Volume: 10 Issues: 76 [September, 2025] pp. 57 - 72
Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.academicinspired.com/jised
DOI: 10.55573/JISED.107605

LOCAL AUTHORITY PERSPECTIVES ON FLASH FLOOD VULNERABILITY AND DISASTER RISK MANAGEMENT IN BINTULU, SARAWAK

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Article history
Received date : 20-8-2025
Revised date : 21-8-2025
Accepted date : 28-8-2025
Published date : 17-9-2025

To cite this document:
Mohamed Khaidir, M. K. I., & Said, M. Z. (2025). Local authority perspectives on flash flood vulnerability and disaster risk management in Bintulu, Sarawak. *Journal of Islamic, Social, Economics and Development (JISED),* 10 (76), 57 - 72.

Abstract: *Flash floods present a growing threat to urban regions across Southeast Asia, and Bintulu, Sarawak, is no exception. This study investigates flash flood vulnerability and disaster risk management (DRM) strategies from the perspective of local authorities in Bintulu. Using a qualitative case study approach, data were gathered through semi-structured interviews with key stakeholders from the Civil Defence Force (APM), Bintulu Development Authority (BDA), Fire and Rescue Department (JBPM), and the Department of Irrigation and Drainage (DID). Thematic analysis revealed two primary drivers of vulnerability, which are climate change, such as rising sea levels, erratic rainfall, and rapid urbanisation that outpaces infrastructure development. Challenges in public awareness, limited inter-agency coordination, and insufficient funding further exacerbate the situation. Nevertheless, agencies have taken steps to improve structural infrastructure, implement early warning systems, and foster community engagement. The findings underscore the need for an integrated, community-centred approach to flood risk governance. Policy recommendations include targeted infrastructure investment, more vigorous enforcement of urban planning regulations, and the institutionalisation of inter-agency disaster coordination platforms. This research contributes to the broader discourse on climate-resilient urban governance in developing regions*

Keywords: *Flash Flood, Urbanisation, Disaster Risk Management, Local Authorities, Bintulu*

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Introduction

Flash floods are among the most destructive natural hazards worldwide, characterised by their sudden onset and severe impacts on human life, infrastructure, and socioeconomic systems (Abd-el-Kader et al., 2021). Historically, they have devastated agriculture, infrastructure, and human and animal populations across regions (Abd-el-Kader et al., 2021). According to the World Meteorological Organisation, flash floods claim over 5,000 lives annually, surpassing other flood types in lethality (He et al., 2024). This alarming figure underscores the urgent need for a deeper understanding and more effective management of flash flood risks, particularly as climate change intensifies their frequency and magnitude (Abd-el-Kader et al., 2021).

Human activities further exacerbate these risks. Rapid urbanisation and land-use changes, including deforestation and expansion of artificial surfaces, have increased vulnerability to flash floods (Yu et al., 2023). Approximately 800 million people reside in flood-prone areas, with an average of 70 million exposed each year. Between 1980 and 2018 alone, this resulted in CAD 1 trillion in economic losses and over 223,000 fatalities (Mohanty & Simonović, 2020). In Europe, floods accounted for 40% of total economic damages from natural hazards between 1989 and 2008 (Papagiannaki et al., 2015). These escalating impacts underscore the critical need for robust disaster risk management strategies and community resilience-building (Abd-el-Kader et al., 2021).

Globally, floods and storms have been the most frequent natural disasters over the past three decades, with floods alone representing more than half of all incidents in 2020 (Mavrouli et al., 2022). Annual urban flood damage is estimated at USD 120 billion, a figure expected to rise due to population growth and increasing asset exposure in vulnerable areas (Bodoque et al., 2023). Urbanisation, particularly in coastal lowland cities, amplifies risks through uncoordinated land-use planning, environmental degradation, and compounding effects such as sea-level rise and intensified rainfall (Bodoque et al., 2023). These trends stress the importance of adaptive and forward-looking flood risk management strategies (Bodoque et al., 2023).

