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Digital innovation and social adaptation in urban flood risk reduction: A study on community-based coping strategies

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ABSTRACT

Background: Flooding in the capital city of DKI Jakarta is still a serious problem that has a broad impact on society. Rapid urbanization, suboptimal drainage systems, and climate change contribute to the increasing frequency and impact of flooding. Flooding not only causes economic losses, but also impacts on health, loss of livelihoods, agriculture and livestock sectors, disruption to education, and damage to public and private infrastructure, effective strategies are needed to increase community resilience in the face of these disasters. **Methods**: This study used a methodological approach related to coping strategies in the face of flooding. The theory of coping strategies developed by Lazarus & Folkman (1984) is used as the basis of analysis to understand how communities can adapt and respond to floods. In addition, a study of digital platforms such as petabencana.id was conducted to see the role of technology in improving community preparedness. **Findings:** The results show that communities use various coping strategies in dealing with floods, both those that focus on problem-focused coping and those that focus on emotion-focused coping. Technology-based approaches, such as the use of petabencana.id, allow communities to share information in real-time, improve coordination in emergency response, and speed up decision-making in disaster situations. This research also highlights the importance of a combination of proactive and reactive coping strategies in dealing with floods. In addition, utilizing digital technology in disaster mitigation can increase the effectiveness of emergency response efforts and strengthen community engagement. **Conclusion**: This study confirms that the application of appropriate coping strategies, supported by technology and multi-stakeholder collaboration, can help communities deal more effectively with the impacts of flooding. **Novelty/Originality of this article:** Increasing education on coping strategies, optimizing the use of information technology, and strengthening social networks are important steps in flood mitigation and management in Jakarta.

KEYWORDS: flood; coping strategies; community collaboration; urban; technology.

1. Introduction

Flooding is a natural disaster that often occurs in Indonesia. In the last nine years, the National Disaster Management Agency/ *Badan Nasional Penanggulangan Bencana* (BNPB) recorded that floods have the highest number of cases compared to other natural and non-natural disasters. Almost all regions in Indonesia have the potential for flooding due to the country's tropical climate with high rainfall and other causes, including the lack of water catchment areas, low public awareness in disposing of garbage properly, and sanitation systems that are not functioning optimally in various regions. The impact caused by flooding is very detrimental to people's lives, such as damage to infrastructure (houses, public

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places), loss of time due to disruption of daily activities, and other material losses, including interruptions to agricultural and industrial production, as well as the loss of human resources and financial losses for companies and individuals. For example, flooding that occurred in Jakarta in early 2020 is estimated to have caused economic losses of 5 trillion rupiah (The World Bank, 2021).

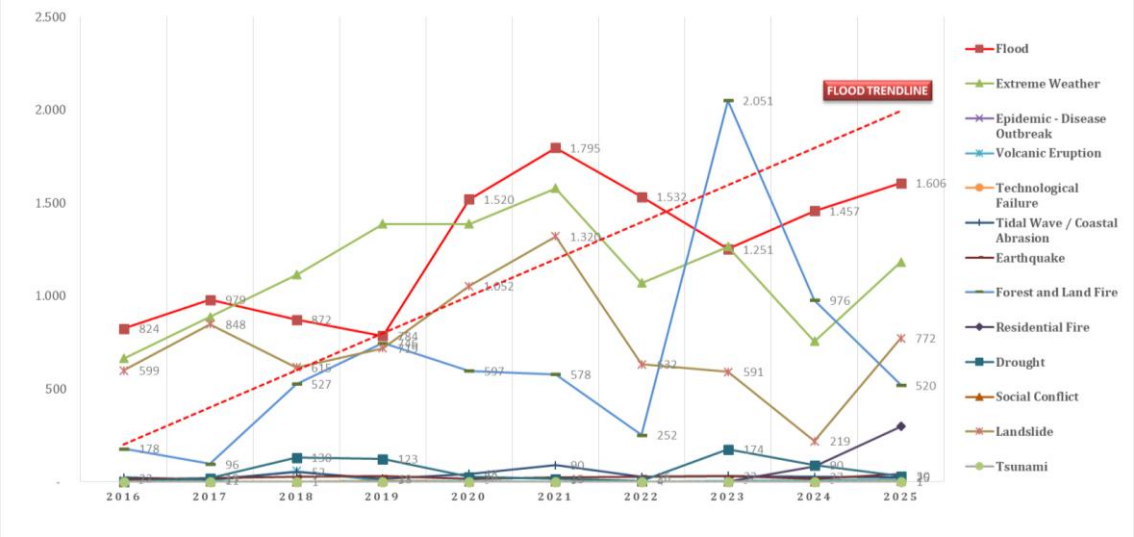

Fig.1. Disaster statistics in Indonesia 2016-2025
(Pusdatinkom BNPB, 2025)

Risk mitigation against disasters, especially in big cities, should be taken seriously by various parties, not only the government. Therefore, flood risk management requires good coordination between the central and local governments, ministries and agencies, non-profit organizations, the private sector, educational and research institutions, and all elements of society. It is also important to understand the capacity of each party. Often, state priorities such as infrastructure development with high economic impact and the expansion of community settlements due to urbanization erode land that should serve as water catchment areas. This creates flood vulnerability, especially in urban areas. Despite the construction of dams and engineering of drainage systems in urban areas, the impacts of climate change and urbanization require new and more innovative approaches to reduce risk (Vun et al., 2019).

Flood risk mitigation can be seen in several countries, such as Singapore, which has a Public Utilities Board (PUB), Singapore's National Water Agency, that manages water supply, water storage, and daily water needs. The Singapore government has prepared systematic disaster mitigation by utilizing smart technology in watershed management combined with forecasting and early warning systems to increase flood awareness. In addition, Singapore also treats water collected in reservoirs so that it can be further processed and made safe for consumption (PUB Singapore, 2022).

