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Communication Technologies and Local Authorities in Flood Disaster Risk Management: Insights from Malaysia

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Abstract

This paper examines the integration of communication technologies in local-level disaster risk management (DRM) in Malaysia, focusing on floods as the country's most frequent and costly natural hazard. Using a qualitative document analysis approach, the study reviews key policy documents such as NADMA Directive No. 1/2023 and the Public Sector ICT Policy 2021–2025, alongside academic literature and official reports, to explore the application of digital tools across the four phases of the Disaster Risk Management Cycle: mitigation, preparedness, response, and recovery. The findings indicate that technologies such as Geographic Information Systems (GIS), Internet of Things (IoT), mobile applications and social media platforms have been adopted by local authorities as frontline implementers to support risk monitoring, early warning, community engagement, and inter-agency coordination. However, their implementation remains fragmented due to limited technical capacity, inconsistent digital protocols, and weak integration between federal agencies and local governments. This study contributes a context-specific framework that underscores the importance of standardized ICT protocols, enhanced training for local authority staff, and inclusive community engagement mechanisms. While aligned with international standards such as the Common Alerting Protocol (CAP), the framework also addresses institutional and sociocultural barriers unique to Malaysia. The paper provides policy recommendations that emphasize contingency planning, ICT capacity building, and public–private collaboration to strengthen digital disaster governance. The findings offer practical insights for policymakers and most importantly for local authorities as key actors bridging national policy and community-level implementation, while also providing lessons for other ASEAN countries facing similar flood-related risks.

Keywords: Communication Technologies, Disaster Risk Management, Floods, ICT Policy, Local Authorities, Malaysia

Introduction

Malaysia is among the most disaster-prone countries in Southeast Asia with floods representing the most frequent and destructive natural hazard. Hydro-meteorological events, particularly seasonal monsoon floods have consistently caused extensive socio-economic disruption across both urban and rural areas. Recent estimates indicate that flood-prone zones cover approximately 10.1% of the national land area, placing more than 5.7 million people at risk annually and resulting in average annual losses exceeding RM1 billion (DID, 2023) (Hassan et al., 2020). Catastrophic events such as the 2014 *Bah Kuning* flood in Kelantan, which displaced over 200,000 residents and the 2021 floods in Selangor and Pahang, which caused damages valued between RM5.3 and RM6.5 billion, illustrate the scale and severity of flood impacts (Mabahwi & Nakamura, 2024; Abid et al., 2024). More recent national statistics reinforce this trend: flood-related losses reached RM755.4 million in 2023 (0.04% of nominal GDP) and RM933.4 million in 2024 (0.05% of GDP), with residential and infrastructure sectors bearing the heaviest impacts (DOSM, 2024). These figures underscore the persistent and evolving economic burden of floods, amplified by rapid urbanization, deforestation, and climate variability.

The governance of disaster risk management (DRM) in Malaysia is complicated by fragmented institutional arrangements and overlapping mandates across federal, state, and local levels. While the National Disaster Management Agency (NADMA) provides national coordination, local authorities (LAs) act as the “last-mile” responders during flood events. They are responsible for disseminating early warnings, mobilizing evacuations, managing temporary shelters, and coordinating relief logistics at the community level (Yaacob et al., 2024; Azli et al., 2024). Although disaster management strategies are formulated at the national level, LAs are the front line directly responsible for implementation in community areas. This is crucial as their effectiveness directly impacts community resilience during flood events. However, their effectiveness is constrained by limited financial resources, shortages of skilled personnel and uneven communication infrastructures, which have repeatedly resulted in inconsistent responses and public dissatisfaction during major flood events (Mohamed et al., 2024; Hassan et al., 2024

In this context, information, and communication technologies (ICTs) have become pivotal tools for strengthening disaster governance. Applications such as Geographic Information Systems (GIS), Internet of Things (IoT) sensors, mobile apps and social media platforms are increasingly utilized to support hazard monitoring, early warning, and inter-agency coordination (Leeonis et al., 2025; Fernando et al., 2024). Federal initiatives including the *InfoBanjir* portal, the *MyCuaca* app and NADMA’s national disaster dashboard have expanded digital infrastructure, however, their uptake by LAs remains inconsistent, often relying on ad hoc networks such as WhatsApp groups led by community representatives (Milyane et al., 2024; Nuzuli, 2024). This gap between national- level investments and local-level practices reflects a broader challenge across ASEAN, where technological innovation frequently outpaces institutional readiness for systematic implementation (Saad et al., 2024; Azhari Razak et al., 2024).