In Asia, the situation is particularly alarming. Extreme weather events have intensified markedly in recent decades, with flash floods emerging as one of the most destructive hazards for urban populations. Triggered by sudden and torrential rainfall, these floods cause rapid inundation, posing a threat to lives, livelihoods, and urban infrastructure. Climate change is recognised as a major driver behind their increasing frequency and severity, making them a pressing concern for policymakers and disaster management authorities throughout the region (Syafrina et al., 2017; Mohd Zulhafiz et al., 2024).

In Malaysia, rapid urban expansion into flood-prone areas has significantly heightened flood risks. Many residential and industrial developments are located on low-lying floodplains, increasing community exposure and complicating management strategies (D'Ayala et al., 2020). Bintulu, a fast-growing industrial hub in Sarawak, illustrates this challenge vividly. The town's geographical setting, where steep inland slopes converge with low-lying coastal plains, intensifies surface runoff, and overwhelms drainage capacity during heavy rainfall, resulting in frequent and widespread flash floods (Buslima et al., 2018; DID, 2021).

Bintulu's vulnerability is not solely shaped by its physical geography. Infrastructural constraints limited early warning systems, and inadequate public preparedness further exacerbated the community's exposure. Repeated flash floods have caused severe human and economic consequences, including property damage, disruptions to business operations, road

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closures, and health crises linked to waterborne and vector-borne diseases (Rosmadi et al., 2023). National statistics attribute an average of 20 deaths and over 100 injuries annually to flash floods; however, the local situation in Bintulu has been especially alarming, with 31 incidents recorded in 2018 alone (DID Sarawak, 2025). The social toll is equally stark. More than 4,687 victims remain displaced in temporary evacuation centres (Pusat Pemindahan Sementara, PPS), marking one of the worst flood crises the community has endured. Long-term residents described the event as the most devastating flood in over three decades, underscoring the escalating severity of flood hazards in the region (DID Sarawak, 2025).

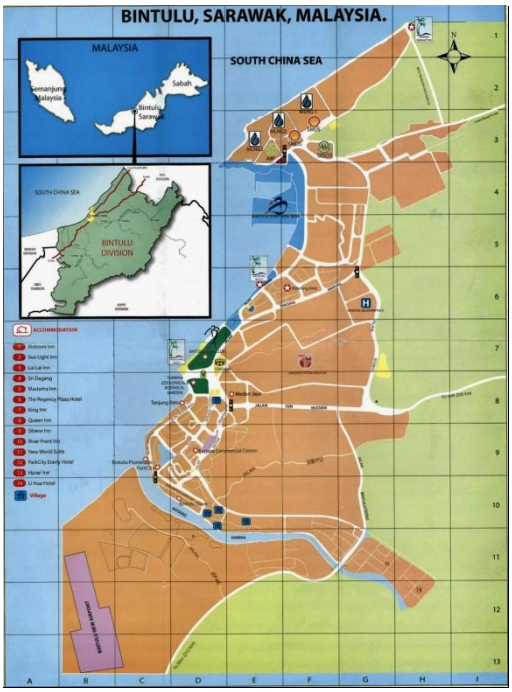

Figure 1: Map of Bintulu Division

Source: Sarawak Tourism, 2025.

In this context, local governments are under mounting pressure to strengthen their disaster risk management (DRM) frameworks. Understanding the perspectives of local authorities is crucial, as they represent the front line in planning, responding to, and mitigating the impacts of flash floods. In Malaysia and particularly in Bintulu, there is still limited empirical evidence on how local authorities plan for, respond to, and recover from recurrent flash floods. Much of the existing literature focuses on hydrological modelling, engineering interventions, or broad national-level statistics, but it pays insufficient attention to the governance dimension. Specifically, there is a limited understanding of how systemic weaknesses, such as infrastructural limitations, gaps in early warning systems, and inadequate preparedness, shape community vulnerability and constrain local disaster management efforts (Mohd Zulhafiz et al., 2024).