An ethnographic study conducted by Indonesia Science Fund National Development Planning Agency/ *Dana Ilmu Pengetahuan Indonesia Badan Perencanaan Pembangunan Nasional* (DIPI Bappenas) in collaboration with UNDP Accelerator Lab, RCUS, and the communities of seven cities in Indonesia (Banjarmasin City, DKI Jakarta Province, Semarang City, Surabaya City, Cirebon City, Malacca Regency, and Malacca City) indicates that the urban ecological infrastructure framework highlights the importance of the interconnectedness between social and physical infrastructure in forming systemic resilience. Flood risk management often ignores the social dimension. This study also examines the persistence of community perceptions of flooding, the diversity of relationships between the community and the government—which is a determining factor in the formation of social cohesion—as well as the quality and quantity of adaptation and mitigation actions at the group and individual levels, and the influence of socio-economic

capacity in dealing with flooding. For instance, the upper middle class raises the ground floor and adds floors to buildings, while the lower middle class constructs additional temporary devices such as levees and shelves (Bappenas, 2021).

People's perceptions that differ from the government regarding flood disasters greatly affect urban ecological infrastructure, potentially disrupting the surrounding ecosystem. This is because the behavior of individuals and communities directly or indirectly influences factors such as the closure of waterways. Therefore, community involvement in protecting the environment is very important. Maintaining drainage system infrastructure and fostering community participation are like two magnetic poles that attract each other. Without the support of both parties, the risk of flooding cannot be effectively mitigated.

Further community involvement is very helpful for the government in emergency response efforts, such as what is done by Petabencana.id which collects information from the community to report through social media related to natural disasters in real time. This platform is a forum for community support to take precautions and reduce risks to disasters, accelerate emergency response times, and update the latest information on conditions that are occurring. Data from this platform is also used as a basis for decision-making by BNPB (Petabencana.id, 2020). Petabencana.id also provides training for the community to become Climate Ambassadors, which is a mobilizer in a community to support disaster risk reduction efforts. Emergency response to floods is not only the responsibility of the government, but the community also has a role. For this reason, disaster preparedness is needed in the community so that when a disaster occurs, the community already knows the steps to be taken and efforts to prevent disasters.

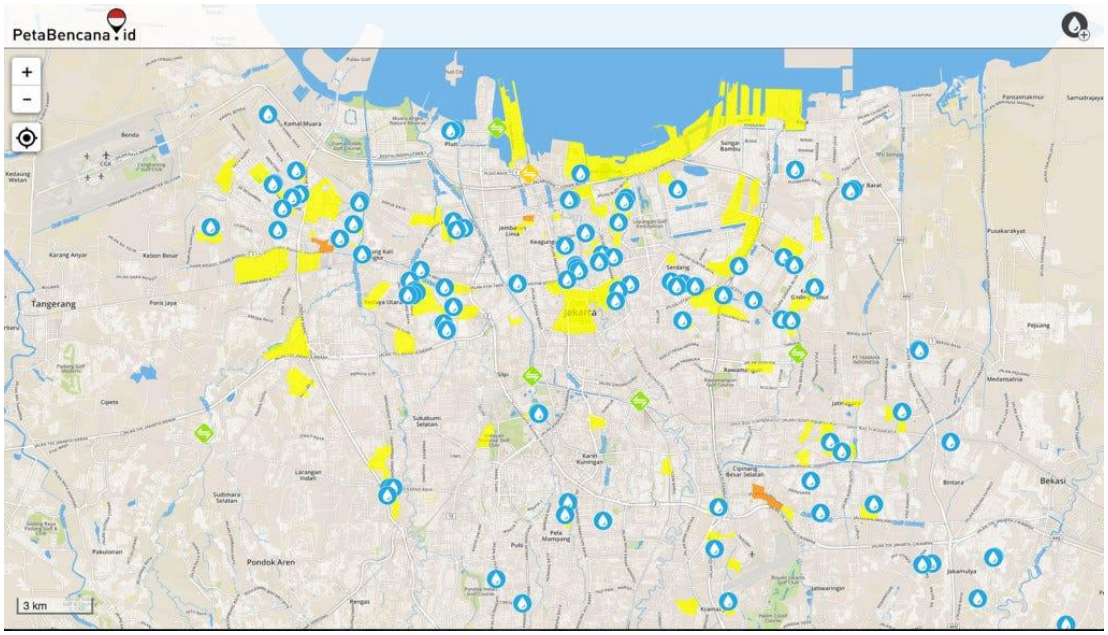

Fig. 2. This image was taken from the Mapbox blog (the underlying mapping platform used by PetaBencana.id) while highlighting the Jakarta flood map in February 2017 (Petabencana.id, 2017)

The visualization presents geospatial information derived from citizen reports submitted through social media platforms. These data are processed in real time to generate situational awareness, thereby enabling more effective coordination of disaster response efforts by the Regional Disaster Management Agency (BPBD) and other relevant institutions. Several previous studies have demonstrated the importance of social media for people to obtain disaster-related information. For example, research by Alharbi & Haq (2024) examined the DistilBERT model to classify disaster related tweets, refining its predictive accuracy through hyperparameter tuning. This study also employed a comprehensive analysis of the dataset and iterative refinement of the model. The DistilBERT model achieved a training accuracy of 92.42% and a validation accuracy of

82.11%, demonstrating strong potential in disaster response applications. Its compactness, speed, and robust text classification capabilities enhanced through preprocessing, hyperparameter tuning, and K-Fold validation allowed it to outperform other models. Overall, DistilBERT shows significant promise in improving disaster communication and emergency management through efficient analysis of social media data.