However, the effectiveness of LAs is often hampered by technology coordination issues and the lack of a standard digital protocol, which is the focus of the discussion in this paper. While national-level investments have expanded, their uptake by local authorities

remains inconsistent. The international policy context adds further urgency. The Sendai Framework for Disaster Risk Reduction 2015–2030 highlights four key priorities understanding risk, strengthening governance, investing in resilience, and enhancing preparedness through "Build Back Better" and explicitly emphasizes the frontline role of local governments in risk reduction (Pearson & Pelling, 2015). Thus far, empirical evidence shows that in Malaysia and across the region, local institutions often lack the financial, institutional, and sociocultural capacity to integrate ICT effectively into DRM operations (Nadzirah et al., 2024; Hassan et al., 2024). Addressing this gap is essential for building disaster-resilient communities. Against this backdrop, this study investigates the integration of ICT into local-level DRM in Malaysia, with a particular focus on floods as the country's most recurrent and costly hazard. Using qualitative document analysis of policy texts, official reports and academic literature, the study assesses how ICT tools are embedded or remain underutilized within the four phases of the DRM cycle (mitigation, preparedness, response, and recovery). The novelty of this research lies in its focus on local authorities as the middle layer of disaster governance, an area often overlooked in Malaysian and international literature. By situating ICT adoption within the realities of local authority governance, the study develops a context-specific framework that connects national ICT policy ambitions with operational practices on the ground. Accordingly, the study has four objectives:

i. Identify ICT applications across the DRM cycle in Malaysia.
ii. Critically assess their effectiveness and limitations in supporting local disaster governance.
iii. Examine institutional and inter-agency challenges constraining ICT integration at the local level.
iv. Propose a context-specific framework to strengthen ICT-based disaster communication systems with relevance for other ASEAN countries facing similar governance challenges.

This research contributes to disaster science and public policy in three main ways. First, it develops a Malaysia-specific ICT framework that aligns national policies with the operational realities of local authorities, addressing a persistent gap in existing scholarship (Leeonis et al., 2025; Mohamed et al., 2024; Sakurai, 2019). Second, it provides empirical insights through qualitative analysis of official documents, reports, and policies, clarifying how ICT tools are embedded or underutilized within the DRM cycle. Third, it advances policy discourse by offering actionable recommendations to enhance ICT-based disaster communication systems, relevant not only for Malaysian policymakers and disaster managers but also for ASEAN counterparts confronting similar governance and flood-related risks (Abid et al., 2024; Saad et al., 2024). By framing ICT adoption within local authority governance, the paper highlights that technological capability must be matched by institutional readiness, policy integration and inter-agency coordination.

Literature Review

The use of Information and Communication Technologies (ICTs) in disaster management has attracted increasing scholarly interest, particularly for their role in enhancing preparedness, enabling rapid response, and strengthening community resilience. A wide range of tools including Geographic Information Systems (GIS), Internet of Things (IoT) sensors, mobile applications and social media platforms have been deployed to support hazard mapping, monitoring, and early warning systems. However, their effectiveness remains uneven in

developing contexts where technical expertise, data availability and institutional capacity are limited (Alkhzaimi & Bakar, 2025; Leeonis et al., 2025; Tarigan, 2024). For instance, GIS has proven valuable for spatial risk analysis and resource allocation. So far, its application is still constrained by access to reliable datasets and skilled personnel. Similarly, IoT systems and mobile applications provide real-time monitoring and decision-making support (Zoha et al., 2025; Mostafiz, 2022; Kumar et al., 2025), while social media offers low-cost, two-way communication channels, but these platforms often suffer from misinformation and reliability issues that can compromise response effectiveness (Mohamed, 2024; Kaur et al., 2022, Mohd Zahari et al., 2022).

In Southeast Asia, digitalization and recurrent hydro-meteorological hazards have accelerated ICT integration into disaster risk management (DRM). Countries such as Indonesia and the Philippines have demonstrated the potential of community-based early warning systems and mobile disaster applications to improve local preparedness and citizen participation (Anggraeni & Alijoyo, 2025; Tolentino et al., 2025). Thus far, the regional experience also highlights enduring constraints uneven adoption, fragmented governance, and a persistent gap between informal peer-to-peer communication and formal disaster response frameworks (Abid et al., 2024; Sa'adi et al., 2024). These challenges reflect the broader tension between technological promise and institutional realities, a theme consistently emphasized in comparative DRM literature (Rosmadi et al.,2023).

Malaysia illustrates these dynamics clearly. National-level initiatives such as InfoBanjir and MyCuaca have enhanced access to real-time flood information, but uptake by local authorities remains inconsistent, shaped by technical barriers and institutional weaknesses (Leeonis et al., 2025; Sa'adi et al., 2024). At the same time, grassroots reliance on informal platforms such as WhatsApp groups demonstrates the critical role of community networks in disaster communication (Mohamed, 2024; Abid et al., 2024). While these channels are effective for rapid dissemination, their exclusion from formal protocols raises concerns about standardization, accountability and accuracy. Moreover, ICT use in the recovery phase remains minimal, particularly in data reporting and institutional learning, limiting long-term resilience building (Abid et al., 2021).

The adoption of communication technologies in flood disaster risk management in Malaysia can be understood through both the Technology Acceptance Model (TAM) and Institutional Theory, revealing a dual dependency: on user perceptions and on institutional frameworks. According to TAM (Davis, 1989), perceived usefulness (PU) and perceived ease of use (PEOU) drive the acceptance of technologies. In Shah Alam, local authorities have struggled to adopt digital communication mechanisms not because the tools are inherently inadequate, but because inter-agency coordination and data-sharing systems are weak, undermining the perceived benefit and accessibility of such technologies (Rosmadi et al., 2025). This systemic fragmentation aligns with Institutional Theory (Meyer & Rowan, 1977) by demonstrating how institutional norms, limited governance authority, and resource constraints impede the practical utilization of technological interventions. Mabahwi et al. (2020) further corroborate this by highlighting how local flood-related agencies suffer from limited enforcement power, inadequate funding, poor cooperation, and communication breakdowns be the factors that institutional structures directly influence. Thus, while TAM underscores the significance of intuitive and beneficial technological design, Institutional

Theory contextualizes the structural and organizational barriers that hinder technology adoption in the context of flood risk management in Malaysia.