To address this gap, the present research investigates flash flood vulnerability and disaster risk management practices in Bintulu from the standpoint of local authorities. The study aims to evaluate institutional preparedness, assess the effectiveness of early response mechanisms, and identify systemic shortcomings in flood risk governance. By analysing the challenges and capacities of local stakeholders, this research develops targeted recommendations to strengthen disaster risk management frameworks, enhance urban resilience, and safeguard socioeconomic

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stability. Ultimately, the findings from this case study will contribute to broader debates on climate adaptation and urban flood mitigation in rapidly developing regions of Southeast Asia.

Literature Review

Flash Floods

Flash floods are defined as the rapid onset of flooding resulting from intense rainfall or sudden water release, often occurring within six hours of the triggering event. These events are hazardous because of their unpredictability, rapid water rise, and potential for widespread destruction. Commonly affecting urban areas and high-elevation regions, flash floods are exacerbated by impermeable surfaces, which hinder water absorption (Sene, 2012).

The unpredictability of flash floods presents challenges for issuing timely warnings and coordinating evacuations (He et al., 2024). This is especially true in under-resourced areas lacking adequate meteorological systems and emergency communication infrastructures (Dilip K et al., 2024). Community-based flood warning mechanisms, such as volunteer patrols and informal weather monitoring, have shown some effectiveness, although they are insufficient for large-scale urban management (FEMA, 2020).

Topographic factors, including steep slopes and narrow valleys, further contribute to the sudden onset of these floods. Rapid runoff, landslides, and the failure of man-made flood control structures can result in catastrophic surges (APFM, 2007). Unlike slow-onset riverine floods, flash floods transport heavy debris and sediment, damaging infrastructure and disrupting lives with little warning.

Factors Influencing Flash Floods

A complex interplay of natural and human-induced factors influences flash floods. Meteorologically, extreme rainfall events, thunderstorms, and tropical cyclones are primary triggers (Sene, 2012). In urban environments, human activities such as land clearing, deforestation, and unplanned development significantly increase surface runoff and reduce infiltration. For instance, in areas where only 20% of land remains permeable due to heavy urbanisation, the risk of surface flooding rises sharply (Haliza & Rapeah, 2018).

In Malaysia, urban flash floods are frequently attributed to inadequate drainage systems and rapid urban sprawl, particularly in floodplains. Construction activities, mining, and squatter settlements reduce vegetation cover, increasing vulnerability to intense runoff (Safiah Yusmah & Rafidah, 2021). Jamil et al. (2012) further noted that the overflow of riverbanks due to sustained rainfall is a typical pattern preceding urban flash floods.

Deforestation has particularly damaging effects on the water cycle. Forest canopies and root systems usually act as natural sponges, intercepting rainwater and facilitating gradual infiltration. Their removal results in direct exposure of the soil, accelerating runoff and soil erosion (Runyan & D'Odorico, 2016).

Disaster Risk Management

Disaster risk management (DRM) is a critical framework for reducing the impact of natural hazards like flash floods. As noted by Coppola (2015) and Sawalha (2020), DRM has evolved as a systematic approach over the past decades, offering structured procedures for mitigation, preparedness, response, and recovery. Its conceptual origins trace back to crisis management

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models developed in the early 20th century (Neal, 1997), but more recent versions emphasise resilience-building and community participation (Coetzee & Niekerk, 2012).

Noraini & Khairul Hisyam (2018) assert that an effective DRM strategy can significantly reduce loss of life and economic disruption if supported by strong institutional frameworks and coordination between stakeholders. The DRM cycle is often divided into pre-disaster (mitigation and preparedness) and post-disaster (response and recovery) phases (Alexander, 2002). Each phase targets specific functions necessary for managing emergencies effectively.

However, the traditional DRM cycle has been criticised for its lack of integration with climate change adaptation. Swain et al. (2020) and Trenberth et al. (2015) emphasise that the increasing unpredictability of natural disasters due to global warming necessitates a paradigm shift in DRM. Scholars such as Birkmann et al. (2022) argue for the incorporation of adaptive capacity and climate resilience into disaster planning to make DRM frameworks more robust in the face of changing risk profiles.