Government agencies in Indonesia increasingly utilize social media platforms to disseminate information regarding disaster hazards and preventive measures, which has proven effective in raising public awareness. Similar to findings from previous studies, Twitter (now X), with its rapid and wide-reaching information flow, enhances the effectiveness of early warning systems. For instance, the use of social media for flood early warning dissemination by the Jakarta Provincial BPBD (Harahap, 2024) integrates several key prevention components: risk knowledge, monitoring and warning services, dissemination and communication, and response capability. Social media platforms such as X, Facebook, and Instagram are actively employed to deliver real-time updates on upstream rainfall, local precipitation, and tidal flooding, supported by inter-agency coordination with BMKG and the Water Resources Agency. Nevertheless, challenges persist, particularly in sustaining public trust, preventing information overload, and ensuring message clarity. Given Jakarta's high internet penetration and widespread mobile phone usage, social media represents a strategic tool for disaster communication, though enhancing accuracy, credibility, and institutional coordination remains crucial to maximizing its impact.

A study conducted by Gelgel et al. (2023) examined the preventive role of alternative social media platforms, such as Instagram @bpptkg, managed by the Geological Disaster Technology Research and Development Center under the Geological Agency of the Ministry of Energy and Mineral Resources (ESDM). This account has been consistently utilized as a communication channel for the Mount Merapi disaster, providing updates on volcanic activity, early warnings, mitigation measures, educational content, and institutional initiatives. Grounded in media dependency theory, the platform demonstrates effectiveness in delivering timely, accurate, and accessible information, while fostering two-way communication through interactive features. Its effectiveness is further evidenced by positive public engagement, including the ability to counter misinformation, enhance awareness, and reduce panic during crises. These findings highlight the strategic function of social media in disaster communication and its contribution to strengthening community preparedness.

Building on the preceding discussion, the utilization of social media as a tool for disaster resilience is further illustrated by cases in the United States during Hurricanes Sandy, Harvey, and Isaac. These events revealed Twitter's effectiveness in emergency communication, the role of crowdsourcing, and the disparities in community access and resilience. Policy recommendations highlight the need for regulatory frameworks, privacy protection, standardization, and stronger collaboration between institutions and communities (Lam et al., 2023). In addition to social media, emerging technologies such as drones play a critical role in facilitating evacuation efforts during disasters. Drones equipped with electronic devices and deep learning–based image classification systems have proven effective in supporting search and rescue operations by detecting victims on land with accuracy rates of up to 99% in both static and dynamic conditions, with optimal performance recorded at a flight altitude of two meters (Hadi et al., 2024).

The integration of advanced technologies into disaster risk management highlights the pivotal role of digital innovation in strengthening both technical operations and community resilience. Artificial intelligence models such as DistilBERT enhance disaster response through real-time data processing (Alharbi & Haq, 2024), while infrared cameras and GPS, exemplified by Petabencana, enable precise situational mapping for faster decision-making (Hadi et al., 2024). Social media platforms also contribute significantly, with Instagram fostering public awareness and preventive action (Gelgel et al., 2023), and the Jakarta Provincial BPBD utilizing X, Facebook, and Instagram to disseminate early flood warnings, reduce panic, and improve inter-agency coordination (Harahap, 2024). Extending these insights, Lam et al. (2023) underscore that social media, as a form of digital innovation,

facilitates real-time communication and community-based coordination, though challenges such as misinformation, unequal access, and digital divides remain. Collectively, these studies demonstrate that the convergence of AI, geospatial technologies, and social media not only enhances disaster communication and decision-making but also acts as a catalyst for strengthening social adaptation, preparedness, and resilience in urban flood risk reduction.

2. Methods

The method used in this research was a literature study of various scientific studies related to flood management strategies. This literature study includes various academic sources, research reports, and documentation from institutions related to disaster mitigation. The main objective of this method is to understand how strategies that have been applied in various contexts can help communities deal with flood disasters, especially in urban areas. One of the main theories used in this analysis is the theory of coping strategies, which focuses on how communities, particularly urban communities, face and cope with the impacts of flood disasters. This approach provides a deeper understanding of how individuals and communities adapt to the pressures and challenges posed by natural disasters. The theory used refers to the concept of coping strategies as proposed by Lazarus & Folkman (1984). According to them, coping is defined as "cognitive and behavioral efforts to manage specific demands (external and/or internal) that are judged to burden or exceed individual resources." In other words, coping is a mechanism that individuals use to deal with difficult situations, including floods, with various strategies that enable them to survive and adapt.

In the context of disaster, coping strategies refer to the ways individuals evaluate, accept, and adjust to negative events such as floods. Through proper evaluation, individuals can turn challenges into more effective adaptations. This allows them not only to survive emergency conditions but also to develop skills that can help in dealing with similar events in the future. According to Maryam (2017), coping strategies are strongly influenced by various factors such as cultural background, individual experience in dealing with problems, environmental factors, personality, self-concept, and social support. These factors play an important role in determining the extent to which a person can face and cope with the stresses that arise from flood disasters.

Table 1. Definition of coping strategies from WCQ (Ways of Coping Questionnaire)

Coping strategy	Definition
Planful problem-solving	"Deliberate problem-focused effort to after the situation"
Escape-avoidance	"Wishful thing and behavioral efforts to escape or avoid"
Accepting responsibility	"Acknowledges one's own role in the problem with a concomitant theme of trying to put thing right"
Positive reappraisal	"Create positive meaning by focusing on personal growth"
Confrontive coping	"Aggressive efforts to alter the situation"
Distancing	"Efforts to detach oneself" and "creating a positive outlook"
Self-controlling	"Regulate one's own feelings and actions"
Seeking social support	"Seek informational support and emotional support"

(Folkman et al., 1986; Stanisławski, 2019)

Cultural backgrounds can influence how communities respond and adapt to disasters. For example, communities that have a tradition of gotong royong tend to be more resilient in the face of disasters due to high social solidarity. In contrast, communities that are more individualistic may rely more on independent coping strategies. Experience in dealing with problems also affects the effectiveness of coping strategies. Individuals or communities that have experienced flooding repeatedly tend to have better preparedness compared to those who have faced a similar disaster for the first time. This experience helps in building a more structured and effective response pattern. Environmental factors, such as geographical conditions and city infrastructure, also determine the coping strategies that people use. For

example, residents living in flood-prone areas may develop adaptation strategies such as building houses on stilts, improving drainage systems, or preparing better evacuation routes. In addition to individual and environmental factors, social support also plays a major role in determining the success of coping strategies. Support from family, neighbors, and the community can help individuals reduce their psychological burden and obtain necessary assistance during and after a disaster. By understanding the various factors that influence coping strategies, communities can be better prepared to deal with flood disasters. Applying the right coping strategies not only increases individual resilience but also strengthens the community's capacity to cope with disaster impacts more effectively and sustainably.

