



Incorporating complexity of stakeholder roles into socio-spatial flood risk governance: A case in Tangerang City, Indonesia

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Abstract

Flooding is a critical environmental concern exacerbated by rising watershed flood susceptibility linked to population growth and land use changes. The complexities of flood risk management and stakeholder involvement throughout all phases present significant challenges. Despite the participation of multiple stakeholders, flood risk management efforts have yet to yield the intended outcomes. This study aims to propose a flood risk governance framework considering the interdependence among flood susceptibility, community flood resilience, and complex stakeholder roles. Using Soft Systems Methodology (SSM), the study conducted in-depth interviews with key representatives from five stakeholder groups: government, society, academia, business, and mass media. The analytic hierarchy process was employed to identify the most critical criteria for flood resilience based on an assessment of disaster management experts. The study found the importance of implementing collaborative governance as a flood risk management strategy through a forum that involves multiple stakeholders, including community nodes. Collaborative leaders can facilitate this process by addressing differences among forum members and fostering a shared sense of ownership, resulting in effective flood risk management strategies. The study proposed a novel socio-spatial flood risk governance framework emphasizing the spatial aspect of watershed flood susceptibility, the social aspect of community flood resilience, and the role of multi-stakeholders based on interdependence as its primary foundation. The study results will be helpful for local authorities in enhancing the effectiveness of flood risk governance and optimizing resource allocation.

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Introduction

Flooding is becoming increasingly intense due to population growth and land use change (Fekete et al., 2020). As a result, the government has recognized the need to integrate flood risk assessment into spatial planning. However, implementation has encountered regulatory, institutional, funding, and inter-institutional communication problems (Esmaiel et al., 2022). Furthermore, the susceptibility of watersheds to flooding is also affected by human activities aimed at fulfilling social and economic needs. Studies have found that urban land use change increases the susceptibility of river basins to flooding (Santosa et al., 2022). Therefore, flood risk reduction strategies should consider human activities' impacts on watersheds (Rahman et al., 2021). Failure to take action may lead to recurring floods, necessitating the need for communities to build flood resilience at a community level (Fekete et al., 2020), which is influenced by various factors (Haque et al., 2022). Therefore, involving stakeholders in flood risk governance is necessary to mitigate floods, considering watershed flood susceptibility and flood resilience.

Indonesia has implemented Law Number 24/2007 regarding Disaster Management to enhance its disaster risk management efforts. The law created national and local disaster management agencies responsible for disaster preparedness, response, and recovery. The legislation outlines the duties and responsibilities of these agencies and includes provisions for public and community involvement and international humanitarian aid. The Government of Indonesia will develop sustainable arrangements for effective disaster management at all levels through this legal framework (Soetanto et al., 2020). This effort aligns with the mission of The Sendai Framework for Disaster Risk Reduction 2015–2030 to protect lives, health, livelihoods, ecosystems, cultural heritage, and critical infrastructure from natural and human-caused hazards until 2030 (Wahlström, 2015).

The Tangerang City Regional Spatial Plan 2012–2032 designates Periuk District as a City Service Center, emphasizing trade and service functions, medium to high-density housing, and environmentally friendly industries (Kota, 2019). Industries in Periuk District are required to have integrated wastewater treatment plants and employee housing. The construction of a drainage system is prioritized for flood management in Tangerang City; however, due to budget limitations, it has not been fully implemented (Dinas PUPR Kota Tangerang, 2017). Vulnerable areas in Periuk District, including

several housing complexes, face significant flood risks. Additionally, as is typical in Indonesia, flood insurance has not yet become a cultural norm.

Tangerang's city government faces flood risk governance and stakeholder participation issues due to rapid population growth and development caused by Jakarta's nearby development. Meeting residents' needs for improved living conditions has increased flood susceptibility, especially in the Kali Ledug watershed (Santosa et al., 2022). Despite having a City Drainage System Master Plan, Tangerang City still faces recurring flooding issues due to urbanization exceeding the capacity of flood defense infrastructure, with the most severe flooding occurring in 2020. Stakeholders, including the local government, public, and business community, have volunteered to assist during floods. Cross-stakeholder coordination has been established to organize and distribute aid to victims, but stakeholder collaboration is also necessary for mitigation and preparedness, as flood risk management is a continuous cycle.