This significant also considering the Sendai Framework for Disaster Risk Reduction 2015–2030, which stresses the central role of local governments in risk reduction and resilience building (Sa'adi et al., 2024). Addressing this gap, the present study focuses on how ICT tools are adopted, adapted, and constrained at the local authority level in Malaysia's flood DRM. By engaging with this "middle layer" of governance, the study aims to advance current debates by situating ICT adoption not only in terms of technological capability but also within the institutional realities that determine community-level outcomes.

Methodology

Table 1 summarizes the deployment of ICT tools across the four phases of the Disaster Risk Management Cycle (DRMC), while **Figure 1** illustrates the policy–practice nexus that positions local authorities (LAs) at the centre of coordination between national ICT policies and community practices. Together, they provide a comprehensive picture of how communication technologies are utilised, adapted, and constrained in Malaysia's disaster management context.

Table 1
ICT tools in disaster risk management phases in Malaysia

DRM Phase	ICT Tools / Platforms	Key Functions	Main Agencies / Users	Strengths	Weaknesses / Challenges
Mitigation	GIS flood maps, IoT river/rainfall sensors, remote sensing	Hazard modelling, flood risk mapping, environmental monitoring	DID, Local Authorities	Identify flood-prone zones; support land-use planning	Limited inter-agency integration; uneven adoption
Preparedness	Early warning systems (Sirens, SMS, CAP), *MyCuaca*, *InfoBanjir*, WhatsApp/Telegram groups	Risk awareness, drills, information sharing	MetMalaysia, DID, NADMA, Community leaders	Early warning dissemination; community engagement	Unequal ICT capacity among LAs; lack of training
Response	Social media (Facebook, Twitter, TikTok), NADMA dashboard, evacuation apps, hotlines	Alerts, coordination, evacuation, collaboration	NADMA, State Committees, NGOs	Real-time updates; situational awareness; faster coordination	Risk of misinformation; fragmented inter-agency communication
Recovery	MyFlood, e-Bencana, digital aid distribution (e-wallets,databases), GIS needs assessment	Aid disbursement, rehabilitation tracking, accountability	NADMA, Ministry of Finance, Local Authorities	Aid distribution; post-disaster assessment	Inconsistent data collection; ICT literacy gaps among staff

Source: Table developed by the authors based on synthesis from policy texts (NADMA, 2023; Public Sector ICT Policy 2021–2025 (Jabatan Digital Negara, 2021), official reports (DID,

MetMalaysia) and recent studies (Leeonis et al., 2025; Mohamed, 2024; Abid et al., 2024; Sa'adi et al., 2024; Tarigan, 2024; Rosmadi et al.,2023; Sakurai, 2019).

ICT in the Mitigation Phase

In the mitigation phase, technologies such as GIS flood maps, IoT-based rainfall and river sensors and remote sensing applications have been introduced by agencies including the Department of Irrigation and Drainage (DID) and selected LAs. These tools support hazard modelling, zoning of flood-prone areas and environmentally informed land-use planning (Leeonis et al., 2024). However, the evidence indicates limited adoption and weak cross-agency integration, which restricts the potential of these tools to systematically inform long-term flood risk reduction. The uneven diffusion of such technologies reflects broader institutional capacity gaps, particularly at the local government level where technical expertise is inconsistent.

ICT in the Preparedness Phase

Preparedness activities are increasingly supported by geo-targeted SMS alerts, siren systems, simulation applications and platforms such as *MyCuaca* and *InfoBanjir*. Informal channels, particularly WhatsApp and Telegram groups, are also widely used for rapid information sharing at the community level (Mohamed, 2024; Abid et al., 2024). These technologies enhance early warning dissemination and strengthen local engagement. However, their integration into official disaster management protocols remains partial. Unequal ICT literacy and resource disparities across LAs further limit the consistent and reliable application of early warning tools (Sa'adi et al., 2024).

ICT in the Response Phase

During the response phase, social media platforms (Facebook, Twitter, TikTok), the NADMA dashboard, AI-based forecasting tools, evacuation apps and emergency hotlines play a critical role in enabling real-time communication, situational awareness, and rapid coordination (Mabahwi & Nakamura, 2024; Alexander, 2014). These technologies allow both authorities and citizens to share and access information almost instantaneously (Azmi & How, 2025). At the same time, however, reliance on social media exposes responders to misinformation, fragmented reporting and challenges of verifying data in fast-moving emergencies (Grace, 2025; Reuter & Kaufhold, 2019). Inter-agency communication gaps further compound these risks, demonstrating that the effectiveness of ICTs depends as much on institutional coordination as on technical sophistication (Yap et al.,2023; AS et al., 2022).

