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Governance Assessment for Climate Resilience: Insights from an Open-source Platform Adoption in Indonesia and Implications for Pakistan

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Abstract

As climate-related disasters grow more frequent and severe, many governments are turning to digital tools to enhance disaster response. This thesis explores how governance influences the use of an open-source platform that gathers citizen-generated data, using PetaBencana.id in Indonesia as a case study. It also aims to address the lack of existing research on how governments can better integrate open-source and crowdsourcing technologies as part of their official systems for climate resilience efforts. Using a qualitative case study approach, the research applies the Governance Assessment Tool (GAT) and includes interviews with 20 experts from government, civil society, and academia. The findings show mixed results: challenges in coordination and resources, but also growing potential through stronger collaboration and stakeholder engagement. The thesis also examines AafatInfo.pk, a new platform in Pakistan based on the same open-source software, which is still in beta testing. Together, this thesis aims demonstrate how governance can help cities (especially in the Global South contexts) to adopt participatory digital solutions for disaster management, thereby providing insights for scholars and policymakers.

Keywords: governance, disaster management, PetaBencana, AafatInfo, open-source platforms, crowdsourcing, geospatial, climate resilience

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Abbreviations

APBN	Anggaran Pendapatan dan Belanja Negara/State Revenue and Expenditure Budget
Basarnas	Badan Nasional Pencarian dan Pertolongan/National Search and Rescue Agency
BIG	Badan Informasi Geospasial/Geospatial Information Agency
BMKG	Badan Meteorologi, Klimatologi, dan Geofisika/Meteorology, Climatology, and Geophysics Agency
BNPB	Badan Nasional Penanggulangan Bencana/Disaster Management National Agency
BPBD	Badan Penanggulangan Bencana Daerah/Regional Disaster Management Agency
CIT	Contextual Interaction Theory
COP	Conference of the Parties (e.g. COP28, United Nations Climate Change Conference)
CRED	Centre for Research on the Epidemiology of Disasters
EM-DAT	Emergency Events Database
GAT	Governance Assessment Tool
GHG	Greenhouse Gas
GIS	Geographic Information System
HOT	Humanitarian OpenStreetMap
ISIF	Information Society Innovation Fund
KLHK	Kementerian Lingkungan Hidup dan Kehutanan/ Ministry of Environment and Forestry
IFRC	International Federation of Red Cross and Red Crescent Societies
IPCC	Intergovernmental Panel on Climate Change
MIT	Massachusetts Institute of Technology
NGO	Non-governmental Organization
OECD	Organization for Economic Cooperation and Development
OSI	Open-source Initiative
OSM	OpenStreetMap
OSS	Open-source Software
Polri	epolisian Negara Republik Indonesia/National police
Pusdalops	Pusat Pengendalian Operasi/ Emergency Operations Center
SOP	Standard Operating Procedure
TNI	Tentara Nasional Indonesia/Indonesian National Armed Forces
TRC	Tim Reaksi Cepat/Rapid Response Teams
UNDRR	United Nations Office for Disaster Risk Reduction
UNISDR	United Nations International Strategy for Disaster Reduction (renamed UNDRR in 2019)
USAID	United States Agency for International Development
WMO	World Meteorological Organization
VGI	Volunteered Geographic Information
YPB	Yayasan Peta Bencana

1 Introduction

The severity of climate change continues to pose unprecedented challenges to humanity, with impacts escalating at an alarming rate. Since the 1950s, human activities have been the dominant driver of rising greenhouse gas (GHG) levels in the atmosphere, leading to global warming. Despite the efforts under the Paris Agreement to limit global warming to below 2°C above pre-industrial levels, projections indicate that global surface temperatures are likely to exceed 2°C, with sea levels expected to rise between 2.6 and 8.2 meters by the end of the 21st century (IPCC, 2014).

The consequences of climate change, including an increase in temperature and extreme weather conditions significantly impact cities worldwide (Sahu & Debsarma, 2023). In the past two decades alone, more than 7,000 disaster events worldwide have resulted in the loss of over 1.23 million lives, highlighting the escalating global threats caused by disasters (UNDRR & CRED, 2020).

Asia and the Pacific remained the most disaster-impacted region in 2023 (WMO, 2023), with Southeast Asia particularly vulnerable to nearly all types of natural hazards, including meteorological, hydrological, climatological, and geophysical events (Nazir et al., 2021). Between 2000 and 2019, Asia experienced the highest number of disasters globally, with 3,068 events, followed by the Americas (1,756) and Africa (1,192). The most affected countries were China, the United States, India, the Philippines, and Indonesia (UNDRR & CRED, 2020).