Due to the complexity of the physical conditions of the river area and the social activities of the people within it, a comprehensive understanding of the causes of flooding is necessary, along with efforts to reduce the risk of flooding. A transdisciplinary approach involving non-academic knowledge in constructing and developing scientific research must be applied to mitigate flood risk effectively (Marchezini, 2020). This approach must consider the complex interdependencies between flood risk management (FRM) components and programs to optimize resource utilization. These efforts should ensure that FRM initiatives reduce flood risks and promote sustainable living in flood-prone areas (Anisah et al., 2022). Reducing flood risk involves numerous factors, including watershed flood susceptibility, community flood resilience, and stakeholder involvement. However, many regions, particularly in developing countries, face limited resources and budgetary constraints, exacerbating the issue of flooding. Although the literature extensively discusses stakeholder collaboration in flood risk governance, there is limited focus on the social-ecological interactions with increasingly flood-susceptible watershed conditions. This study aims to propose a framework for the optimal utilization of collaborative governance, engaging multiple stakeholders in flood risk management while considering the flood susceptibility of the watershed. The framework considers watershed flood susceptibility, community resilience, and the various roles of stakeholders in implementing the principle of interdependence between social and ecological systems.

Literature Review

Countries in the world have agreed to The Sendai Framework for Disaster Risk Reduction 2015–2030, which is a commitment by countries to try as hard as possible to protect lives, health, livelihoods, ecosystems, cultural heritage, and critical infrastructure from natural and human-caused hazards (Wahlström, 2015). Flood risk governance has been implemented in various regions with various approaches (Driessen et al., 2016). Traditional flood risk management employs a top-down approach, prioritizing scientific knowledge and centralized decision-making (Puzyreva et al., 2022). However, incorporating multi-stakeholder involvement is critical to enhancing resilience and preparedness. This participatory approach results in more inclusive and resilient outcomes (Hendricks et al., 2022).

A growing body of literature on flood risk governance elaborates on the importance of stakeholder participation. Recent studies indicate that flood risk governance arrangements are transitioning towards more horizontal forms of governance involving a diverse range of public and private actors (Matczak & Hegger, 2020). Such rearrangements can lead to various benefits, such as time and cost savings, increased revenue, and faster implementation of flood management strategies (Chereni et al., 2020). Effective negotiation and balancing of stakeholders' interests in managing flood risks can be achieved by recommending interactive governance (Nouzari et al., 2022); furthermore, building resilient communities and enhancing flood risk management capability should also be prioritized (Pan et al., 2022). However, the discrepancies between responsibility-sharing expectations and the willingness to reduce individual flood risk highlight the need for further improvements in flood risk governance (Raška et al., 2020). In this context, it is necessary to evaluate the relationships between influential individuals and their immediate contacts in flood risk management settings.

Recent studies highlight the increasing urgency of incorporating community participation into flood risk management strategies (Ardaya et al., 2019; Fekete et al., 2021; Sinthumule a& Mudau, 2019; Tauzer et al., 2019). Participatory governance in flood risk management has been shown to provide stakeholder satisfaction through negotiating and balancing stakeholders' interests, facilitated by transparency in the process (Nouzari et al., 2022). Nevertheless, common constraints on participation are observed in different international settings. It highlights the need to customize participatory approaches to suit particular circumstances and recognize the capabilities

and willingness of stakeholders to engage (Fekete et al., 2021). This context emphasizes the significance of cross-sector collaboration in flood risk management while highlighting power imbalances in the water sector. Collaborative governance frameworks can offer possibilities for successful cross-sector collaboration, but trade-offs may need to occur to guarantee flood safety (Avoyan & Meijerink, 2021). Implementing participatory governance does not guarantee that all stakeholders will become winners (Matczak & Hegger, 2020). In practice, the diversity of roles, interests, and stakeholder engagement results in a condition that requires serious attention from collaborative governance leaders to facilitate the mobilization of actors, manage conflicts, and sustain sufficient shared motivation throughout the process. Additionally, the success of implementing collaborative flood risk management can be influenced by a region's socioeconomic conditions and cultural characteristics, and the generalization of flood risk governance requires further case studies from multiple regions (Avoyan, 2022).

Within the framework of interdependence theory, disaster management is undergoing a paradigm shift. This theory emphasizes the interdependence between social and ecological systems (Buergelt & Paton, 2014; Keating et al., 2017). As a result, disaster management strategies must now consider this interdependence to increase resilience and adaptation (Dade et al., 2022). Applying the principle of interdependence lies in strengthening community capacity for Disaster Risk Reduction (DRR) by considering the close relationship between human welfare and the natural environment (Buergelt & Paton, 2014). However, challenges remain in the form of multi-agency collaborations facing obstacles in communication, resource allocation, and data sharing, all of which are critical to achieving an integrated understanding of the disaster context (Abdeen et al., 2021). Additionally, the complexity and uncertainty inherent in disasters require knowledge-sharing strategies that can be adapted and structured based on understanding social-ecological adaptive capacity (Mariano et al., 2022).