Lazarus & Folkman (1984) distinguish two basic categories of coping, namely problem-focused coping and emotion-focused coping, as responses aimed at "managing or changing problems that cause distress" and "regulating emotional responses to problems" (Stanisławski, 2019). Lazarus & Folkman divide coping strategies into two main categories, namely problem-focused coping mechanisms/direct action and emotion-focused coping strategies/palliative form. Both types of strategies are used by individuals in the face of pressure or challenges, including in disaster situations such as floods, depending on the conditions and resources available.

Problem-focused coping strategies aim to change or overcome the problem at hand. This approach is considered more active because it involves direct efforts to reduce or overcome the impact of the problem. In the context of disaster, this strategy is more effective when individuals have control over the situation they face. Furthermore, problem-focused coping strategies are divided into three categories. First, planful problem solving involves deliberate efforts aimed at changing a situation. Examples include planning for evacuation before flooding occurs, preparing alternative routes, or building infrastructure that is more resistant to flooding. Second, confrontive coping refers to actions taken to actively change circumstances, often involving calculated risk-taking. For example, someone may choose to stay in their home during a flood while strengthening the building and preparing supplies, despite facing high risks. Third, seeking social support involves reaching out to external parties for information, tangible assistance, or emotional support. In a flood situation, individuals can seek help from the community, government, or social institutions to obtain guidance or resources on necessary actions.

On the other hand, emotion-focused coping strategies are used when individuals perceive the situation as difficult to change or control. This approach aims to manage emotional reactions to stress or pressure. Emotion-focused coping strategies include several categories. First, positive reappraisal involves giving a positive interpretation of the situation. For example, a person affected by a flood may view the event as an opportunity to increase vigilance and preparedness in the future. Second, accepting responsibility emphasizes individual accountability for the circumstances. In the context of flooding, individuals aware that their area is prone to disasters may take proactive mitigation efforts, such as building independent drainage systems or avoiding littering. Third, self-controlling entails maintaining self-discipline under disaster-induced pressure by thinking clearly, avoiding panic, and making rational decisions. Finally, distancing and escape-avoidance are strategies that individuals often use when situations are perceived as overwhelming. For example, those traumatized by flooding may choose not to talk about the event or may relocate to safer areas to avoid similar experiences in the future. By understanding these various coping strategies, individuals and communities can be better prepared for flood disasters. A combination of problem- and emotion-focused strategies can help communities manage disaster impacts more effectively and build long-term resilience to flood risk.

3. Results and Discussion

3.1 Government efforts in handling flood disasters

Several flood resilience strategies can be chosen, but it is mostly the government that implements countermeasures. Flood resilience management is one of the chosen strategies

as it focuses on adapting to and recovering from floods rather than simply preventing them. This approach incorporates resilience into a risk management framework that enables more sustainable and adaptive flood control measures (Pandit, 2024). However, collaboration is needed for disaster management, shifting from being solely the responsibility of the government to a governance collaboration that involves relevant stakeholders, including the private sector and communities. This approach will lead to the integration of various expertise to improve flood resilience (Forrest, 2024).

Other flood prevention measures can be implemented in housing by elevating buildings and in open spaces by increasing greenery and small-scale infrastructure, but these solutions are complementary to larger flood protection schemes. Systemic approaches such as flood risk management, which evaluate and implement coordinated actions across stakeholders, are needed (Vanelli et al., 2024). However, what is really needed during a flood is the community life aspect. People will experience impacts due to flooding such as health issues, loss of livelihoods, agriculture, livestock, education, and infrastructure. An example in Pakistan focuses on nutrition for flood victims by involving multiple sectors for post-disaster recovery. Interventions carried out through assistance from the United States Government to Pakistan due to the floods in 2022 included promoting breastfeeding, implementing food fortification, providing micronutrient supplementation, treating severe acute malnutrition, providing nutrition education, and ensuring access to clean water, sanitation, and hygiene facilities to improve food security, enhance nutrition, support the health of vulnerable groups, rehabilitate agriculture and livestock, and provide stress management (Rakha et al., 2025).

The Regional Disaster Management Agency (BPBD) of DKI Jakarta Province has made several efforts to overcome flooding in urban areas (Putri, 2021). The mitigation includes embankment construction to prevent tidal flooding in northern Jakarta, where the provincial government is preparing the NCICD (National Capital Integrated Coastal Development). NCICD is a giant dike that can store water from 13 rivers in the northern part of Jakarta, with priority locations for development including Kamal Muara, Kali Blencong, Kali Adem - Muara Angke, Muara Beach, Sunda Kelapa, and Tanjung Priok. The Jakarta Provincial Government is also preparing infiltration wells (vertical drainage), which are artificial infiltration systems that can collect and absorb water into the ground. In addition, DKI Jakarta Province has pumps located in 178 locations, with 487 stationary pump units with capacities ranging from 4,000 to 5,000 liters per second, which are used to construct and rehabilitate polder pumps. Through the Water Resources Agency, the provincial government is also dealing with flooding with mud raids, a program aimed at increasing the capacity of rivers and reservoirs during the rainy season. The location of the mud raids is mainly in the 13 rivers that drain Jakarta, one of which is the Ciliwung River, as well as lakes and reservoirs. Furthermore, the Guidebook entitled *Community Flood Preparedness*, published in 2020 by BPBD DKI Jakarta, provides information related to evacuation locations, early warning systems, predictions of flood events and impacts, and preparations for necessities to be carried by the community in the event of a flood.

