integrating them into the planning stages of development projects, has revealed gaps in current building codes. These codes, in their current state, do not adequately address the resilience required for structures in flood-prone zones. The unpredictable and increasingly extreme nature of flood events necessitates a review of these codes, borrowing from international practices such as those from FEMA in the USA. The Department of Irrigation and Drainage (DID), acknowledging these gaps, has begun to foster collaborations with academia, NGOs, and the broader community to integrate flood management into the development discourse. The recently instituted National Disaster Management Agency (NADMA) holds promise for coordinated action, but it faces its own set of challenges, such as limited staff and nascent operational mechanisms. In summation, the rapid pace of development projects has both compounded and spotlighted challenges in flood risk management. Solutions demand a multi-faceted approach: increased stakeholder engagement in development projects, the infusion of resilient building codes, enhanced community training, and the strategic incorporation of new technologies like EASOS. A holistic view, which marries development projects with flood management, will be paramount to achieving sustainable urban growth in Malaysia. The findings for priority 4, as depicted in the figure below (Figure 9).

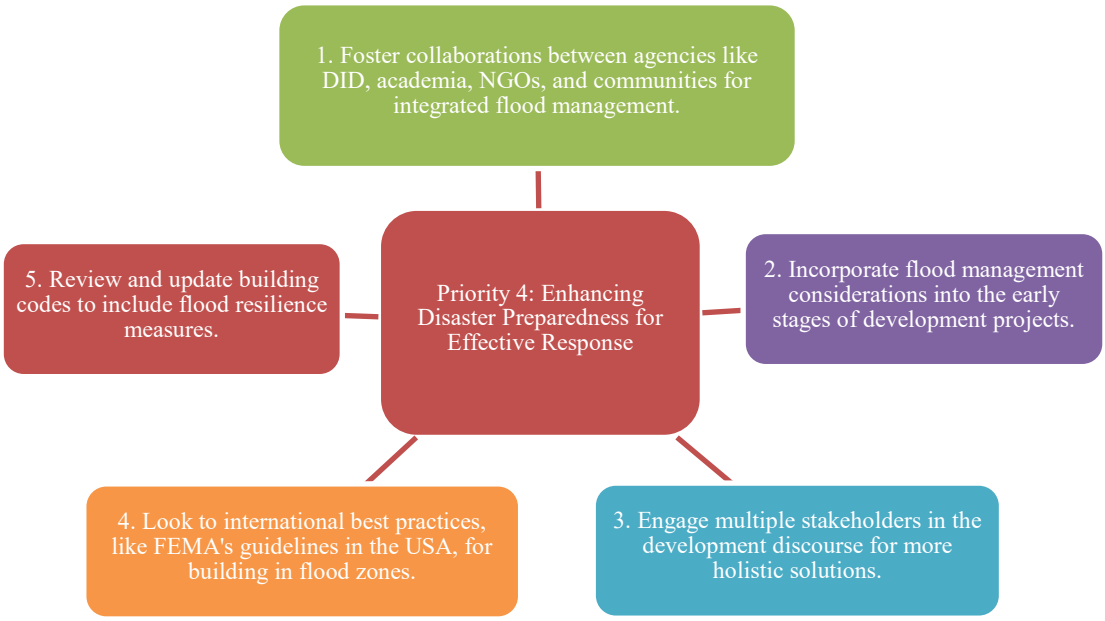

Figure 9. Finding for Priority 4

Malaysia has taken significant steps in flood management through the establishment of the National Flood Forecasting and Warning System (NaFFWS) and collaborations like the Earth and Sea Observation System (EASOS). Despite these advancements, rapid urban development projects have exposed gaps, such as the minimal warning time for flash floods and outdated building codes that don't account for flood resilience. Additionally, challenges like the nascent operational capacity of NADMA and the community's complacency towards flood warnings have emerged. There's a clear need to integrate flood management considerations at the onset of development projects, foster broader stakeholder engagement, and adapt global best practices to ensure urban resilience against flooding.

Malaysia's journey in flood risk management is emblematic of a developing nation grappling with the dual challenge of urbanization and climate change. While notable advancements such as the MSMA guidelines, National Physical Plan-4. The presence of intermittent projects advocating concepts like 'Living with Flood' and 'Integrated Flood Management' signal a paradigm shift. The challenge, as this study underscores, lies not in the lack of knowledge but in its translation to on-ground action, financing, and fostering a culture of collective responsibility. The conceptual framework in Figure 10 below, which is a flood risk management framework for a development project in Malaysia, serves this aim.