Floods, specifically, have the greatest impact in Asia, accounting for 41% of all floods and affecting a total of 1.5 billion people across the continent (UNDRR & CRED, 2020). As postulated by Rentschler et al. (2022), the 5 countries with the highest total populations at risk from flooding include China, India, Bangladesh, and Pakistan. Meanwhile, countries most vulnerable by percentage of population at risk are the Netherlands (59%), Bangladesh (58%), Vietnam (46%), Egypt (41%), and Myanmar (40%).

Recent events further illustrate this growing threat: In April 2024, unprecedented flooding in Rio Grande do Sul, Brazil, displaced hundreds of thousands and affected millions (Médecins Sans Frontières, 2024). Moreover, in September 2024, Super Typhoon Yagi struck northern Vietnam, triggering devastating floods and landslides, with record-high

water levels submerging parts of Hanoi and causing major infrastructure damage (IFRC, 2024). These events highlight the urgent need for countries to enhance their preparedness and develop adaptation strategies to mitigate the impacts of extreme weather events.

As cities confront an increasing number of threats from climate change, the need for innovative and collaborative technology has never been more critical. During the 2023 United Nations Climate Change Conference (COP28), discussions highlighted how digitalization could be key in addressing the climate crisis and supporting the most vulnerable communities. However, governments and communities still often struggle to collect reliable climate and disaster data, which makes it harder to plan and respond effectively during emergency phases.

To this end, citizen-driven data serve as a vital solution for supporting during disasters (Migliorini et al., 2019). Additionally, open-source software offers another solution that is cost-effective solution that can be developed quickly and has become widely used in many humanitarian efforts. When combined with crowdsourced data directly from citizens, open-source software presents a promising and sustainable approach to addressing complex climate challenges. Notwithstanding the perception that citizen-driven data is often seen as inadequate due to concerns about accuracy, lack of formal structure, and missing metadata, the acceptance of crowdsourced mapping data as a valuable and useful source of information for the government has been growing (Haklay et al., 2014).

Open-source software (OSS) like CogniCity, developed as part of the PetaJakarta.id (translation: Jakarta Map) project between 2013 and 2016, has proven highly effective during Jakarta's severe flooding events by harnessing crowdsourced data from social media for flood monitoring and response. Efforts are now underway to expand the platform’s use to other cities and to adapt it for a wider range of disaster scenarios. This aligns closely with the disaster landscape in Indonesia, where the most frequent disasters include floods, earthquakes, volcanic activity, and water-triggered events such as landslides and mudslides. As shown in Figure 1.1, floods are by far the most common disaster type in Indonesia between 2000 and 2025, followed by earthquakes, mass movements, and volcanic activity (CRED, 2025). Beyond Indonesia, the Philippines (MapaKalamidad.ph platform) and Pakistan (AafatInfo.pk platform) have also adopted CogniCity OSS by customizing it to suit local needs.