Wu (2025) and Peiris & Osada (2024) converge on the argument that urban flood resilience cannot be attained merely through physical or hard infrastructure development but requires a multidimensional, integrative approach that links spatial planning, adaptive policy, and community engagement. Wu (2025), through case studies in Zhengzhou and Mumbai, demonstrates how rapid urbanization coupled with limited drainage capacity exacerbates flood risks, underscoring the urgency of adopting concepts such as sponge cities and nature-based solutions, including green spaces, wetlands, and permeable surfaces, to restore ecological balance and reduce runoff. Similarly, Peiris & Osada (2024) highlight the vulnerability of cities overly reliant on gray infrastructure and propose a spatial planning framework that assesses resilience across physical, social, economic, and institutional dimensions. Both studies emphasize that flood governance must evolve toward inclusive, data-driven, and long-term planning models that embed nature-based strategies while fostering collaboration among government agencies, private stakeholders, and local communities. The complementarity of these perspectives reveals a common paradigm shift:

sustainable flood management hinges not only on technological and infrastructural innovation but also on robust institutional capacity, multisectoral coordination, and the active participation of communities in shaping resilient urban systems.

In the Indonesian context, these insights find practical resonance in the efforts of BPBD, which provides a dedicated website to facilitate public access to disaster maps, with dibi.bnpb.go.id offering comprehensive disaster statistics such as type, timing, location, and damage levels. This open-access system aligns with the broader call for data-driven flood governance, as emphasized by Wu (2025) and Peiris & Osada (2024), by enabling timely decision-making and fostering transparency. The urgency of integrating such approaches is further reinforced by the recognition that current and future levels of flood impacts demand flood risk management to become a political and policy priority (The World Bank, 2011). Nevertheless, community-based coping mechanisms often remain sporadic and fragmented due to socio-economic disparities, which limit their capacity to serve as holistic solutions (Bappenas, 2021). To bridge this gap, platforms like Petabencana.id illustrate how technological innovation can operationalize participatory disaster governance, functioning not only as a monitoring and reporting tool but also as a communication bridge between communities and authorities. This integration of digital platforms, institutional frameworks, and active citizen engagement exemplifies the multidimensional strategy necessary to strengthen resilience against floods in rapidly urbanizing cities such as Jakarta.

Building on these insights, Jakarta emerges as a critical case where the synthesis of Wu's (2025) and Peiris & Osada's (2024) findings can be operationalized. The city faces a confluence of challenges: rapid urbanization, land subsidence, limited drainage infrastructure, and seasonal hydrometeorological hazards that mirror the vulnerabilities highlighted in Zhengzhou and Mumbai. To address these risks, Jakarta must move beyond reliance on gray infrastructure projects, such as sea walls and drainage expansion, by embedding spatially adaptive planning frameworks that integrate nature-based solutions, including urban green belts, retention basins, and permeable pavements. Equally important is the establishment of strong institutional capacity and inter-agency coordination that ensures inclusivity in decision-making processes while leveraging platforms like Petabencana.id to enhance community-driven resilience. In this regard, Jakarta's flood governance would benefit from adopting a hybrid approach that merges data-driven policymaking, ecological restoration, and active civic participation, thereby positioning the city as a model for sustainable flood management in flood-prone megacities across the Global South.

3.2 Urban community movement in flood disaster prevention

Charisna et al. (2018) concluded that several factors affect the way people survive or employ coping strategies in disaster management, namely physical resilience. Physical health is important because, to overcome stress, individuals are required to expend considerable energy. For example, when a flood occurs and lasts for days, the community is expected to expend substantial energy in implementing disaster management strategies before, during, and after the flood. In the phase before the flood, they renovated houses and raised the front of their homes. During the flood, they moved valuables, staple foods, and clothes to higher ground. In the post-flood phase, they cleaned homes filled with mud and debris caused by the flooding. It can be concluded that physical health is indispensable as a factor in the community's flood disaster management strategy.

The second factor is a positive outlook. Beliefs in destiny that lead individuals to feel helpless can reduce the community's ability to implement disaster management strategies. Some members of the community may view flooding as a recurring problem and become resigned to it. Third, problem-solving skills encompass the ability to seek information, analyze situations, identify problems, generate alternative actions, and evaluate these alternatives in terms of expected outcomes. The community addresses flooding by seeking information from relevant agencies to prevent water from entering homes. Fourth, social skills include the ability to communicate and behave in accordance with prevailing social

values; in stress relief, some community members may focus solely on talking with neighbors rather than addressing the flood directly. Fifth, social support involves fulfilling individuals' informational and emotional needs, provided by parents, family members, relatives, friends, and the surrounding community. For instance, people exchange information to overcome challenges, such as blocking roads with wooden chairs to prevent floodwaters from entering homes. Sixth, material factors influencing coping strategies include resources such as money, goods, or services that can typically be purchased. Communities require these materials when implementing coping strategies, particularly when trapped in flooded houses or facing difficult access; for example, people may order food online.

Petabencana.id exemplifies a community-driven platform that facilitates flood disaster prevention, rapid emergency response, and early flood hazard detection. By utilizing a geographic information system (GIS), community members can geotag flooded locations. In January 2020, DKI Jakarta experienced heavy rainfall, causing severe flooding that inundated much of the city, resulted in dozens of casualties, and forced thousands of residents to evacuate. Petabencana.id saw a 24% increase in activity as active citizens monitored maps to understand flood conditions, avoid flooded areas, and make safety-related decisions. BPBD DKI Jakarta also monitored the maps to respond to residents' needs, coordinate emergency responses, and update information on flood-affected areas in real time (Petabencana, 2020).

