

COMPLEXITY-BASED DISASTER GOVERNANCE: MULTI-ACTOR COORDINATION IN FLOOD RESILIENCE BUILDING IN MAKASSAR

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Abstract: This study examines flood disaster management through the lens of Complexity Theory to understand multi-actor coordination dynamics in building urban resilience. Using a qualitative case study approach with in-depth interviews, observation, and document analysis, the research investigates five key dimensions of complex adaptive systems: actor interactions, policy processes, decision-making patterns, power distribution, and information/value systems. Findings reveal a governance system characterized by fundamental contradictions between formal institutional structures and adaptive requirements for managing complex urban disasters. While community-level actors demonstrate emergent self-organization and rapid adaptive responses, formal institutions remain constrained by bureaucratic rigidity, sectoral fragmentation, and hierarchical control mechanisms. The policy process lacks iterative learning cycles, with evaluations functioning as administrative requirements rather than genuine learning mechanisms. Decision-making remains centralized despite the need for distributed authority during emergencies, creating critical response delays. Power asymmetries marginalize community knowledge while informal political networks disproportionately influence policy directions. Information systems suffer from fragmentation and trust deficits, with communities relying more on informal networks than official channels. The study demonstrates that effective flood governance requires transformation from command-and-control approaches toward collaborative networks that recognize distributed intelligence, enable polycentric decision-making, and integrate diverse knowledge systems. These findings contribute to complexity applications in public administration by revealing how theoretical principles manifest in specific governance contexts while highlighting the critical importance of aligning institutional designs with inherent complexity of contemporary urban challenges.

Keywords: Complex adaptive systems, disaster governance, multi-actor coordination, urban resilience, adaptive management

INTRODUCTION

Urban flooding represents one of the most pervasive and complex challenges facing rapidly developing cities in Southeast Asia, where the convergence of climate change impacts, urbanization pressures, and governance capacity constraints creates compounding vulnerabilities (Tierolf, L et al 2021). The increasing frequency and intensity of flood events in coastal metropolitan areas have necessitated a fundamental shift from traditional hazard-focused approaches toward more adaptive and integrated disaster governance frameworks that recognize the inherent complexity of urban socio-ecological systems (Winter & Karvonen, 2022). Recent studies have demonstrated that flood resilience in Asian megacities cannot be achieved through technical interventions alone but requires sophisticated coordination mechanisms that engage multiple actors across different scales and sectors (Marpaung et al 2025; Dwirahmadi et al 2019).

The city of Makassar, as Eastern Indonesia's primary economic hub and home to over 1.5 million residents, exemplifies the intricate challenges of flood management in rapidly urbanizing coastal contexts where traditional governance structures struggle to address the non-linear dynamics of disaster risk (Handam, 2025; Abdillah et al 2025). Despite its moderate national disaster risk index, Makassar experiences recurrent flooding that affects thousands of residents annually, with particularly severe impacts on informal settlements and peripheral urban areas where vulnerability intersects with exposure in complex patterns (Yahya et al 2025; Ariyaningsih et al 2023). The city's flood challenges are not merely technical or infrastructural but emerge from the complex interplay of rapid land-use changes, inadequate drainage capacity, institutional fragmentation, and limited cross-sector coordination mechanisms (Rusnaedy et al., 2021).

Table 1. Flood Impact and Response Patterns in Makassar (2020-2024)

Year	Number of Flood Events	Affected Population	Displaced Persons	Most Affected Districts	Response Coordination Actors
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2020	12	15,432	2,876	Manggala, Biringkanaya	BPBD, Military, Local Gov
2021	8	11,205	1,654	Tamalate, Manggala	BPBD, NGOs, Community Groups
2022	15	18,967	3,421	Biringkanaya, Rappocini	BPBD, Red Cross, Private Sector
2023	11	21,543	1,869	Manggala, Panakkukang	Multi-agency Task Force
2024*	7	9,876	1,234	Biringkanaya, Tallo	Integrated Command Center

Complexity theory offers a particularly valuable lens for understanding flood governance challenges in urban contexts where multiple interdependent systems interact in unpredictable ways, producing emergent properties that cannot be reduced to simple cause-effect relationships (Zhang et al., 2025; Abujder Ochoa et al 2025). In disaster governance contexts, complexity manifests through the dynamic interactions among governmental agencies, civil society organizations, private sector actors, and affected communities, each operating with different logics, timeframes, and resource constraints (Stewart, 2004). The non-linear nature of these interactions means that small changes in one part of the system can cascade through networks to produce disproportionate effects elsewhere, challenging conventional command-and-control approaches to disaster management (Bajpai & Sameer 2025).