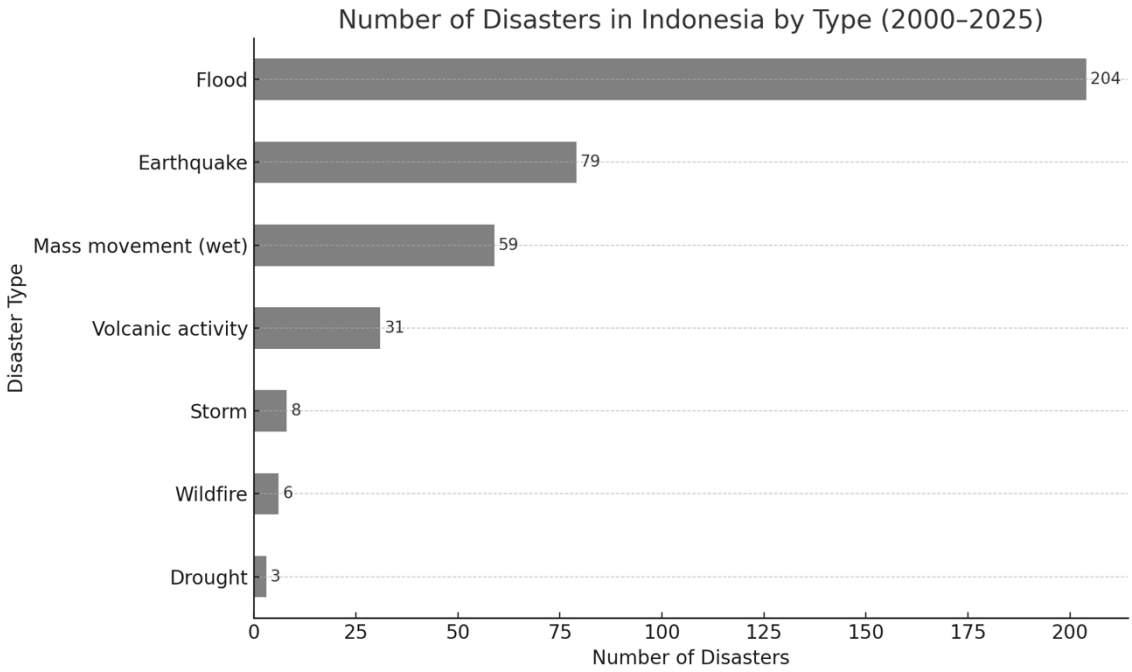

Figure 1.1 Number of different types of disasters in Indonesia from 2000 to 2025 (CRED, 2025)

1.1 Research Gap

Several studies have examined the challenges and opportunities of flood mapping platforms like PetaJakarta.id or PetaBencana.id (translation: Disaster Map). Most focus on a single-case perspective, including work by Ogie et al. (2019), Widyanarko (2018), and Hidayat (2020), with the exception of Fadmastuti et al. (2024), who offer comparative insights between Indonesia and Belgium. While these studies provide important aspects of how the platform works and its role in disaster response, they often overlook different forms of governance theories, long-term institutional sustainability, and the perspectives of diverse stakeholders. For example, Hidayat (2020) applies collaborative governance theory but does so with limited depth, based on only 3 interviews and minimal discussions about other theoretical governance perspectives. Moreover, to date, to the best of the author's knowledge, no research has examined AafatInfo or Pakistan's adaptation of Cognicity OSS, despite its potential as models for other countries. Understanding the governance dynamics behind these platforms is crucial not only for improving their effectiveness and scalability, but also for shaping more inclusive, transparent, and adaptive disaster management policies.

Another critical gap exists in the integration of open-source technology with crowdsourced data into official disaster management systems. While studies have explored the use of open-source technology for humanitarian efforts, there remains limited research that specifically address how both open-source technology and crowdsourced data can be effectively validated and integrated (Haklay, et al., 2014) into authoritative datasets and systems used by governments for climate resilience efforts. Addressing this gap would help governments more confidently adopt such digital solutions and develop stronger strategies for integrating citizen participation into formal disaster response processes.

1.2 Research Objectives

Building on the key gaps outlined in earlier paragraphs, the objectives of this research are threefold:

First, it aims to explore the governance challenges and opportunities presented by the case study of PetaBencana.id. In this context, this research provides valuable insights into how different governance factors can either support or hinder the adoption of open-source platforms with crowdsourced data for climate resilience initiatives. In doing so, this thesis builds on existing research on PetaBencana.id, including studies by Ogie et al. (2019), Widyanarko (2018), Hidayat (2020), and Fadmastuti (2024). Insights from PetaBencana.id case study form the foundation for examining the challenges and opportunities facing AafatInfo in Pakistan.

Second, the findings aim to contribute to enhancing climate resilience strategies in the Global South, as in a broader sense, scholarship on governance practices related to climate resilience in the Global South is still largely underexplored (Akther & Evans, 2024).

Finally, this research seeks to assist cities in improving their disaster management approaches, particularly through the use of free, customizable open-source software, which is especially beneficial for regions with limited budgets or countries most vulnerable to the climate crisis (Nkwunonwo et al., 2020; Park et al., 2024).

1.3 Research Questions

Thus, this thesis aims to seek to answer the following questions:

1. *How do different governance aspects support or hinder the adoption of an open-source platform for climate resilience initiatives in Indonesia?*

    a. *How do different government agencies perceive crowdsourced data within open-source platforms be utilized for climate resilience efforts?*

2. *What lessons can be derived from Indonesia's case to support Pakistan in scaling its open-source climate resilience platform?*

    a. *What lessons from Indonesia and Pakistan can guide the adoption of open-source climate resilience platforms in other countries?*

1.4 Research Structure

The thesis is structured as follows. Section 1 provides the background, identifies the existing research gap, and highlights the significance of this research as outlined above.