Case Studies

In Thailand, the 2006 Uttaradit flood and recurrent southern coastal floods highlight how monsoon bursts and tide-affected drainage systems create severe hazards (Kongmuang et al., 2020), while the Disaster Prevention and Mitigation Act (2007) and community-based flood management pilots demonstrate the value of legal frameworks and local participation in preparedness (Sayama et al., 2015).

In the Philippines, destructive events such as Typhoon Ketsana (2009), Typhoon Vamco (2020), and Tropical Storm Washi (2011) (Alfonso, 2019; Vicario-Merino et al., 2019) underscore vulnerabilities in densely populated basins and informal settlements, while the Disaster Risk Reduction and Management Act (2010) and subsequent community-based early warning systems improved local preparedness, evacuation, and last-mile communication (Morin et al., 2016)

In Indonesia, flash flood risks arise not only from intense rainfall but also volcanic lahars, as seen in the Garut flood (2016), Cyclone Seroja (2021), and cold-lahar floods near Marapi (2024) (Yumarni et al., 2020; Zain et al., 2021; Wibowo et al., 2022), with DRM efforts centred on Law 24/2007, the establishment of BNPB, and digital innovations such as InaSAFE and InaRISK to enhance contingency planning and risk awareness (Yulianto et al., 2021)

In terms of DRM practices, all three countries have enacted legal frameworks and improved hydrometeorological networks, but persistent gaps remain in local enforcement, equipment maintenance, institutional integration, and communication during nighttime events (Sayama et al., 2015; Yulianto et al., 2021; Morin et al., 2016)

Methodology

Since the study is qualitative, the goal is to gather deep insights into the causes of flash floods, how local authorities prepare and respond, and the effectiveness of current disaster management strategies in Bintulu. The key sections include research design, study area, sample selection, data collection, and data analysis.

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Research Design

This study uses a qualitative case study approach, which helps to explore complex issues like disaster preparedness in detail. The case study focuses on Bintulu, allowing an in-depth understanding of how flash floods are managed locally. Semi-structured interviews are used to collect data, giving flexibility to explore essential topics while ensuring consistency across interviews. This method helps understand personal experiences and strategies used by local authorities (Crowe et al., 2011).

Research Area

The research takes place in Bintulu, Sarawak, a rapidly developing area prone to flash floods due to its geography and heavy rainfall. The Batang Kemena River plays a significant role in local flooding patterns, as rainwater quickly flows from nearby hills to low-lying areas. Urban development in flood-prone zones exacerbates the situation. Studying Bintulu helps uncover challenges that could apply to other similar regions.

Data Collection

Primary data were collected using purposive sampling through in-depth interviews with four key stakeholders representing the local governing body of Bintulu, the Civil Defence Force (APM), Bintulu Development Authority (BDA), Drainage and Irrigation Department (DID), and Balai Bomba dan Penyelamat Bintulu. These stakeholders were selected based on their direct involvement in disaster risk management and their responsibilities in flash flood preparedness and response. Their substantial knowledge and understanding of the issues enabled them to provide comprehensive insights into relevant policies and strategies. Each interview was conducted over a duration of one to two hours.

Data Analysis

Thematic analysis was employed to examine the interview transcripts, enabling the identification of patterns and key themes related to disaster preparedness and response strategies in Bintulu. To enhance the validity and reliability of the findings, methodological triangulation was applied. Data from the four stakeholder groups, the Civil Defence Force (APM), Bintulu Development Authority (BDA), Drainage and Irrigation Department (DID), and Balai Bomba dan Penyelamat Bintulu, were compared and cross-verified to identify converging perspectives as well as unique viewpoints.

Findings and Discussion

These findings were obtained from in-depth interviews with four key local agencies involved in flash flood management in Bintulu, namely the Department of Irrigation and Drainage (DID), Bintulu Development Authority (BDA), Fire and Rescue Department (JBPM), and Civil Defence Force (APM). The discussion is organised according to the flash flood vulnerability in Bintulu (Table 1). It centres around key emerging themes, supported by direct quotes from participants and relevant literature to contextualise and validate the insights.