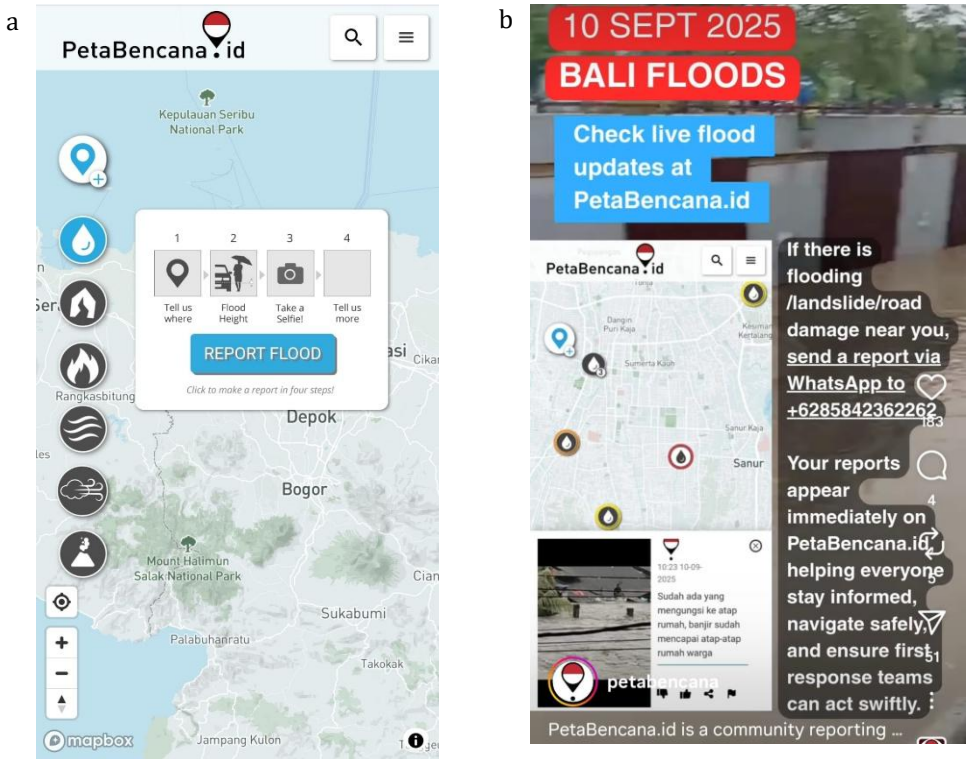

Fig. 3. (a) The Petabencana.id reporting feature; (b) Social media interface (Petabencana.id, 2025)

Figure 3 (a) illustrates the reporting feature of Petabencana.id, which functions as a participatory mechanism enabling community involvement in disaster reporting, while Figure 3 (b) presents its social media interface, designed to disseminate real-time updates and georeferenced disaster alerts that enhance public awareness and support timely response actions. In accordance with the theory put forward by Lazarus & Folkman, Petabencana.id can be seen as one of the community tools for coping strategies (survival strategies) in facing flood disasters, specifically representing a problem-focused coping strategy (a problem-focused form of coping mechanism or direct action).

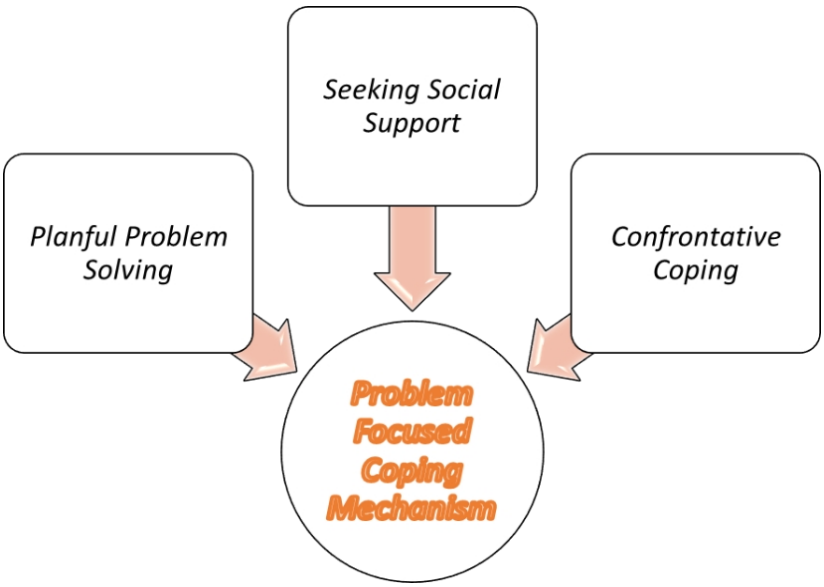

Fig. 4. Coping strategies of urban communities through the Petabencana.id portal in addressing flood disasters

3.2.1 Planful problem solving

Jakarta is the capital city of the country with a high population density. Data from the World Population Review in 2024 indicate that the Greater Jakarta area has a population of more than 30 million with an area of 4,384 square kilometers (1,693 square miles). The population density in the city area is very high, at 14,464 people per square kilometer (37,460 per square mile), while the population density reaches the highest level in the region at 4,383 people per square kilometer (11,353 per square mile). The increasing population density in DKI Jakarta necessitates the government to strengthen risk-based spatial planning, particularly by identifying flood-prone areas and ensuring the development of effective drainage systems throughout the city. A comprehensive flood risk assessment is crucial because it provides a stronger basis for evidence-based decision-making and the formulation of appropriate risk reduction measures. Flooding in Jakarta is not only driven by natural factors such as high rainfall, but is also exacerbated by human-induced pressures including uncontrolled land conversion, inadequate drainage infrastructure, and limited public awareness in maintaining the environment.