Methodology

Research Model

This study employs a framework that considers the interaction between several components, including watershed flood susceptibility, community flood resilience, multi-stakeholder roles, and collaborative governance, within the context of flood risk management.

The extensive land conversion for settlements, industry, and other socioeconomic purposes has significantly increased the vulnerability of watersheds to flooding. The increased watershed flood susceptibility results in more frequent and intense flooding, causing significant losses for communities in flood-prone areas. Enhancing flood resilience is essential to mitigate these effects, enabling communities to recover swiftly and reduce losses. A practical flood risk governance framework must engage diverse stakeholders, each playing distinct roles in flood management. The key to maximizing the use of both material and non-material resources lies in stakeholder collaboration. Additionally, this governance must account for the interdependence between the social and physical aspects of the watershed. Consequently, a flood risk management approach that fosters collaboration and considers the watershed's social and physical dimensions can significantly enhance community resilience to flooding and minimize its adverse impacts.

Study Area

The study was conducted in the flood-affected area of Periuk Sub-district, Tangerang, Indonesia. Periuk is a suburban area of the national capital undergoing rapid urbanization and development. Topographically, Periuk in Tangerang City is a lowland area with flat to gently sloping morphology, with Kali Ledug as the main river. In Periuk, flooding occurs downstream due to the accumulation of surface runoff from the entire Kali Ledug watershed. Moreover, surface runoff discharge from the upstream and middle areas of the watershed continues to increase temporally due to land conversion to meet socioeconomic needs. Flooding in the study area has occurred since the

late 90s with a frequency that is not too high. Residents call it the five-year flood because, on average, high-intensity floods occur once every five years. However, since 2010, the frequency of flooding has increased. Every high-intensity rainfall causes flooding in the area, with floods occurring on average twice in five years.

Data Collection

Qualitative data were collected through in-depth interviews to understand the flood risk management situation in the study area. Interviews were conducted with key stakeholders from five groups: government (chairs of local authority agencies), community (neighborhood leaders), academia, businesses (companies assisting during floods), and mass media. The number of interviewees from each group was as follows: government ($n = 6$), community ($n = 10$), academia ($n = 3$), businesses ($n = 3$), and mass media ($n = 3$). The selection of key informants considers their positions and three criteria: knowledge of stakeholder roles, institutional representation, and participation in flood management.

The topics discussed with informants included community social capital, the environment, flood emergency response institutions, information and communication, community perceptions of flood events, and community involvement in flood prevention planning, with several questions for each topic. Regarding the topic of identifying people's perceptions of flood events in their area, the following questions, among others, were asked: (1) In your opinion, what causes flooding in this area?; (2) Where does the floodwater come from?; and (3) Is it necessary to trace the contributors to large flood discharges from various sources?

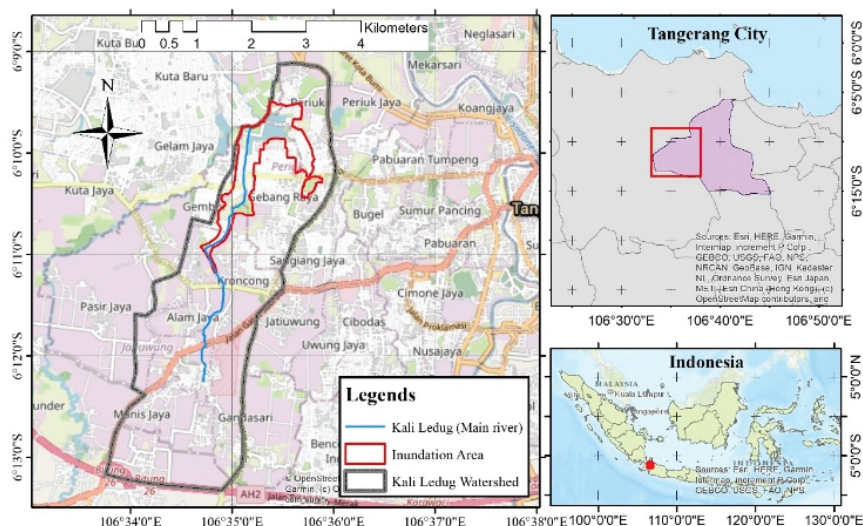


Figure 1 The map of the study area in Tangerang City, Indonesia

For the topic of identifying community participation in planning flood prevention infrastructure, the following questions, among others, were asked: Have you ever proposed building water structures to prevent flooding through local authorities, regional people's representative council members, or other channels?