Table 1: Flash Flood Vulnerability in Bintulu

Vulnerabilities Leading to Flash Floods	• Climate Change and Rising Sea Levels • Rapid Urban Development
Disaster Preparedness	• Coordination Among Agencies • Challenges in Public Awareness
Prevention and Mitigation Measures	• Structural Measures

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	• Community-Based Initiatives
Emergency Response Management	• Rapid Deployment of Resources • Communication and coordination
Recovery and Reconstruction Management	• Infrastructure Rehabilitation • Building Community Resilience

Vulnerabilities Leading to Flash Floods

Climate Change and Rising Sea Levels

Climate change and rising sea levels were identified as major contributors to the increasing frequency and intensity of flash floods in Bintulu. Informants described unpredictable and extreme weather events, such as unusually heavy rainfall and high tides, which exceed the capacity of existing drainage systems. These factors are putting pressure on ageing or undersized infrastructure, leading to floods in previously unaffected areas.

> *"..Sebenarnya kita dapat tengok hujan kadang-kadang terlampau lebat, bacaan hujan pun lebih dari apa yang kita jangka..memang kita punya parit tak dapat nak tampung..." (Informan 2)/ "..Actually, we can see that sometimes the rain is extremely heavy, with rainfall readings higher than we expected… our drains really can't cope with it…"*
>
> *(Informant 2)*

> *"..Sekarang ni banjir kilat boleh jadi dekat tempat yang tak pernah kena banjir pun..tempat yang kita kira tempat selamat..tapi kalau air dah terlampau laju naik..memang banjir jugak..." (Informan 3)/"..These days, flash floods can happen in places that have never been flooded before… places we thought were safe… but if the water rises too quickly, it will flood as well…"*
>
> *(Informant 3)*

These findings mirror Syafrina et al. (2017), who highlighted similar climate-driven hydrological disruptions across Southeast Asia. The evidence calls for climate-resilient infrastructure and forward-looking planning strategies in Bintulu.

Rapid Urban Development

Rapid industrial and residential development in Bintulu has resulted in more impervious surfaces, which reduce the natural absorption of rainwater. Informants agreed that unregulated or poorly planned urban expansion has overwhelmed existing drainage systems, especially in older areas. Furthermore, enforcement of mitigation requirements, such as retention ponds, is inconsistent.

> *"...kebanyakan parit di kawasan banjir ni block sebab developer ni kadang-kadang memang tak ada proper mitigation...sebab tu saya cakap pembangunan di Bintulu ni terlalu cepat sampai parit pun tak mampu menampung.." (Informan 3)/"...Most of the drains in this flood-prone area are blocked because developers sometimes don't have proper mitigation in place… that's why I say development in Bintulu is happening so fast that even the drains can't cope…"*
>
> *(Informant 3)*

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"...kawasan bandar ni atau saya cakap urban areas ni membangun dengan sangat cepat sampai sistem perparitan tak sempat nak keep up.." (Informan 4)/"...These town areas, or I should say urban areas, are developing so quickly that the drainage system can't keep up…"

(Informant 4)

"...kami telah mewajibkan setiap pembangunan baru tu mesti ada kolam tadahan air..tapi penguatkuasaan ni pun satu cabaran jugak.."(Informan 2)/ "...We have made it mandatory for every new development to have a water retention pond… but enforcing this is also a challenge…"

(Informant 2)

This echoes Haliza and Rapeah (2018), who warned that uncoordinated urbanisation can exacerbate flood risks. The findings emphasise the need for integrated urban planning, improved regulation, and investment in sustainable stormwater management systems.

Disaster Preparedness in Bintulu

Coordination Among Agencies

Coordination among disaster management agencies in Bintulu is seen as relatively effective, facilitated by the Disaster Management Committee under the Resident's Office. Regular inter-agency meetings, joint training, and shared communication channels have enhanced preparedness and reduced duplication of efforts. However, challenges remain in aligning objectives and optimising resource sharing during large-scale events.