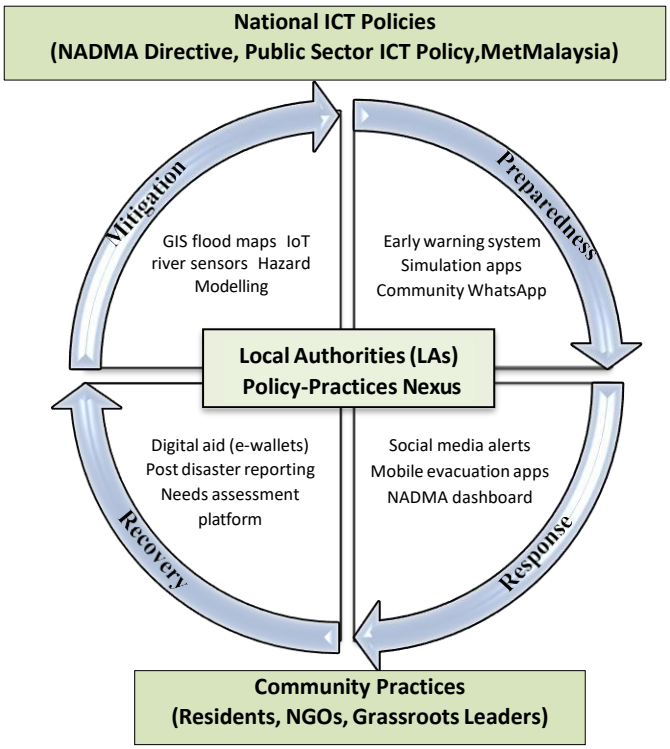
ICT in the Recovery Phase

In the recovery phase, Malaysia increasingly employs GIS-based damage and needs mapping and digital aid distribution systems such as e-wallet and databases to improve transparency in aid delivery and post-disaster assessment (Tew et al., 2024; Iqbal et al., 2024; Ambikapathy et al., 2024; Mohamed et al., 2024). In practice, digital information systems platforms such as MyFlood and e-Bencana as documented in official agency materials are used alongside these geospatial and database tools to register beneficiaries, track assistance and support reporting (Mohamad Zain, 2024). While these initiatives signal a growing effort to institutionalize ICT in recovery, their impact has been constrained by inconsistent reporting practices, low ICT literacy among local staff and the absence of harmonized data-sharing protocols (Ghadge,

2022 & Setyawan et al., 2024). As a result, opportunities for institutional learning and long-term resilience building remain underutilized.

ICT in Disaster Risk Management Cycle (Policy–Practice Nexus)

Figure 1 highlights the central role of local authorities as intermediaries between national ICT policies (NADMA Directive 1/2023, Public Sector ICT Policy) and community practices (residents, NGOs, grassroots leaders). While national-level policies provide clear direction and advanced technological tools, their successful translation into practice depends heavily on the capacity and willingness of LAs to embed these tools into operational structures. Community-led communication networks, especially WhatsApp groups, illustrate the strength of grassroots mobilization but also underscore risks of accountability and standardization when informal systems operate outside official frameworks (Mohamed, 2024).



Source: Adapted from the Disaster Risk Management Cycle (UNDRR, 2022) and synthesized from multiple ICT-related studies (Leeonis et al., 2025; Houston et al., 2021; Shaw et al., 2017).

Figure 1. Model for integrating ICT into the Disaster Risk Management Cycle in Malaysia

This study is based on a combination of Technology Acceptance Model (TAM) and Institutional Theory. TAM is used to understand how local authorities (LAUs) accept and adapt communication technology based on perceived usefulness and ease of access. Meanwhile, Institutional Theory provides a framework to analyze how external factors such as NADMA Directive No. 1/2023 and the Public Sector ICT Policy 2021-2025 shape the LAU organizational structure in managing flood risk. This combination allows for a holistic analysis of the gap between digital policy and practice at the grassroots level.

Taken together, **Table 1** and **Figure 1** indicate that ICTs play a dual role in Malaysia's disaster risk management (DRM): first, as technical tools for hazard modelling, monitoring,

and communication; and second, as governance mechanisms that enhance coordination, accountability, and resilience building. However, their effectiveness remains uneven across DRM phases and is shaped by institutional capacities, system interoperability and the ability of local authorities to bridge the gap between policy and practice. These findings highlight the need for future disaster management efforts to prioritize capacity-building for local authorities, institutional harmonization across agencies and stronger integration of community-level communication practices into formal disaster governance systems.

Conclusion

This study examined the integration of information and communication technologies (ICTs) into local-level disaster risk management (DRM) in Malaysia. The findings show that tools such as GIS mapping, IoT sensors, mobile applications, and social media platforms are increasingly used across all four phases of the Disaster Risk Management Cycle (DRMC). However, ICT adoption remains fragmented, with local authorities constrained by limited expertise, poor interoperability, and inadequate resources.