The in-depth interview data were recorded, transcribed, and coded using open coding to generate codes and axial coding to classify codes into themes or categories. The axial coding process involves hierarchically grouping open codes into a single theme (Naeem et al., 2023). Data needed to provide weight to the factors influencing community flood resilience were obtained by assessing disaster management experts in Indonesia using pairwise comparison based on the Analytical Hierarchy Process (AHP) method. The five disaster management experts involved in this research are experts from Indonesia who are recognized in their field through scientific publications and field practice. Their scientific background covers several areas of expertise, including geography, disaster management, environmental science, disaster psychology, and disaster policy.

Data Analysis

In this study, the methodology applied in data analysis includes the steps within the Soft Systems Methodology (SSM), which aims to systematically formulate and implement actions to improve problematic organizational situations (Checkland & Poulter, 2010). Soft Systems Methodology (SSM) is an action-oriented inquiry process for addressing problematic and complex situations. Users use purposeful action models, each encapsulating a single worldview, as intellectual tools to explore the situation and structure discussions about improving it (Hanafizadeh & Mehrabioun, 2018). Through this organized process, users learn their way from understanding the situation to taking action to improve it (Figure 2).

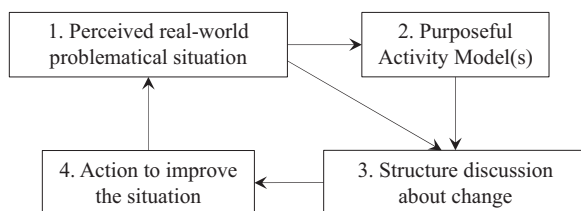


Figure 2 The SSM's process cycle

Source: Adapted from Checkland and Poulter (2010)

In the first stage, perceived real-world problematic situations and complex and uncertain issues are considered problematic (Reynolds & Holwell, 2010). Data were collected through document analysis, interviews, informal discussions, and noting roles, norms, and values (Checkland & Poulter, 2010) to design flood risk management for multiple stakeholders with different roles and interests. Stakeholders involved in flood risk management were categorized into five groups, which have also been applied in other fields: government, community, academia, business, and media (Romero-Rodríguez et al., 2020), and key informants are identified from each group.

SSM is a method that aims to improve organizational situations through systematic steps (Wang et al., 2015). The first step involves three analyses: intervention, social system, and political analysis. A rich picture is created to depict the real-world situation, including structures, processes, relationships, and concerns (Avison et al., 1992). This picture should address two questions regarding resource distribution and monitoring/control in the operational process, as well as function as the basis for the root definition. A root definition describes a problematic human activity system (Checkland 1997) and uses the PQR formula (Performing P using Q to achieve R). The CATWOE tool is used to test the accuracy of the root definition (Basden & Wood-Harper, 2006). The 3E criteria (Efficacy, Efficiency, and Effectiveness) can be used to measure system performance.

The second stage, the purposeful activity model, creates conceptual models using the PQR formula, root definition, and CATWOE tool (Checkland & Tsouvalis, 1997). The models serve as intellectual tools for engaging in discussions, debates, and dialogues about the situation. They would help SSM practitioners and stakeholders engage in discussions about the real-world situation and include Customers, Actors, Transformation, Worldview, Owners, Environment, and 3E criteria (Efficacy, Efficiency, and Effectiveness). In the third stage, structure discussion about change, the conceptual model is compared to real-world situations and involves questioning the validity of depicted activities, who carries them out, and exploring alternatives (Checkland & Poulter, 2010). This process stimulates alternative perspectives and recommendations for flood risk management, including preventive measures, disaster mitigation-based spatial planning, flood control infrastructure, green open spaces, and coordination. All stakeholders, including government, business, academia, media, and the community, can be involved in each phase of flood risk management.

Lastly, in the fourth stage, action to improve the situation, actionable recommendations are formulated based on the discussions and debates held in the previous stage, accommodating the parties' opinions (Checkland & Poulter, 2010). The recommendations should meet the suitability criteria for human activity systems and cultural acceptability. Aspects of change include structure, process, procedure, and attitude. Research discussions involve scholars, while stakeholders are involved in problem-solving applications.

Results

Perceived Real-World Problematical Situation

Land-use change has led to an escalation in flood susceptibility in the study area, and regions with high and very high susceptibility have shown a quasi-linear growth pattern between 2001 and 2020 (Santosa et al., 2022). As the region continues socioeconomic progress, land-use transformation in built-up regions will likely continue. If physical development continues as usual, flood susceptibility will also increase, necessitating adequate flood resilience in the community. Expert judgments were analyzed using the AHP method and showed that risk perception (37.57 percent) and home environment (17.72 percent) were the most dominant criteria, whereas communication and information, institution, social capital, economic, and social criteria had varying weights. Data analysis from interviews with key persons revealed problematic situations in the study area. These situations were structured and subjected to thematic analysis, resulting in identifying the main issues each stakeholder faced (Table 1).