"..kami memang banyak bekerjasama dengan BDA dan BOMBA untuk share semua data dan planning kami..lagi-lagi masa musim monsoon.." (Informan 1)/ "..We work closely with BDA and the Fire and Rescue Department to share all our data and planning, especially during the monsoon season…"

(Informant 1)

"...Pejabat Residen memang ada buat meeting selalu, setahun tu mesti ada dalam 2 atau 3 kali..dari situ memang kami akan dapat tugas yang berkaitan dengan bidang kami..benda ni bagus sebab agensi akan dapat buat tugas dengan lebih tersusun.." (Informan 3)/ "...The Resident's Office does hold regular meetings, usually two or three times a year… from there, we will receive tasks related to our respective fields… this is good because it allows agencies to carry out their duties in a more organised manner…"

(Informant 3)

"...dengan adanya pos kawalan operasi memang dapat elakkan penyebaran maklumat yang berulang... dapat juga improve kami punya response time.."(Informan 4)/ "...With the operational control post in place, we can avoid the repetition of information being circulated… it also helps improve our response time…"

(Informant 4)

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Alamgir et al. (2019) emphasised that cohesive coordination frameworks are crucial for successful disaster management—a point reinforced by the experiences in Bintulu.

Challenges in Public Awareness

Despite various outreach efforts, public awareness and engagement remain limited. Informants reported poor attendance at workshops and a general lack of community interest in preventive practices. This leads to increased reliance on government interventions during flood events.

> *"..kami memang selalu buat workshops.. tapi tulah kehadiran biasanya tak memuaskan..jadi impak dia sangat limited.." (Informan 4)/"..We often hold workshops… but attendance is usually unsatisfactory, so the impact is very limited…"*
>
> *(Informant 4)*

> *"..kerjasama dari penduduk setempat itu amat penting..tapi saya rasa dalam 15% sahaja yang amat menjaga kebersihan sungai atau parit.." (Informan 2)/ "..Cooperation from local residents is very important… but I think only about 15% really take care of the cleanliness of rivers or drains…"*
>
> *(Informant 2)*

> *"..kebiasaanya orang akan sambal lewa kalau diberi amaran tentang bahayanya risiko banjir jika tidak menjaga kebersihan sehingga mereka rasa benda ni dah terlambat.." (Informan 3)/ "..Usually, people take warnings about the dangers and flood risks from poor cleanliness lightly—until they feel it's already too late…"*
>
> *(Informant 3)*

According to FEMA (2020), active community participation is vital for disaster readiness. The findings suggest that more targeted, accessible, and innovative public awareness campaigns are needed, including digital tools and local partnerships, to foster greater community ownership.

Prevention and Mitigation Measures

Structural Measures

All informants stressed the importance of upgrading physical infrastructure, such as drainage systems and retention ponds, as a primary line of defence. However, limited funding and slow implementation hamper the effectiveness of these initiatives, especially in older developments.

> *"..kami memang ada implement retention ponds dekat semua development yang baru untuk manage runoff air tu..tapi development yang lama tu masih tak cukup infrastructure.." (Informan 2)/"..We have implement retention ponds in all new developments to manage water runoff… but older developments still lack sufficient infrastructure…"*
>
> *(Informant 2)*

> *"..kapasiti parit dah bertambah dekat certain area..tapi dari segi funding tu yang limited untuk kita buat dekat semua tempat..." (Informan 1)/ "..Drain capacity has been increased in certain areas… but funding is limited for us to do this everywhere…"*
>
> *(Informant 1)*

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"..kita perlukan dana yang konsisten untuk implement infrastruktur naik taraf berskala besar ni.." (Informan 4)/ "..We need consistent funding to implement large-scale infrastructure upgrades…"

(Informant 4)

These findings align with FEMA (2020), which underscores that while engineering solutions are essential, sustained financial and policy support is required to realise their full potential.