The evolution of flood governance in Makassar reflects broader shifts in disaster management paradigms, moving from reactive emergency response toward more proactive risk reduction strategies that emphasize resilience building and adaptive capacity (Malik et al 2021). However, this transition remains incomplete and contested, as evidenced by the persistence of technocratic approaches that prioritize infrastructure solutions while underutilizing the potential of community-based adaptation strategies and local knowledge systems (Bhanye, 2025). The establishment of the Regional Disaster Management Agency (BPBD) represented an important institutional innovation, yet coordination challenges persist across horizontal boundaries between sectoral agencies and vertical linkages between administrative levels (Pangalima et al 2025).

Multi-actor coordination emerges as a critical determinant of effective flood governance, particularly in complex urban systems where authority is distributed across multiple organizations with overlapping jurisdictions and sometimes conflicting mandates (Ziga-Abortta et al 2025). Research on collaborative disaster governance has demonstrated that successful coordination requires not only formal institutional mechanisms but also informal networks, trust relationships, and shared cognitive frameworks that enable collective sensemaking and joint action during crisis situations (Coleman 2012). The challenge lies in creating governance arrangements that can accommodate both the stability needed for effective planning and the flexibility required for adaptive response to unexpected events (Craig et al 2017).

The political ecology of flood risk in Makassar further complicates governance efforts, as vulnerability patterns reflect deeper inequalities in access to resources, political representation, and risk mitigation infrastructure (Ismayanti & Aljurida 2023). Informal settlements along riverbanks and coastal areas face disproportionate flood impacts due to their precarious tenure status, limited access to formal drainage systems, and exclusion from official disaster planning processes (Tavares et al 2024). These communities have developed sophisticated local adaptation strategies and early warning systems through religious networks and social media platforms, yet these grassroots initiatives remain poorly integrated with formal disaster governance structures (Westoby,et al., 2021).

Despite the growing body of research on urban flood governance in Southeast Asian cities, significant gaps remain in understanding how complexity-informed approaches can enhance multi-actor coordination for building flood resilience. While Yani et al (2023) provide valuable insights into the cascading impacts of floods in Makassar's informal settlements, their analysis focuses primarily on vulnerability assessment rather than governance dynamics and coordination mechanisms. Similarly, Ulum & Chaijaroenwatana, (2013) examine adaptive governance for flood mitigation in Bojonegoro but concentrate on formal institutional arrangements without adequately addressing the role of informal networks and emergent coordination patterns that characterize complex disaster governance systems. This study aims to address these gaps by applying complexity theory to analyze multi-actor coordination mechanisms in Makassar's flood governance system, examining how different actors interact, adapt, and collaborate across scales to build urban flood resilience in the face of increasing uncertainty and systemic complexity

METHODOLOGY

This study employed a qualitative case study design to examine the complexity of flood disaster management systems in Makassar through the lens of complexity theory. Data collection was conducted from April to June 2025 using purposive sampling to identify nine key informant categories representing different actors in the flood governance system: Regional Disaster Management Agency (BPBD), Regional Development Planning Agency (BAPPEDA), Public Works and Spatial Planning Department, Environmental Agency, Health

Department, humanitarian volunteer communities, media representatives, Regional House of Representatives members, and affected community residents. Primary data were gathered through semi-structured in-depth interviews with informants (n=9), direct observation of flood-prone areas and government coordination mechanisms, and participatory observation during emergency response activities. Secondary data were obtained through systematic document analysis of disaster management policies, flood incident reports from the Si-Andalan Provincial Disaster Database (2020-2025), spatial planning documents, and inter-agency coordination protocols. The data analysis followed Miles and Huberman's interactive model, involving iterative cycles of data collection, data reduction, data display, and conclusion drawing/verification. To ensure research rigor, multiple validation strategies were employed: triangulation across data sources (comparing government documents with community perspectives), member checking with key informants to verify interpretations, rich thick descriptions of coordination processes and governance dynamics, and reflexive documentation of researcher positionality. Reliability was enhanced through systematic transcript checking, maintenance of coding consistency using a detailed codebook, and cross-checking of analytical interpretations between research team members. The complexity theory framework guided the analysis by focusing on five key dimensions: non-linearity in cause-effect relationships, emergent properties of multi-actor interactions, adaptive capacity of governance systems, feedback loops in coordination mechanisms, and self-organization patterns during crisis response.