Based on these insights, three key policy recommendations are proposed. First, institutionalizing ICT-based contingency planning is critical, particularly through formal standard operating procedures, redundancy protocols, and regular simulation exercises (NADMA, 2023; UNDRR, 2022). Second, the effectiveness of ICT systems relies not only on infrastructure but also on human capacity. Building technical expertise through targeted training programmes and collaborations with universities, NGOs, and private sector partners is essential for strengthening ICT literacy and operational readiness (Ambikapathy & Hamid, 2024; Nghia, 2023; Shaw, 2016). Third, stronger standardization and inter-agency coordination are needed. Adopting global frameworks such as the Common Alerting Protocol (CAP) could streamline warning dissemination, while partnerships with technology providers could enhance system resilience (Sakurai, 2019; Abid et al., 2025).

This study also links ICT adoption directly to the Disaster Risk Management Cycle (DRMC) and identifies local authorities as a central layer of governance. It emphasizes that institutional trust, system interoperability and socio-political context are crucial factors in ICT adoption for disaster management, but these areas remain underexplored (Kaur et al., 2022; Ab Aziz, 2019). It is important to note that this study's reliance on secondary documents limits visibility into informal and community-level communication practices. Future research should therefore adopt mixed method designs that combine interviews, surveys and quantitative assessments to triangulate institutional perspectives with lived community experiences (Fusch et al., 2018; Schreier, 2012). Comparative studies with other ASEAN countries such as Indonesia and the Philippines could further strengthen regional learning and identify lessons that are transferable across contexts (ESCAP, 2020; Kangana et al., 2024; Kong, 2024).

In conclusion, this study highlights that ICT integration in disaster risk management (DRM) is not merely a technical issue but also a critical governance priority. Bridging the gap between national ICT strategies and local implementation requires a communication system that is coordinated, standardized, and community-focused (Sakurai, 2019). Strengthening institutional capacity at the local level would enable Malaysia to advance towards disaster management practices that are technologically resilient, socially inclusive and consistent with

the people- centred vision of the Sendai Framework for Disaster Risk Reduction 2015-2030 (UNDRR, 2022; Nghia et al., 2022; Kaur et al., 2022; Shaw et al., 2017; Shaw et al., 2016).

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References

Ab Aziz, N. F., Akashah, F. W., & Aziz, A. A. (2019). Conceptual framework for risk communication between emergency response team and management team at healthcare facilities: A Malaysian perspective. *International Journal of Disaster Risk Reduction*, *41*, 101282. https://doi.org/10.1016/j.ijdrr.2019.101282

Abid, S. K., Sulaiman, N., & Wei, C. S. (2021). Building resilient future: Information technology and disaster management—A Malaysian perspective. *IOP Conference Series: Earth and Environmental Science*, *795*(1), 012026. https://doi.org/10.1088/1755-1315/795/1/012026

Abid, S. K., Sulaiman, N., Al-Wathinani, A. M., & Goniewicz, K. (2024). Community-based flood mitigation in Malaysia: Enhancing public participation and policy effectiveness for sustainable resilience. *Journal of Global Health, 14,* 04290.https://doi.org/10.7189/jogh.14.04290

Alexander, D. E. (2014). Social media in disaster risk reduction and crisis management. *Science and Engineering Ethics*, *20*(3), 717-733. https://doi.org/10.1007/s11948-013-9502-z

Alkhzaimi, A. H. M. K., & Bakar, A. (2025). Insights on enhancing strategic value in disaster management through IoT technology: A review paper from UAE perspective. *International Journal of Academic Research in Business & Social Sciences*, *15*(1). https://doi.org/10.6007/ijarbss/v15-i1/24143

Ambikapathy, M., & Hamid, M. K. A. (2024). Crisis communication strategies during natural disaster crisis case studies: Selangor flood, Malaysia. *Asian Journal of Research in Education and Social Sciences*, *6*(2), 133-141. https://doi.org/10.55057/ajress.2024.6.2.10

Anggraeni, R., & Alijoyo, F. A. (2025). The effect of technology awareness and government support on the acceptance of Identitas Kependudukan Digital Apps in Sumedang using TAM framework. *Journal of World Science*, *4*(1). https://doi.org/10.58344/jws.v4i1.1271

AS, A. M., Mardiana, O., & Rosliza, A. M. (2019). Role of social media in disaster management. *International Journal of Public Health and Clinical Sciences*, *6*(2), 77-99.

Azahari Razak, K., Hayatun Syamila Ramlee, L., Yusra Sapiee, H., Siow, Y. M., Sabri Muda, R., Abu Bakar, R & Koh Poh Lee, C. S. N. (2024). Advancing Local Disaster Resilience Strategies: A Transdisciplinary Approach. *In EGU General Assembly Conference Abstracts* (p. 18315). https://doi.org/10.5194/egusphere-egu24-18315, 2024

Azli, T. S. E. T. A., Akhir, N. M., & Rajaratnam, S. (2024). Exploring the Roles of Flood Disaster Workers in Flood Disaster Management: A Narrative Review. *International Journal of Academic Research in Accounting, Finance and Management Sciences, 14*(4). https://doi.org/10.6007/ijarafms/v14-i4/24223

Azmani, S., Juliana, N., Idrose, A. M., Amin, N. A., & Saudi, A. S. M. (2017). Challenges of communication system during emergency disaster response in Malaysia: A review. *Journal of Fundamental and Applied Sciences*, *9*(4S), 890-904. https://doi.org/10.4314/jfas.v9i4s.51

Azmi, E. S., & How, V. (2025). Technology Potential in Improving Disaster Response Communication: A Qualitative Study in Malaysia. *Malaysian Journal of Medicine & Health Sciences*, *21*(3).

Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *NursingPlus Open, 2,* 8–14. https://doi.org/10.1016/j.npls.2016.01.001

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27–40. https://doi.org/10.3316/QRJ0902027

Dash, A. (2024). Understanding citizen adoption of smart governance: Integrating technology acceptance and readiness theories. *Global Knowledge, Memory and Communication*. https://doi.org/10.1108/gkmc-08-2024-0509

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340. https://doi.org/10.2307/249008

Department of Irrigation and Drainage Malaysia (DID). "Flood Risk Management: A National Approach." Accessed in August 2025. Online. Available: http://www.water.gov.my

Department of Statistics Malaysia (DOSM). (2024). *Selected Statistics on Flood Losses in Malaysia 2023–2024.* Putrajaya: DOSM.

ESCAP, U. (2020). Enhancing the role of ICTs for disaster risk management.

Fernando, A., Yudhatama, D., Murti, N. W., Hamid, M. H., & Fernando, E. (2024). Early Flood Detection with SIMOBI: IoT and Mobile Integration. *Jurnal Pekommas*, *9*(2), 201-207. https://doi.org/10.56873/jpkm.v9i2.5433

Flick, U. (2018). *An introduction to qualitative research* (6th ed.). Sage.

Fusch, P. I., Fusch, G. E., & Ness, L. R. (2018). Denzin's paradigm shift: Revisiting triangulation in qualitative research. *Journal of Social Change, 10*(1), 19–32. https://doi.org/10.5590/JOSC.2018.10.1.02

Ghadge, A. (2022). ICT-enabled approach for humanitarian disaster management: A systems perspective. *International Journal of Logistics Management*. https://doi.org/10.1108/ijlm- 11-2021-0532

Grace, R. (2025). Technologies in Crisis Communication: Tools, Systems, and Infrastructures. *The Handbook of International Crisis and Risk Communication Research*, 637-655. https://doi.org/10.1002/9781394180844.ch48

Hassan, M. S., Jaffar, M. A., Abdulameer, S. K., Radzi, S. F. M., & Kanasan, V. (2020). Preparedness for disaster risk management (drm), case studies: kelantan flood, malaysia. *Advances in Social Sciences Research Journal*, 7(5), 382-392. https://doi.org/10.14738/assrj.75.8296

Hassan, S., Zainol, N. A. M., Yaacob, S., Abidin, Z. Z., Taib, K. N., Zahari, H. M., & Sofian, M. H. (2024). The exploration of strengthening elements for community awareness in facing flood disasters in the northern zone of Peninsular Malaysia. *International Journal of Law, Government and Communication, 9*(37). https://doi.org/10.35631/ijlgc.937024

Houston, J. B. (2021). COVID-19 communication ecologies: Using interpersonal, organizational, and mediated communication resources to cope with a pandemic. *American Behavioral Scientist*, *65*(7), 887-892. https://doi.org/10.1177/0002764221992837

Jabatan Digital Negara. (2021). *Pelan Strategik Pendigitalan Sektor Awam (Public Sector Digitalisation Strategic Plan) 2021–2025* [PDF]. Retrieved from https://www.jdn.gov.my/pelan-strategik-pendigitalan/

Kangana, N., Kankanamge, N., De Silva, C., Goonetilleke, A., Mahamood, R., & Ranasinghe, D. (2024). Bridging community engagement and technological innovation for creating smart and resilient cities: A systematic literature review. *Smart Cities*, *7*(6), 3823-3852. https://doi.org/10.3390/smartcities7060147

Kaur, M., Kaur, P. D., & Sood, S. K. (2022). ICT in disaster management context: A descriptive and critical review. *Environmental Scienceand Pollution Research*. https://doi.org/10.1007/s11356-022-21475-5

Kaur, M., Kaur, P. D., & Sood, S. K. (2022). ICT in disaster management context: a descriptive and critical review. *Environmental Science and Pollution Research*, *29*(57), 86796-86814. https://doi.org/10.1007/s11356-022-21475-5

Kong, F. (2024). Post-Disaster Governance in Southeast Asia: Response, Recovery, and Resilient Societies. *Singapore Journal of Tropical Geography*, *45*(1).

Kuckartz, U., & Radiker, S. (2019). *Analyzing qualitative data with MAXQDA: Text, audio, and video.* Springer. https://doi.org/10.1007/978-3-030-15671-8

Kumar, N. (2025). An IoT-based ensemble framework for climate change monitoring and forecasting of disasters. *International Journal of Information Technology*, 1-6. https://doi.org/10.1007/s41870-025-02519-8

Kyngas, H. (2020). Qualitative research and content analysis. In H. Kyngas, K. Mikkonen, & M. Kaariainen (Eds.), *The application of content analysis in nursing science research* (pp. 3–11). Springer. https://doi.org/10.1007/978-3-030-30199-6_1