Community-Based Initiatives

Community initiatives, such as tree planting and local drainage maintenance, have been implemented but face participation challenges. Informants suggested that these initiatives offer long-term benefits and could complement structural solutions if public involvement were higher.

"..kami ada organise event macam tree-planting untuk improve water absorption tapi ini untuk jangka masa panjang..tapi penglibatan macam kurang memuaskan.." (Informan 4)/"..We organise events like tree planting to improve water absorption, but this is a long-term effort… however, participation has been rather unsatisfactory…"

(Informant 4)

"..kalau nak educate penduduk memang kami buat, kami pesan supaya mereka sentiasa membersihkan parit...ada positif impak juga terhadap banjir kilat.." (Informan 3)/"..When it comes to educating residents, we do it—we remind them to clean the drains regularly… it has also had a positive impact on flash floods…"

(Informant 3)

"..penglibatan penduduk setempat boleh mengurangkan beban kerajaan namun kempen kesedaran ni sebenarnya memerlukan lebih dana.."(Informan 2)/ "..Local community involvement can help reduce the government's burden, but these awareness campaigns actually require more funding…"

(Informant 2)

This reflects Haliza and Rapeah's (2018) findings that bottom-up approaches enhance resilience. Thus, strengthening public education and offering incentives for participation could yield better results in Bintulu's context.

Emergency Response Management

Rapid Deployment of Resources

Efficient response during flash floods depends heavily on the timely deployment of rescue teams and equipment. While efforts have been made to improve response time through training and pre-positioning of resources, constraints such as staffing shortages and limited equipment persist.

"..kami punya water rescue team memang akan ada latihan setiap minggu..tapi masalah sekarang ni kami cuma ada empat boat untuk seluruh kawasan Bintulu.."(Informan 3)/ "..Our water rescue team does have training every week… but the problem now is we only have four boats for the whole Bintulu area…"

(Informant 3)

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"..keroodinasi dengan pihak NGO untuk menolong kami bagi ketika bencana banjir sangat memberi impak besar...kerana kadang-kadamg resources kami ni limited.." (Informan 4)/"..Coordination with NGOs to assist us during flood disasters has a huge impact… because sometimes our resources are limited…"

(Informant 4)

"..kami sangat bergantung dengan data dari kes banjir-banjir yang lepas untuk kami anticipate the resources need supaya kami boleh execute dengan baik.."(Informan 1)/ "..We rely heavily on data from past flood cases to anticipate resource needs so that we can execute effectively…"

(Informant 1)

Alamgir et al. (2019) advocate for proactive resource planning, and the findings support the expansion of cross-sector partnerships (e.g., NGOs, private sector) to enhance response capabilities.

Communication and Coordination

Effective communication, both among agencies and with the public, is a central factor in managing emergencies. Informants reported using tools like walkie-talkies, WhatsApp groups, and centralised operation centres to streamline updates and avoid information redundancy.

"..kami akan guna walkie-talkie atau Whatsapp group untuk stay updated ketika bencana banjir.." (Informan 1)/"..We use walkie-talkies or WhatsApp groups to stay updated during flood disasters…"

(Informant 1)

"..ada jawatankuasa pengurusan bencana yang sentiasa memantau semua agensi..mereka memastikan semua agensi mendapat maklumat yang sama.."

(Informan 3)/

"..There is a disaster management committee that constantly monitors all agencies… they ensure every agency receives the same information…"

(Informant 3)

"..kempen kesedaran awam sebelum ni banyak membantu orang ramai untuk mengetahui siapa mereka nak hubungi ketika berlaku bencana.."(Informan 4)/ "..Previous public awareness campaigns have greatly helped people know who to contact when a disaster occurs…"

(Informant 4)

This finding aligns with Swain et al. (2020), who emphasise that synchronised, real-time communication significantly enhances disaster response efficiency. Bintulu's experience shows promise, but it could benefit from improved public access to emergency information channels.