RESULTS AND DISCUSSION

Actors in the Flood Management System

The flood management system in Makassar demonstrates a fragmented multi-actor network characterized by weak horizontal coordination and persistent institutional silos. Government agencies operate within sectoral boundaries, with the Regional Disaster Management Agency (BPBD) often working in isolation during flood events while other technical agencies such as Public Works (PUPR) and Environmental Services only engage reactively after disasters occur. This sectoral fragmentation prevents the formation of permanent collaborative structures necessary for adaptive responses to flood risks. The absence of integrated planning mechanisms means that infrastructure projects implemented by PUPR frequently conflict with spatial planning decisions by other departments, resulting in drainage systems becoming ineffective shortly after construction due to uncoordinated residential development approvals.

Community actors and local media demonstrate significantly higher adaptive capacity and rapid response capabilities compared to formal institutions, yet remain marginalized from official decision-making processes. Community-based disaster preparedness groups possess detailed local knowledge about flood-prone areas and have developed autonomous Standard Operating Procedures based on experiential learning, enabling them to mobilize resources before official assistance arrives. Local media platforms effectively disseminate real-time flood information through social networks, often reaching affected populations faster than government channels. However, these informal actors lack formal recognition and integration into policy formulation processes, being treated merely as data sources rather than legitimate policy partners with valuable contextual expertise.

The actor network exhibits characteristics of complex adaptive systems as described by Eppel (2017), where interdependence among actors should generate emergent behaviors and collective learning capabilities. The research findings reveal that while spontaneous self-organization occurs at the community level during flood events, the formal governance system fails to capitalize on these emergent properties due to rigid hierarchical structures and limited mechanisms for cross-sector collaboration. The disconnect between formal institutions' procedural rigidity and informal actors' adaptive flexibility creates a dual-track system where community resilience operates independently from official disaster management frameworks. To enhance system adaptivity, establishing permanent multi-stakeholder platforms that institutionalize informal actor participation while maintaining flexibility for emergent responses is essential, as demonstrated by successful collaborative governance models in disaster-prone cities (Reypens et al 2021).

2. Policy Process Dynamics

The policy process in Makassar's flood management system remains predominantly linear and bureaucratic, lacking the iterative learning cycle's essential for adaptive governance. Evaluation mechanisms function as administrative requirements rather than genuine learning processes, with post-disaster assessments rarely translating into substantive policy adjustments or preventive strategies. Annual flood evaluations consistently produce similar recommendations focusing on technical infrastructure solutions such as drainage improvements and embankment construction, without addressing underlying systemic issues including uncontrolled land-use changes and inadequate spatial planning enforcement. This repetitive cycle indicates an absence of institutional learning mechanisms that would enable the system to evolve based on accumulated experience and changing environmental conditions.

Information flows between policy stages suffer from significant delays and disconnections, preventing real-time adaptation to emerging flood patterns. Technical departments report receiving outdated or incomplete data about new flood-prone areas, while coordination meetings occur sporadically without systematic follow-up or implementation monitoring. The policy process becomes further complicated by political interventions that

override technical assessments, with program changes often driven by elite political pressures rather than evidence-based evaluations. This politicization of the policy process undermines efforts to establish consistent, long-term flood mitigation strategies grounded in empirical data and community needs.