The intervention analysis in the study area identified the parties involved in problematic situations, forming the basis for further social and political analyses. This comprehensive approach enables stakeholders to work together and develop effective flood risk management strategies. Subsequently,

the stakeholder analysis revealed that the government collaborates with various stakeholders to mitigate the impact of floods and enhance community resilience. Established norms govern stakeholder relationships, upholding the values of togetherness, openness, justice, and equality. The government's comprehensive flood mitigation development policy is being prepared, while non-governmental stakeholders remain committed to their values. These findings suggest that effective flood risk management requires collaboration among stakeholders and a commitment to shared values, which a comprehensive and inclusive approach can facilitate.

The political analysis reveals that the Tangerang City Government is responsible for prevention, preparedness, response, and rehabilitation activities in disaster management. In the case of big flood events, it has become customary in the study area to mobilize resources from various stakeholders. Field implementers include local government agencies, district/sub-district offices coordinating logistical assistance and equipment at their respective levels, and neighborhood leaders coordinating community programs. Academic, business, and mass media stakeholders allocate resources to help according to their respective fields of work. The Tangerang City Government has allocated its budget for flood risk management through planning. Social capital within the community promotes mutual cooperation for common goals, while academic, business, and mass media stakeholders possess their work culture, capabilities, knowledge, and resources. In general, multi-stakeholder collaboration has been in the study area, especially during the response and rehabilitation to flood events. However, resource and knowledge sharing has not been intensive because the collaboration is sporadic and not facilitated by any institutional framework. There has been limited collaboration between stakeholders in the prevention and preparedness phases. The city government predominantly leads the planning and implementation of programs, resulting in a lack of resource sharing compared to the response and rehabilitation phases.

Table 1 Key interview results per stakeholder

Stakeholder	Key points
Local Government	Existing flood mitigation programs and a master plan, constraints: poor river flow, land-use changes, waste management, inadequate infrastructure, budget limitations, sectoral conflicts, no permanent institutions in place across all stakeholders for FRM
Community	Existing of strong social cohesion despite the urban diversity, knowing budget problems, flood causes, the urgency of a flood control infrastructure
Business	Emergency humanitarian aid, volunteer dispatch, government rehabilitation efforts, CSR funds (not allocated explicitly for flood mitigation)
Academician	Forming disaster studies programs, research on disaster issues, public service and education, and supporting the government in scientific aspects
Mass media	Delivering disaster information and education, collaboration with the government and academia

The existing conditions of flood risk management in the study area, including the multiple stakeholders involved, their roles, and their interactions, are integrated into a comprehensive representation to facilitate understanding (Figure 3 Rich picture of existing conditions for flood management in Tangerang City). This study employs a rich picture approach, where elements are grouped based on the response process to flood events caused by land conversion. These process groups include development planning, flood prevention and preparedness, emergency response during floods, and rehabilitation actions (Armenakis et al., 2017). The rich picture presents the elements (stakeholders and activities) and their relationships for each process group. In the development planning, prevention, and preparedness process, the city government dominates activities involving academics and the community on a limited scale. In contrast, a multi-stakeholder approach has been implemented during flood events, with collaboration and resource sharing among stakeholders to minimize loss of life and material damage.

In terms of intensity and frequency, the occurrence of floods has been directly impacted by development programs, resulting in changes in land use and an increase in flood susceptibility (Santosa et al., 2022). Despite the government's planned flood defense infrastructure

and non-structural policies for flood prevention, local government-dominated planning and budget limitations have hindered their full implementation. Stakeholders typically become involved only when floods occur, assisting in the response phase. Although coordination and task allocation during this phase have succeeded, there is still room for improvement.