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Recovery and Reconstruction Strategies

Infrastructure Rehabilitation

Post-flood recovery in Bintulu prioritises the repair of damaged infrastructure, especially roads and drainage systems. Informants noted that funding delays often stall these efforts, affecting the speed and quality of recovery, particularly in rural or severely affected areas.

> *"..kami sentiasa prioritize unutk repair infrastruktur yang kritikal..tapi bajet pula satu factor yang boleh membuatkan kerja kami delat.."*
>
> *(Informan 2)/*

> *"..We always prioritise repairing critical infrastructure… but budget is a factor that can delay our work…"*
>
> *(Informant 2)*

> *"..condition untuk infrastruktur yang kami repair tu perlu sentiasa dipantau sebab kita tak nak ada berlaku lagi kerosakan yang boleh menyebabkan banjir lagi.." (Informan 1)/"..The condition of the infrastructure we repair needs to be constantly monitored because we don't want further damage that could cause flooding again…"*
>
> *(Informant 1)*

Coppola (2015) stresses the importance of infrastructure rehabilitation in reducing long-term vulnerability. The findings indicate that sustainable recovery requires consistent funding, strategic planning, and proper maintenance.

Building Community Resilience

Long-term recovery also involves strengthening community capacity to withstand future disasters. Informants cited initiatives such as community drills and public education campaigns as essential to reducing over-reliance on government aid during emergencies.

> *"..kami dah mula untuk conduct drill untuk komuniti berkaitan tentang preparations untuk mengahadapi banjir di masa hadapan.."(Informan 3)/ "..We have started conducting community drills on preparations for facing future floods…"*
>
> *(Informant 3)*

> *"..mengetengahkan kesedaran di kalangan komuniti ni penting dan mampu mengurangkan beban kami..mungkin juga mereka tidak terlalu berharap kepada semua agensi.."*
>
> *(Informan 4)*

> *"..Raising awareness within the community is important and can help reduce our burden… it may also mean they won't rely too heavily on all the agencies…"*
>
> *(Informant 4)*

Birkmann et al. (2022) support this approach, advocating for the integration of resilience-building into policy and planning. In Bintulu, empowering communities through training and localised planning is critical to sustainable recovery and disaster risk reduction.

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Journal of Islamic, Social, Economics and Development (JISED)
eISSN: 0128-1755
Journal website: www.academicinspired.com/jised
DOI: 10.55573/JISED.107605

Conclusion and Recommendation

This study examined flash flood vulnerability and disaster risk management in Bintulu through the perspectives of local authorities. Key findings show that flash floods are intensified by climate change, poor land-use practices, and uneven topography. Socio-economic issues and public awareness gaps also worsen the situation. While local authorities have taken steps like building drainage systems and using iHydro technology, challenges remain, especially in terms of funding, staffing, and rapid urban development.

Flash flood management in Bintulu requires integrated solutions that combine infrastructure, policy, and community involvement. Despite progress in some areas, continued urban growth and limited resources call for a more inclusive, resilient, and adaptive disaster management strategy. This research highlights the importance of long-term planning, stronger coordination, and sustainable practices to protect communities from future flood risks.

Local authorities should improve and upgrade drainage systems, especially in flood-prone areas like Nyabau Heights and Assyakirin. Regular maintenance is also essential to prevent blockages and ensure the systems work well. Public awareness should be increased through campaigns that teach people how to keep drains clean and why it matters. Simple early warning systems at the community level should also be introduced to help people prepare for floods. Government agencies like BDA, DID, and JBPM need to work more closely together. They should improve communication, do joint training, and partner with NGOs to strengthen flood response efforts. Future research should look at how flash floods affect poor and vulnerable communities. It should also study how fast urban growth changes flood patterns and assess if current flood control measures are working in the long term.

Acknowledgements

The author would like to extend gratitude to Dr. Mohd Zulhafiz Said for comments and guidance on the manuscript, and also for helping in supervising this research. This research is part of a dissertation submitted in partial fulfilment of the requirements for the degree of Bachelor of Human Development with Information Technologies at Universiti Putra Malaysia.

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eISSN: 0128-1755
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