Table 2. Policy Process Characteristics in Makassar Flood Management

Policy Stage	Current Practice	Adaptive System Requirements	Gap Analysis
Planning	Annual budget-driven, sectoral	Integrated, risk-based, participatory	Lack of cross-sector integration
Implementation	Project-based, fragmented	Coordinated, flexible, responsive	Rigid procedures, slow adaptation
Evaluation	Post-disaster, administrative	Continuous learning, feedback loops	No systematic policy learning
Revision	Political influence, ad-hoc	Evidence-based, iterative	Weak link between evaluation and planning
Communication	Top-down, formal channels	Multi-directional, inclusive	Limited community participation

The policy process patterns align with Eppel's (2017) observation that complex systems require continuous feedback loops and iterative adaptation rather than linear progression through predetermined stages. The findings demonstrate that while community organizations exhibit strong learning capabilities through regular revision of emergency procedures based on flood experiences, formal policy mechanisms remain trapped in procedural routines that inhibit systemic learning. The absence of structured reflection processes and limited integration of diverse knowledge sources prevents the emergence of innovative solutions that could address the multifaceted nature of urban flooding. Implementing adaptive management frameworks with embedded learning mechanisms and regular policy experiments would enable more responsive governance, as evidenced by successful applications in other Southeast Asian cities facing similar challenges (Butler et al., 2016).

3. Decision-Making Patterns

Decision-making in Makassar's flood management system remains highly centralized and hierarchical, with field-level actors dependent on formal authorization from senior officials before taking action. This vertical command structure creates critical delays during flood emergencies, as technical staff and district-level officials must wait for official instructions even when immediate responses are clearly needed. The bureaucratic decision-making process prioritizes procedural compliance over situational responsiveness, with budget regulations and administrative protocols constraining the ability of frontline agencies to deploy resources quickly during crisis situations. This centralized control mechanism contradicts the distributed decision-making requirements of complex adaptive systems, where multiple decision points should operate simultaneously to enable rapid responses to dynamic conditions.

Community actors demonstrate contrasting decision-making patterns characterized by autonomous action and horizontal coordination. Local disaster preparedness groups activate response protocols immediately upon receiving flood warnings through informal networks, without waiting for government directives. These groups make rapid decisions based on collective experience and real-time information sharing through WhatsApp groups and community networks, enabling faster evacuation and resource mobilization than official channels. The stark difference between formal institutions' procedural delays and communities' adaptive responses highlights the existence of parallel decision-making systems operating at different speeds and effectiveness levels.

Table 3. Decision-Making Characteristics across Actor Types

Actor Category	Decision Speed	Authority Source	Information Basis	Coordination Method
Government Agencies	Slow (24-48 hours)	Hierarchical approval	Official reports	Formal meetings
BPBD	Moderate (6-12 hours)	Emergency protocols	Mixed sources	Command center
Communities	Fast (1-3 hours)	Collective consensus	Local knowledge	Social networks
NGOs/Volunteers	Fast (2-4 hours)	Internal SOPs	Field observation	Direct communication
Media	Immediate	Editorial discretion	Multiple sources	Digital platforms

The decision-making dynamics reflect Eppel's (2017) concept of emergent decision-making in complex systems, where effective responses arise from distributed authority and collaborative processes rather than centralized control. The research reveals that while emergent decision-making occurs naturally at the community level through self-organization and mutual aid networks, formal governance structures inhibit such emergence through rigid hierarchical controls and risk-averse bureaucratic cultures. The system's inability to delegate decision authority to operational levels during emergencies reduces overall adaptive capacity and delays critical interventions. Developing polycentric governance arrangements with clearly defined subsidiary decision rights would enhance system responsiveness while maintaining accountability, following successful models implemented in resilient cities worldwide (Yadav et al 2024).

4. Power Distribution

Power dynamics within Makassar's flood management system reveal significant asymmetries between formal authority structures and actual influence patterns. While government agencies hold official decision-making authority and control over resources, their power remains constrained by bureaucratic procedures and political dependencies that limit autonomous action. Department heads require approval from city leadership for most substantive decisions, creating bottlenecks that concentrate power at the apex while leaving technical departments with limited operational flexibility. This concentration of formal power paradoxically weakens the system's overall capacity to respond effectively to flood challenges, as centralized control points become overwhelmed during crisis situations requiring multiple simultaneous decisions.

Informal power networks operating through political connections and business relationships often exert greater influence on flood management policies than technical assessments or community needs. Private developers with direct access to political elites successfully influence spatial planning decisions and infrastructure priorities, sometimes overriding technical recommendations from environmental and public works departments. These informal power channels enable certain actors to shape policy agendas despite lacking formal authority or technical expertise in flood management. The existence of parallel power structures creates policy inconsistencies and undermines evidence-based planning, as decisions reflect political negotiations rather than systematic risk assessments or community vulnerabilities.