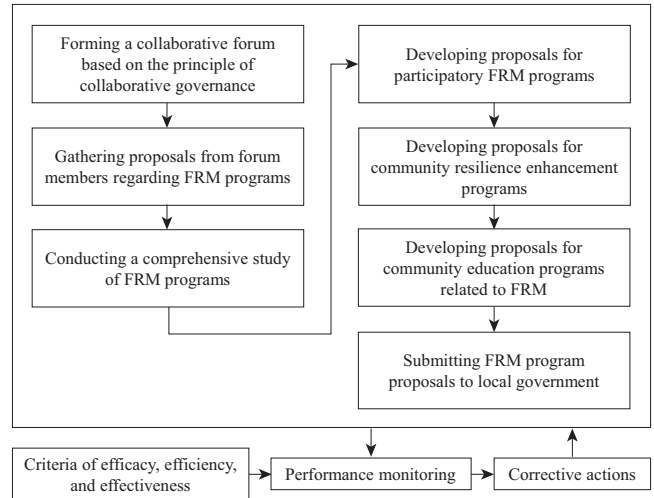


Figure 4 The conceptual model proposed flood risk governance

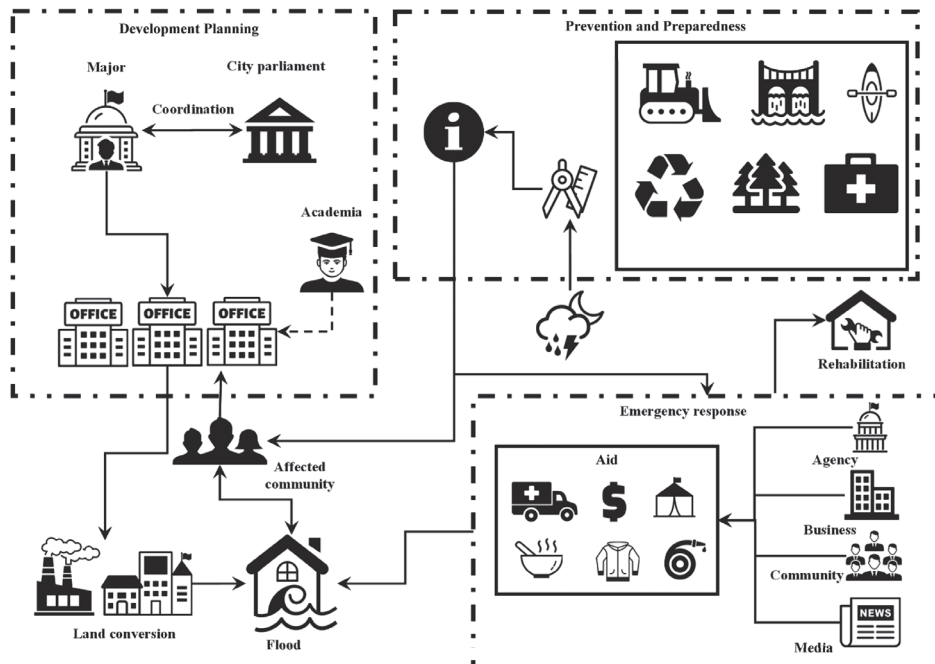


Figure 3 Rich picture of existing conditions for flood management in Tangerang City

Therefore, the root definition in this study is the development of a flood risk management program in the flood-prone area of Periuk District is a governance system owned and operated by the Tangerang City Government (P), applying stakeholder participation and collaboration principles (Q) to achieve flood risk reduction (R). The root definition was then evaluated using CATWOE analysis. The CATWOE framework comprises several components. The flood-affected community is the customer, while multi-stakeholders are the actor(s). Implementing collaborative governance principles is regarded as the transformation, and the development of flood risk management is viewed as the worldview. The Tangerang City Government is the owner of this process. The environment includes the challenges of coordinating and collaborating during flood risk management, particularly in mitigation and preparedness.

This study recognizes stakeholders as active participants in developing flood risk management through participatory and collaborative principles within a governance system (figure 4). A forum should be established to facilitate collaboration among various stakeholders, including communities, NGOs, community organizations, local government, academics/researchers, the private sector, and the mass media. Regular forum meetings will promote alignment of perceptions and build unity. During these discussions, stakeholders should present proposals containing an inventory of flood-related problems, potential solutions, and obstacles faced. Based on these proposals, a comprehensive study of FRM programs should be conducted, encompassing prevention, preparedness, response, and rehabilitation phases. This study should involve consultants and academics/researchers to analyze flood risk data scientifically. These findings should then be integrated with community and stakeholder knowledge. The study results should be categorized into proposals that promote stakeholder

participation in FRM, programs enhancing community resilience to floods, and initiatives for community education about FRM. These proposals should then be submitted to the Tangerang City government through the appropriate mechanisms.

However, managing stakeholders with diverse perceptions and backgrounds can pose a significant challenge (Amis et al., 2020). The collaborative governance theory promotes dialogue, trust-building, and commitment to reach agreements to address this challenge, making it a suitable approach (Ansell & Gash, 2008). Stakeholder governance can provide a platform with an agreed-upon leader to bring together multiple stakeholders and gather proposals from all members for developing a collaborative flood risk management strategy (Mahajan et al., 2022). The focus on flood mitigation, which local governments initially undertook, has evolved into a collaborative effort that leverages the knowledge of various stakeholders. Academic stakeholders, such as scientists, can contribute their knowledge on the scientific aspects of floods as a subject of discussion with other forum members from diverse backgrounds. The primary objective is to attain a consensus among members by exchanging knowledge and information (Pasquier et al., 2020).