Leeonis, A. N., Ahmed, M. F., Mokhtar, M. B., Lim, C. K., & Halder, B. (2024). Challenges of Using a Geographic Information System (GIS) in Managing Flash Floods in Shah Alam, Malaysia. *Sustainability*, *16*(17), 7528. https://doi.org/10.3390/su16177528

Leeonis, A. N., Ahmed, M. F., Mokhtar, M., Halder, B., Lim, C. K., Majid, N. A., & Scholz, M. (2025). Importance of Geographic Information System (GIS) Application to Reduce the Impact of Flood Disasters in Malaysia: A Meta-Analysis. *Water, 17*(2), 181. https://doi.org/10.3390/w17020181

Lungu, M. (2022). The coding manual for qualitative researchers. *American Journal of Qualitative Research*, *6*(1), 232-237. https://doi.org/10.29333/ajqr/12085

Mabahwi, N. A., & Nakamura, H. (2024). Catastrophic flooding in Pahang, Malaysia: What went wrong with the flood response? *Planning Malaysia Journal, 22*(34). https://doi.org/10.21837/pm.v22i34.1627

Mabahwi, N. A., Nakamura, H., & Bhattacharya, Y. (2020). Flood Risk Management in Malaysia: The current hindrances for flood related agencies. *Asian Journal of Behavioural Studies*, *5*(19), 11-24. https://doi.org/10.21834/ajbes.v5i19.190 ajbes.e-iph.co.uk

Meyer, J. W., & Rowan, B. (1977). Institutionalized organizations: Formal structure as myth and ceremony. *American journal of sociology*, *83*(2), 340-363. https://doi.org/10.1086/226550

Miles, M. B., Huberman, A. M., & Saldaña, J. (2020). *Qualitative data analysis: A methods sourcebook* (4th ed.). Sage.

Milyane, T. M., Djuwita, A., Parsono, S., & Mukhlisiana, L. (2024). Disaster Communication among Flash Flood Victims in Garut Regency. *Mediator, 17*(2). https://doi.org/10.29313/mediator.v17i2.3437

Mohamed, M. A. B., Zaman, A., Kajewski, S. L., & Trigunarsyah, B. (2024). Enhancing Flood Disaster Management in Klang Valley. J. Kejuruter, 36, 2709-2715.https://doi.org/10.17576/jkukm-2024-36(6)-40

Mohammed Zain, R., Mohd Zahari, H., & Mohd Zainol, N. A. (2023). Inter-agency information sharing coordination on humanitarian logistics support for urban disaster management in Kuala Lumpur. *Frontiers in Sustainable Cities*, *5*, 1149454. https://doi.org/10.3389/frsc.2023.1149454

Mohd Zahari, H., Zainol, N. A. M., & Ismail, A. (2022). Media information, flood images, and perceptions in times of flood. *Sustainability*, *14*(17), 10623. https://doi.org/10.3390/su141710623

Mostafiz, R. B., Rohli, R. V., Friedland, C. J., & Lee, Y. C. (2022). Actionable information in flood risk communications and the potential for new web-based tools for long-term planning for individuals and community. *Frontiers in earth science*, *10*, 840250. https://doi.org/10.3389/feart.2022.840250

Nadzirah, H., Hisyam, K. K., & Hafiz, M. F. M. (2025) From Risk to Readiness: Exploring Community Preparedness for Monsoon Floods in East Coast Malaysia. https://doi.org/10.25303/181da031037

National Disaster Management Agency (NADMA). (2023). *Directive No. 1/2023: Policy and mechanism for national disaster management.* Putrajaya: NADMA Malaysia. https://www.nadma.gov.my

Nghia, B. P. Q., Pal, I., Chollacoop, N., & Mukhopadhyay, A. (2022). Applying Google earth engine for flood mapping and monitoring in the downstream provinces of Mekong River. *Progress in Disaster Science*, *14*, 100235. https://doi.org/10.1016/j.pdisas.2022.100235

Nortey, E. N. N., Adjei-Twum, A., Okyere-Kwakye, E., & Alhassan, T. (2025). Examining the adoption of information technology in facilities management using the technology acceptance model. *Property Management*. https://doi.org/10.1108/pm-06-2024-0063

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods, 16*(1), 1–13. https://doi.org/10.1177/1609406917733847

Nuzuli, A. K. (2024). Model Komunikasi dalam Mitigasi Bencana Banjir di Kabupaten Kerinci dan Sungai Penuh. *Jurnal PIKMA: Publikasi Ilmu Komunikasi Media Dan Cinema*, *7*(1), 134-147. https://doi.org/10.24076/pikma.v7i1.1772

Pearson, L., & Pelling, M. (2015). The UN Sendai framework for disaster risk reduction 2015–2030: Negotiation process and prospects for science and practice. *Journal of Extreme Events*, *2*(01), 1571001. https://doi.org/10.1142/s2345737615710013

Reuter, C., Kaufhold, M. A., Schmid, S., Spielhofer, T., & Hahne, A. S. (2019). The impact of risk cultures: Citizens' perception of social media use in emergencies across Europe. *Technological Forecasting and Social Change*, *148*(1), 1-17. https://doi.org/10.1016/j.techfore.2019.119724