In response to these challenges, The World Bank (2016) emphasizes that green infrastructure should not be viewed merely as an alternative to conventional concrete-based infrastructure, but rather as an integrative strategy capable of strengthening urban resilience to flooding while delivering broad socio-ecological benefits. Practices such as the restoration of mangroves, the development of green roofs, and the application of permeable pavements are particularly effective in enhancing water infiltration and retention, improving environmental quality, and supporting community well-being. To maximize these benefits, however, green infrastructure must be supported by inclusive planning, rigorous economic–ecological assessments, and strong collaboration across government sectors, private stakeholders, and local communities.

Possible solutions for urban communities in planning flood preparedness are mapping flood-prone areas. Communities need to recognize areas prone to flooding by conducting mapping independently or in collaboration with related parties. Knowing the vulnerable areas can better plan prevention and evacuation measures. Independent infrastructure improvement. This can include building infiltration wells and biopores to help absorb rainwater, improving the neighborhood drainage system so that it is not clogged with garbage and building simple dikes or water barriers to reduce water overflow. Preparation of an emergency response plan. From disaster preparedness groups at the RT/RW level to coordinate assistance and evacuation. Petabencana.id can provide training on Climate

Ambassadors, which is a mobilizer in a community to support disaster risk reduction efforts. Then determine evacuation routes and safe locations that can be used when flooding occurs, and provide emergency equipment such as rubber boats, flashlights, and emergency communication tools. Community education and training. Climate Ambassadors will conduct socialization on the importance of protecting the environment, such as not littering. In, conduct evacuation and first aid training to increase preparedness and provide education on how to survive floods and minimize health risks due to flooding. Participation in government and private programs. Urban communities are expected to support flood management policies, such as river naturalization and urban greening programs. Also participate in community service to clean waterways on a regular basis. Application of technology and information. That is using weather monitoring applications and flood early warnings for early preparation and utilizing social media and citizen communication groups to disseminate information when flooding occurs. Both activities can be done through the petabencana.id application which provides a clear picture of the location of disasters including floods that often occur in urban areas and densely populated settlements.

Urban flood mitigation requires a multidimensional framework that systematically integrates ecological, technological, and governance dimensions. Liu & Zhang (2025) emphasize the strategic contribution of urban green space interventions in enhancing resilience by improving infiltration capacity, mitigating surface runoff, and sustaining ecological equilibrium within sustainable urban design. In parallel, Hong et al. (2025) introduce the FM-LC framework, a land-cover recognition–based hierarchical model that advances flood mapping by facilitating more rapid, systematic, and precise decision-making processes. Complementing this, Jia et al. (2025) demonstrate the transformative potential of deep learning driven three-dimensional flood mapping, which substantially enhances detection accuracy, spatio-temporal predictive capacity, and visualization of high-risk zones. From a broader regional lens, Manandhar et al. (2023) contend that flood management strategies in South Asia remain overly reliant on conventional structural measures (grey infrastructure), while institutional strengthening, adaptive governance, and community participation are insufficiently prioritized, thereby constraining the consistent adoption of long-term resilience-oriented approaches.

A paradigm shift from conventional infrastructure-based flood management approaches to an integrative model that combines nature-based solutions, digital technology innovations (artificial intelligence-based mapping, deep learning, and spatial data), and inclusive collaborative governance is essential. The combination of cutting-edge technology and an ecosystem approach is considered crucial in increasing urban flood resilience while supporting long-term sustainability. However, the effectiveness of this strategy is highly dependent on institutional readiness, community adaptive capacity, and cross-sector policy consistency. Therefore, this literature contributes to strengthening the conceptual and practical framework for more comprehensive, adaptive, and evidence-based urban flood management, particularly in facing the challenges of climate change and accelerated urbanization.

3.2.2 Confrontative coping

Urbanization in the capital city is inevitable because it has positive impacts such as economic growth and increased employment, as well as negative impacts such as increased population density which raises the risk of flooding due to reduced water catchment areas and uncontrolled land use. Therefore, flooding in the capital city must be addressed with careful planning, which can be undertaken by the urban community itself through various mitigation and preparedness strategies. Forrest (2024) emphasizes that flood risk governance should be oriented towards flood resilience, integrating technical, social, economic, and institutional dimensions rather than relying solely on traditional flood defence approaches focused on physical infrastructure. This perspective is particularly relevant to urban flooding in Jakarta, where vulnerabilities are exacerbated by rapid population growth, uncontrolled land conversion, inadequate drainage systems, and limited

public environmental awareness. Addressing these challenges requires a paradigm shift from infrastructure-centered solutions such as river normalization and levee construction towards collaborative and inclusive governance that strengthens adaptive capacity. Within this framework, the roles of key government agencies, including the Jakarta Water Resources Agency, the Regional Disaster Management Agency (BPBD), and the Environmental Agency, must be integrated with active community participation and national policy support. One way to operationalize this community engagement is through initiatives such as Petabencana.id, which provides disaster preparedness training and promotes the development of Climate Ambassadors. These ambassadors play a vital role in enhancing community resilience by improving knowledge, skills, and capacity to cope with disasters, including floods. As community understanding increases, people are empowered to collectively reduce flood risks and impacts through structured and effective actions. Moreover, such training strengthens early detection capabilities, accelerates disaster response, and supports the development of efficient evacuation strategies while ensuring that vulnerable groups such as the elderly, children, and persons with disabilities remain healthy and safe during emergencies. Together, these governance reforms and community-based initiatives form a comprehensive approach to building long-term urban resilience to flooding in Jakarta.