Structure Discussion about Change

After comparing the steps in the conceptual model with the collected data, necessary actions and corresponding actors are identified through a comparative analysis between the model and real-world scenarios. However, the study reveals that the proposed principle of collaborative governance has not been adequately implemented based on the steps outlined in the conceptual model. As a result, the study recommends implementing several actions to address this issue (Table 2).

Table 2 Comparison between Conceptual Model and Real-world

Nr	Conceptual Model	Real World	How and Who
1	Forming collaborative forum	The current procedure is an informal forum	Local authorities establish a stakeholder forum
2	Gathering proposals from members	Insufficient public consideration	The forum leader facilitates stakeholder FRM proposals
3	Conducting comprehensive study	The study lacked community involvement	All stakeholders contribute to the study (facilitated by government/academia)
4	Developing participatory FRM proposals	The relevant agencies prepare program proposals	Stakeholders can co-prepare proposals with government facilitation
5	Proposing community resilience programs	The relevant agencies prepare program proposals	Stakeholders can co-prepare proposals with government facilitation
6	Developing education proposals for the community	The relevant agencies prepare program proposals	Stakeholders can co-prepare proposals with government facilitation

The Desired Model Change and Action to Improve

At this stage, it is recognized that to achieve changes in flood risk management, establishing a forum with solid leadership is essential (Table 3). Collaborative flood risk management involves stakeholders in decision-making and aiming for consensus, along with formal forum management as a crucial criterion of collaborative governance. Effective flood risk management programs require involving stakeholders with experience in flood education and mitigation activities, emergency response programs, and post-flood rehabilitation efforts. Furthermore, comprehensive education on flood risk management plans should be provided to communities directly affected by floods to shape attitudes and behaviors that support achieving goals. Strong social cohesion within flood-affected communities can serve as social capital to achieve common goals, including flood risk management. Additionally, forum leaders can provide sufficient capital to affected communities, strive to mitigate inequalities, and guide transparent deliberations for legitimate outcomes. Collaborative forums provide a platform for all stakeholders to contribute their knowledge and resources to develop effective flood risk management plans.

Discussion

Efforts to reduce flood risk must involve all stakeholders with diverse roles and interests and not rely on the government as the sole responsible entity. It can be achieved by engaging all potential stakeholders to contribute knowledge and other resources to the flood risk management framework. This result is consistent with Matczak & Hegger (2020), who found that flood risk governance arrangements are gradually shifting towards more horizontal forms of governance, with a more diverse range of public and private actors involved. The city government can act as a facilitator in flood risk management planning by optimizing the use of resources

to be effective and facilitating the various stakeholder interests (Chereni et al., 2020; Nouzari et al., 2022).

This study highlights the crucial role of collaborative leadership in bridging differences among forum members, such as varying levels of trust, awareness, motivation, resource ownership, openness, and willingness to participate. Collaborative leaders should foster a shared sense of ownership and connect different interests to address these challenges. This finding is consistent with previous research (Fekete et al., 2021), which found that several communities are reluctant to participate in collaborative efforts due to various barriers, including a lack of awareness and motivation. Therefore, sustaining motivation and promoting dynamic stakeholder interaction is crucial for successful collaboration (Avoyan, 2022). If all stakeholders understand the benefits of a collaborative forum in flood risk management, their motivation to participate can be enhanced, as demonstrated by Ardaya et al. (2019) and Sinthumule and Mudau (2019).

Flood risk management strategies can be effectively disseminated within the community by incorporating community nodes and institutionalized collaborative governance. This collaboration will serve as input for more comprehensive planning, creating a platform for stakeholders to share their knowledge and expertise. Additionally, this dynamic interaction among stakeholders in the forum will bridge the gap between the science-policy-practice continuum. The resulting operational science-based flood risk governance will be a product of the collective effort of the community and stakeholders, creating a more inclusive and effective decision-making process. The findings of this study support the conclusions drawn by Ardaya et al. (2019) and Sinthumule & Mudau (2019) that community knowledge must be considered in developing flood risk management plans. Creating reliable, quantifiable, and user-friendly material for collaborative decision-making and comparison is essential. The combination of local community knowledge and technocratic solutions from government and academics can be jointly designed in a collaborative forum. This integrated approach will lead to

Table 3 The desired changes and possible actions

Change	Logically desirable	Culturally appropriate	Possible Action
Implementing collaborative governance involving multi-stakeholders fosters collaboration, knowledge sharing, and resource utilization	Yes. Stakeholders can assist in implementing the proposed changes	Yes. Indonesian cultural norms support collaborative decision-making and openness to proposed changes	A multi-stakeholder forum in the Kali Ledug watershed implements collaborative governance for flood risk mitigation
Strengthen forum leadership for effective flood risk governance	Yes. Strong leadership can manage differences and reach agreements	Yes. Indonesia has practiced a citizen-based electoral system for decades	Choosing diverse forum leaders is crucial for achieving consensus on flood management efforts

a sustainable solution, reinforcing the conclusions reached by Tauzer et al. (2019). Incorporating community knowledge and designing flood risk management plans collaboratively ensures an effective and sustainable solution that integrates technocratic solutions and meets community needs.