Rosmadi, H. S., Ahmed, M. F., Mokhtar, M. B., & Lim, C. K. (2023). Reviewing challenges of flood risk management in Malaysia. *Water*, *15*(13), 2390. https://doi.org/10.3390/w15132390

Rosmadi, H. S., Ahmed, M. F., Radwan, N., Mokhtar, M. B., Lim, C. K., Halder, B., & Pande, C. B. (2025). Flood Management Framework for Local Government at Shah Alam, Malaysia. *Water (20734441)*, *17*(4). https://doi.org/10.3390/w17040513 MDPI

Sa'adi, Z., Ramli, M. W. A., Tajuddin, W. A. N. W. A., Arman, N. Z., Hassan, C. H. C., Ramzan, M. A., ... & Alias, N. E. (2024). Evaluating flood early warning system and public preparedness and knowledge in urban and semi-urban areas of Johor, Malaysia: Challenges and opportunities. *International Journal of Disaster Risk Reduction*, *113*, 104870.https://doi.org/10.1016/j.ijdrr.2024.104870

Saad, M. S. H., Ali, M. I., Razi, P. Z., & Ramli, N. I. (2024). Flood Risk Management in Development Projects: A Review of Malaysian Perspective within the Sendai Framework for Disaster Risk Reduction 2015–2030. *Construction, 4*(2). https://doi.org/10.15282/construction.v4i2.10592

Sakurai, M., & Murayama, Y. (2019). Information technologies and disaster management–Benefits and issues. *Progress in Disaster Science*, *2*, 100012. https://doi.org/10.1016/j.pdisas.2019.100012

Saldaña, J. (2021). Coding techniques for quantitative and mixed data. *The Routledge reviewer's guide to mixed methods analysis*, 151-160. https://doi.org/10.4324/9780203729434-14

Schreier, M. (2012). Qualitative content analysis in practice.

Setyawan, R., Raharjo, B., & Dewayani, J. (2024). Governance in the digital era: Analyzing the adoption of e-government services in local authorities through quantitative methods. *Journal of Management and Informatics*, *3*(3). https://doi.org/10.51903/jmi.v3i3.54

Shaw, R., Izumi, T., & Shi, P. (2016). Perspectives of science and technology in disaster risk reduction of Asia. *International Journal of Disaster Risk Science*, *7*(4), 329-342. https://doi.org/10.1007/s13753-016-0104-7

Shaw, R., Shiwaku, K., & Izumi, T. (Eds.). (2017). Science and technology in disaster risk reduction in Asia: Potentials and challenges.

Sheikh, S., Roslan, S. N. A., & Shafri, H. Z. M. (2024). Enhancing flood detection and estimation in Johor, Malaysia, during December 2014: Leveraging the power of google earth engine and microwave sensors. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1412, No. 1, p. 012012). IOP Publishing. https://doi.org/10.1088/1755-1315/1412/1/012012

Tarigan, M. F. A. (2024). Development of a Real-Time Data-Based Geographic Information System to Enhance Disaster Management: The Role of Media and Technology in Mitigation. *Jurnal Penelitian Medan Agama*, *15*(2), 213-224.https://doi.org/10.58836/jpma.v15i2.23170

Tew, Y. L., Tan, M. L., Juneng, L., Osman, S., Hassan, M. H., Samat, N., & Li, L. (2024). Flood inundation mapping in the Kelantan River Basin, Malaysia, using Sentinel-1 SAR and Google EarthEngine. *Geografia*, *20*(4), 13-25. https://doi.org/10.17576/geo-2024-2004-02

Tolentino, P. L. M., Williams, R. D., & Hurst, M. D. (2025). Natural flood risk management in tropical Southeast Asia: prospects in the biodiverse archipelagic nation of the Philippines. *Wiley InterdisciplinaryReviews: Water*, *12*(1),e70000. https://doi.org/10.1002/wat2.70000

UNDRR. (2022). *Asia-Pacific disaster report 2022: Pathways for resilient recovery from COVID-19*. United Nations Office for Disaster Risk Reduction. https://www.undrr.org/media/87329/download

Wirapraja, A., & Aribowo, H. (2024). Pengaruh Technology Acceptance Model (TAM) terhadap kepuasan kerja studi kasus pada mitra InDriver Surabaya. *KONSTELASI: Konvergensi Teknologi dan Sistem Informasi*, *4*(2). https://doi.org/10.24002/konstelasi.v4i2.10023

Yaacob, S., Mohaiyadin, N. M. H., Kuzi, F., & Hassan, S. (2024). A review of evacuation policies for flood disaster response in Malaysia. *International Journal of Law, Government and Communication, 9*(38). https://doi.org/10.35631/ijlgc.938005

Yap, C. S., Keling, W., & Abdullah, S. K. (2023). Use of social media for information seeking and sharing during floods in rural Sarawak. *International Journal of Emergency Services*, *12*(1), 38-51. https://doi.org/10.1108/gm-06-2021-0170

Zoha, M. S., Moketar, N. A., Kamalrudin, M., & Akmal, S. (2025). A Web-Based Flood Information Management System for Improved Rescue and Recovery Decisions. *Journal of Advanced Computing Technology and Application (JACTA)*, *7*(1), 40-54.https://doi.org/10.54554/jacta.2025.07.01.004