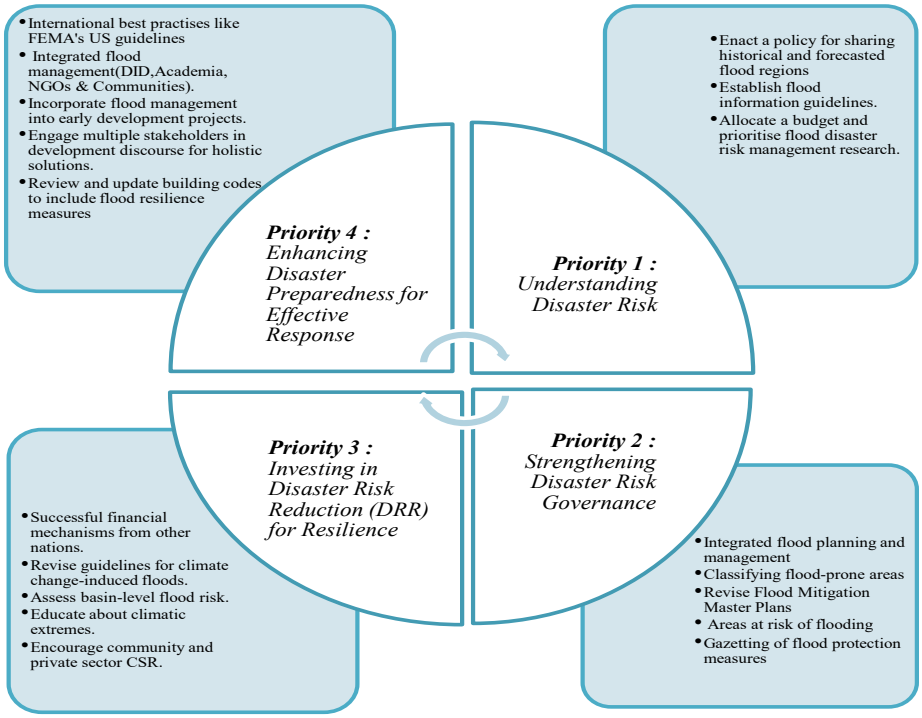

Figure 10. A conceptual framework for flood risk management challenges and opportunities in development projects

5. CONCLUSION

The collective involvement of multiple governmental layers such as the federal government, local authorities across various states in Malaysia, and the Department of Irrigation and Drainage Malaysia is pivotal in orchestrating effective flood risk management strategies. Frameworks such as the National Physical Plan 4 (NPP4) have significantly progressed in addressing flood risks by championing a multifaceted approach. These strategies must be intricately woven into local planning processes to ensure a cohesive and robust application. A pivotal aspect of this integration involves the mandatory inclusion of comprehensive flood risk assessments in the approval processes of development projects. This measure seeks to ensure that each development initiative aligns with national directives while resonating with stakeholders in the construction industry who are instrumental in driving the flood disaster risk reduction agenda. The emphasis here lies on nurturing professionalism, innovation, and knowledge to enhance societal quality of life.

Adopting such an approach necessitates the embrace of a sophisticated and diverse planning paradigm. This paradigm should be rooted in contemporary scientific insights and should foster community resilience measures. The amalgamation of national policies like the NPP4 with local planning initiatives yields several benefits. It ensures the translation of overarching objectives into actionable, on-the-ground outcomes that bolster community resilience against flood risks. Furthermore, it ensures that flood risk management principles are embedded within the essence of each development project, promoting sustainability not only in design but also in long-term societal impacts. The real challenge resides not merely in the adoption of these innovative strategies but in their consistent and meticulous application across projects. The endorsement of each development project should symbolize Malaysia's steadfast dedication to harmonizing developmental aspirations with ecological stewardship. The essential approach encourages the synergy of national strategies like the NPP4 with local planning nuances to foster a future where developmental ambitions coexist gracefully with nature's integrity, and where flood risks are managed with foresight and precision.

While the Sendai Framework provides a global blueprint, its successful embodiment within the Malaysian context necessitates adaptations that cater to localized needs and challenges. This entails leveraging indigenous knowledge, engaging a diverse spectrum of expertise ranging from hydraulic engineers and hydrodynamic modelers to socioeconomic analysts and academic scholars, and cultivating a pervasive culture of preparedness and resilience. Through the alignment of development projects with these refined strategies, Malaysia can navigate a path of progressive growth that safeguards the welfare and safety of its citizens without compromising economic, social, and environmental integrity. This journey toward a resilient and sustainable developmental landscape, fortified against the adversities of flooding, emerges as a shared responsibility transcending governmental realms and permeating the fabric of societal participation and contribution.

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Data Availability Statement

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

AUTHOR CONTRIBUTIONS

Mohammad Syamsyul Hairi Saad: Conceptualization, Methodology, Writing- Original draft preparation

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Putri Zulaiha Razi: Visualization, Investigation

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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