This study has developed a framework for governing flood risk management that considers watershed flood susceptibility, community resilience, and the various roles of stakeholders in implementing the principle of interdependence between social and ecological systems (Buergelt & Paton, 2014; Keating et al., 2017). The framework also emphasizes collaboration and participation to leverage all available resources and to maximize the relationships between flood susceptibility and stakeholder roles, flood susceptibility and flood resilience, and between stakeholder roles and flood resilience. Flood susceptibility can be reduced by implementing a land-use change prevention program while encouraging stakeholder participation and collaboration. Building flood resilience by improving the perception of flood risk can prevent land conversion while dealing with floods due to high flood susceptibility, which can shape perceptions and increase resilience. Programs designed to improve perception and living environments can increase flood resilience scores and the role of stakeholders in flood risk management.

Therefore, as social components, stakeholder participation, collaboration, and flood resilience programs can help mitigate watershed flood vulnerability as an ecological component and increase overall flood resilience

(Figure 5). By incorporating social dimensions in measuring community resilience and designing a flood risk governance model grounded in the spatial evaluation of flood susceptibility, a socio-spatial flood risk management framework has been established, with interdependence as its primary principle.

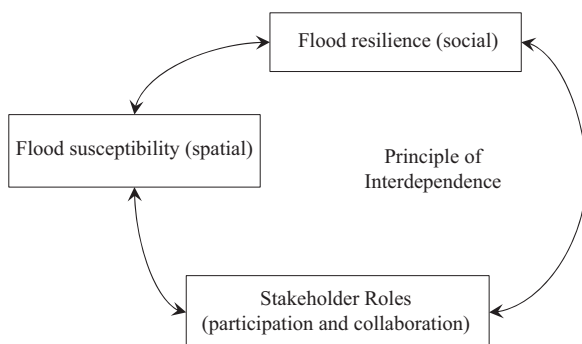


Figure 5 Framework of socio-spatial flood risk governance

Conclusion and Recommendation

This study examined a framework for developing flood risk governance considering watershed flood susceptibility, community flood resilience, and complex stakeholder roles. The study found the need to implement collaborative governance as a flood risk management strategy through a collaborative forum that involves multiple stakeholders. It is crucial to engage all stakeholders in the flood risk management framework to contribute their knowledge and resources, with collaborative leaders playing a crucial role in addressing differences among forum members by fostering a shared sense of ownership and connecting different interests. Effective flood risk management strategies can be disseminated within the community by incorporating community nodes and collaborative governance. This inclusive decision-making process can bridge the science-policy-practice gap and create operational science-based flood risk governance. The interdisciplinary framework for flood risk management developed in this study leverages resources and maximizes relationships between flood susceptibility, flood resilience, and stakeholder roles, enhancing the effectiveness of flood risk management strategies.

As literacy on flood risk management and social bonds within communities play a crucial role in flood risk governance, stakeholders need support for improvement programs in both aspects. Effective programs can be achieved through stakeholder engagement with comprehensive flood education, including mitigation, emergency response, and post-flood rehabilitation efforts. Strong social cohesion within these communities can serve as social capital, and forum leaders can provide resources, mitigate inequalities, and guide transparent deliberations to achieve legitimate outcomes. Local authorities (e.g., the Mayor's Office, the City Disaster Management Office, and the City Development Planning Office) could use this research to coordinate multi-stakeholder participation in spatial planning to reduce watershed flood susceptibility. Furthermore, integrating community flood resilience programs into the flood risk governance framework can enhance effectiveness and optimize resource utilization. However, this study's applicability is limited to flat areas with routine flood problems and high involvement from local governments and stakeholders. Therefore, further research is necessary to involve a more significant number of stakeholder groups in flood-prone areas with different characteristics. Areas with low social cohesion among their citizens,

low public awareness, and inadequate collaboration between local government and stakeholders are very suitable for further research. These areas should face more severe problems in flood preparedness and response, requiring comprehensive studies to address them effectively.

Conflicts of Interest

The authors confirm no conflicts of interest or significant financial support that could have influenced the outcome of this work.

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