Nonetheless, there are still risks in dealing with floods, as their conditions and intensity are often difficult to predict. Therefore, individuals who have participated in disaster resilience training should continue to coordinate with the local government, both at the RT, RW, and provincial levels. This collaboration is crucial to ensure the readiness of emergency infrastructure, such as evacuation posts that can be set up immediately when a disaster occurs, as well as the provision of adequate logistics and assistance for flood victims. With strong synergy between the community and the government, flood mitigation efforts in the capital city can become more effective and sustainable.

3.2.3 Seeking social support

Petabencana.id helps people to get social support during disasters, especially floods that often hit urban areas. Through this platform, people can contribute in reporting flood conditions in their neighborhood in real time, enabling rapid and accurate information dissemination. Thus, affected residents and related parties can immediately take the necessary actions to deal with emergency situations. One of the ways Petabencana.id works is by collecting information about locations affected by flooding through social media and various other communication channels. With this data, the community can more easily determine the steps that must be taken, both in emergency planning and in developing more effective long-term policies. In addition, Petabencana.id presents information in the form of location tags and current photos of the condition of flood-affected areas. This data obtained from the community allows for more accurate mapping, thus becoming an important reference for local residents and disaster management teams in making timely and efficient decisions. The information collected by this platform is not only useful for the general public but also becomes a supporting tool for decision makers at the government level. Agencies such as BPBD DKI Jakarta, the Jakarta Provincial Government through Jakarta Smart City, and the Jakarta Public Works and Public Housing Agency can use the data to determine more effective mitigation and response strategies.

The main advantage of Petabencana.id is its ability to present disaster data in real-time. With quick information updates, authorities can immediately prepare emergency measures, such as evacuating residents, distributing logistical assistance, and coordinating with various related parties to minimize the impact of disasters. In this case, the role of the DKI Jakarta provincial government is also very significant. Through disaster data portals such as BNPB's Disaster Data and Information Indonesia (DIBI) and integration with the Petabencana.id platform, the government can access more comprehensive and accurate information in dealing with floods. This is a step forward in realizing a more responsive and data-driven disaster management system. In addition to assisting in mitigation,

Petabencana.id also contributes to educating the public about disaster preparedness. With easy access to disaster information, communities can better understand the patterns and risks of flooding in their area, so they can better prepare themselves. The platform also encourages active community participation in sharing disaster-related information. With direct involvement from citizens, the data collected becomes more valid and represents the real conditions on the ground. This strengthens collaboration between the government and the community in building a more inclusive and effective disaster management system.

Mitrousi et al. (2013) highlight that "*coping is not a stable style but a dynamic and adaptive process, influenced by situational demands and contextual evaluation*". This insight indicates that disaster management strategies, particularly in urban flood contexts such as Jakarta, must avoid relying on rigid and uniform approaches. Instead, they should remain flexible, situational, and inclusive by integrating structural measures, non-structural innovations, and active public participation. Within this framework, the use of digital platforms such as Petabencana.id illustrates how adaptive coping can be supported by technological innovation. As the platform provides real-time flood information, facilitates rapid and targeted decision-making, and strengthens communication between communities and government, it acts not only as a monitoring tool but also as a "*communication bridge"* that enhances resilience-building (Petabencana.id, n.d.). By aligning adaptive coping theory with digital-based disaster governance, Jakarta can strengthen its capacity to reduce flood risks and empower communities to undertake more systematic, data-driven, and context-specific actions.

In addition to the role of digital platforms, global institutions have emphasized the importance of adopting more integrative and adaptive approaches in flood governance. According to The World Bank (2016), green infrastructure should be seen "*not merely as an alternative to conventional concrete infrastructure, but as an integrative strategy to enhance resilience while delivering broad socio-ecological benefits*." In the Jakarta context, this perspective implies that technological tools such as Petabencana.id must be complemented with ecological strategies, including mangrove restoration, permeable pavements, and green roofs, to manage runoff and reduce the cumulative risks of urban flooding. Such integration of digital and ecological measures reflects a multi-layered coping approach, aligning with Mitrousi et al.'s (2013) assertion that coping is a dynamic and situational process, requiring constant reassessment and adaptation.

Furthermore, community-based engagement has been identified as an essential component in strengthening resilience to disasters. Forrest (2024) argues that "*flood risk governance must move beyond infrastructure-centered solutions towards collaborative and inclusive resilience-building*." This resonates with Jakarta's case, where government agencies such as the Jakarta Water Resources Agency and the Regional Disaster Management Agency (BPBD) must work hand-in-hand with communities trained through initiatives like Climate Ambassadors from Petabencana.id. By empowering local residents with the skills to detect early warning signs, design evacuation strategies, and prioritize vulnerable populations, disaster governance becomes both adaptive and participatory. Such a holistic model of coping, where institutional governance, ecological resilience, and digital innovation intersect, offers the most sustainable pathway for Jakarta to address its recurrent flood challenges.

4. Conclusions

Urban communities employ diverse strategies to cope with recurrent flood disasters, particularly in metropolitan areas such as Jakarta. Community resilience in emergency situations depends largely on adaptive capacity, social networks, and the effective use of available resources. The emergence of Petabencana.id represents a significant advancement in disaster mitigation, enabling citizens to share real-time information, coordinate assistance, and access verified updates that enhance preparedness and response. According to Lazarus & Folkman's (1984) coping strategy framework, such community-based initiatives strengthen collective awareness, reduce vulnerability, and foster proactive

actions in disaster management. Beyond its communicative function, Petabencana.id also provides valuable data for government agencies, facilitating evidence-based policy decisions and more targeted allocation of resources. As a digital platform that simultaneously informs, educates, and mobilizes communities, it contributes to a paradigm shift from government dependency toward a collaborative, technology-driven, and community-centered approach, thereby significantly reducing the impact of floods in urban settings.

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Author Contribution
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