Power distribution patterns demonstrate the complex interplay between formal authority and relational influence described in Eppel's (2017) analysis of power in adaptive systems. The research findings indicate that despite formal hierarchical structures, actual power flows through multiple channels including social networks, resource control, and information access, creating a polycentric but unequal power landscape. Communities possessing critical local knowledge and rapid mobilization capabilities remain excluded from formal decision forums, representing a significant loss of distributed intelligence that could enhance system adaptivity. The mismatch between formal authority structures and actual influence patterns generates governance inefficiencies and legitimacy deficits that weaken collective flood response capabilities. Establishing inclusive governance mechanisms that recognize and integrate diverse sources of power and knowledge would create more balanced and effective disaster governance, as demonstrated by participatory disaster risk reduction approaches in comparable urban contexts (Behnassi et al 2021).

5. Information and Values Systems

Information distribution within Makassar's flood management system exhibits severe fragmentation and asymmetry, with critical data flowing slowly through bureaucratic channels while communities rely on informal networks for timely updates. Government agencies operate with separate databases and reporting systems, lacking integrated platforms for real-time information sharing across departments. This institutional information silo effect means that crucial flood risk data, including new inundation points and drainage capacity changes, often fails to reach relevant agencies in time for preventive action. The absence of standardized information protocols and interoperable systems creates knowledge gaps that compromise coordinated responses and evidence-based decision-making during flood events.

Trust deficits between government information sources and community reception further complicate risk communication effectiveness. Communities consistently express greater confidence in information received through neighborhood WhatsApp groups and local networks than official government announcements, viewing formal channels as slow, inconsistent, and disconnected from ground realities. This trust gap reflects deeper value misalignments between technocratic approaches prioritizing procedural compliance and community values emphasizing rapid, practical responses based on lived experience. The credibility crisis in official information channels undermines government efforts to coordinate public responses during flood emergencies, as communities develop autonomous information systems that may conflict with official directives.

The information and values dynamics exemplify Eppel's (2017) assertion that information in complex systems is never neutral but always interpreted through diverse value frameworks and social contexts. The research reveals that information effectiveness depends not merely on technical accuracy but on alignment with recipient values, trust relationships, and communication modalities that resonate with local contexts. The parallel information systems operating through formal and informal channels represent competing knowledge paradigms that fragment rather than strengthen collective flood response capabilities. The failure to bridge these information divides perpetuates coordination failures and reduces the system's capacity to mobilize

unified responses to flood threats. Developing participatory information systems that integrate official data with community knowledge while building trust through transparent, two-way communication would enhance collective sensemaking capabilities, as successfully demonstrated in community-based disaster information systems across Southeast Asia (Urquhart et al 2025).

CONCLUSION

The investigation of flood disaster management in Makassar through the lens of Complexity Theory reveals a governance system characterized by fundamental contradictions between its formal institutional architecture and the adaptive requirements of complex urban disasters. The analysis across five key dimensions—actors, policy processes, decision-making, power distribution, and information systems—demonstrates that while the flood management system exhibits some characteristics of complex adaptive systems, particularly through emergent behaviors at the community level and distributed responses during crisis situations, these adaptive properties remain constrained by rigid bureaucratic structures, sectoral fragmentation, and hierarchical control mechanisms that inhibit systemic learning and evolution. The persistence of linear policy processes without feedback loops, centralized decision-making that delays emergency responses, power asymmetries that marginalize community knowledge, and fragmented information systems with trust deficits collectively undermine the system's capacity to develop the resilience necessary for addressing intensifying flood risks in a rapidly urbanizing coastal context. The research indicates that transformation toward genuinely adaptive flood governance requires not merely technical adjustments but fundamental reconceptualization of institutional relationships, moving from command-and-control approaches toward collaborative networks that recognize distributed intelligence, enable polycentric decision-making, facilitate continuous learning, and integrate diverse knowledge systems including community-based expertise. Without such systemic transformation that embraces rather than suppresses the complex, emergent properties inherent in urban disaster governance, Makassar's flood management system will continue to exhibit limited effectiveness in responding to dynamic flood risks, perpetuating cycles of reactive responses that fail to build long-term resilience. The study contributes to complexity applications in public administration by demonstrating how theoretical principles manifest in specific governance contexts while highlighting the critical importance of aligning institutional designs with the inherent complexity of contemporary urban challenges.

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