Section 2 presents a literature review, focusing on key governance concepts, their relevance to climate resilience initiatives, and the role of open-source platforms in enabling such initiatives. This review elaborates on the Governance Assessment Tool (GAT), which is used as a core part of the research methodology.

In Section 3, the research methodology, data analysis, and the limitations of this method are presented.

Section 4 outlines the broader climate governance context in Indonesia and introduces the case study of PetaBencana.id platform.

In Section 5, the results of this research are explained.

Section 6 presents the discussion, exploring the implications of the findings and offering recommendations for policymakers and practitioners in Indonesia and Pakistan. These recommendations are also relevant for other countries seeking to adopt similar approaches. The section further elaborates on the thesis's academic contributions and proposes directions for future research.

2 Literature Review

This literature review establishes a foundation for understanding governance and the role of open-source platforms for climate resilience initiatives. It explores governance forms, including collaborative, open, network, and adaptive governance, to identify common themes of multi-stakeholder collaboration between government agencies, NGOs, and local communities.

To comprehend the factors that influence the adoption of an open-source platform for climate resilience, including drivers, barriers, and enabling conditions, this study considers how governance processes are shaped by these factors. In this context, assessing governance effectiveness becomes important to examine how institutional arrangements, stakeholder dynamics, and decision-making processes support or hinder platform adoption. As part of this analytical approach, the study draws on the Governance Assessment Tool (GAT) to evaluate key governance dimensions and qualities.

Additionally, this chapter considers the socio-cultural dimensions of open-source platforms within humanitarian contexts, with a particular focus on how crowdsourcing empowers governments, NGOs, and citizens to share real-time information and coordinate disaster response efforts.

2.1 Rethinking Governance in the Face of Global Complexity

The term ‘governance’ has evolved significantly over time, becoming increasingly blurred and ambiguous. Today, the term has been used to mean different interpretations across different cultural and political contexts (Ansell & Torfing, 2022). While this lack of precision can be challenging, the term ‘governance’ also gives a certain flexibility and positive connotation, allowing it to be widely applied across disciplines (Pollitt & Hupe, 2011). This conceptual shift reflects a broader move away from viewing governance solely as top-down governmental control, toward a focus on how power is distributed and exercised across state, business, and civil society actors (Pollitt & Hupe, 2011; Drechsler, 2004; Ansell & Torfing, 2022).

In line with a focus on the interactions between different actors, emerging governance theories encourage us to ask fundamental questions about how policies and regulations can be transformed to better address complex global issues. These theories provide a

critical lens for analysing empirical conditions, processes, and outcomes, helping researchers make sense of our increasingly interconnected world. This shift in understanding of governance and the rise of various governance theories is particularly relevant in the context of climate resilience governance, where diverse stakeholders must collaborate to address pressing global challenges.

Among the emerging governance theories, the concept of 'good governance' has gained prominence in the early 1990s (Doornbos, 2001). Initially adopted by international organizations, such as the United Nations and the World Bank, the concept of 'good governance' was introduced to encourage governments, especially in developing countries in the Global South, to adopt effective and transparent administrative practices while also promoting the more efficient use of development aid from international donor organizations. Over time, the concept was used as a basis for assessing the quality of policies, regulations, and governing institutions. Attributes used for the governance assessments include stability, transparency, interaction, and responsiveness. Many international institutions and NGOs have integrated these principles into their assessments, particularly when considering sustainable development and the effectiveness of institutional frameworks (Ansell & Torfing, 2022). At present, in many developing countries, NGOs play an integral role in governance, participating in both policymaking and implementation. NGO leaders often collaborate with government officials on national and local committees, and their programs are frequently incorporated into formal planning processes (Brass, 2012).

This research specifically explores governance in an attempt to understand how to build resilient governance structures capable of addressing complex societal challenges. In this context, numerous governance trends have emerged, making it increasingly ambiguous and challenging to define clear boundaries. This leads to several and often largely overlapping trends across various governance forms and models, such as good governance, network governance, collaborative governance, and adaptive governance (Ansell & Torfing, 2022).

A common thread across these governance models is that they are not mutually exclusive; in practice, governments, NGOs, and other organizations often employ a combination of these approaches depending on the context, challenges, and policy goals (Ansell & Torfing, 2022). Another critical aspect with these modern forms of governance is that

there is no single actor, whether government, business, or civil society, holds absolute authority. Effective governance relies on multi-stakeholder engagement, where problems are collectively defined and solved through cooperation. This aligns with Mazzucato's (2023) perspective that fostering collaboration, sharing knowledge and ensuring transparency is essential to creating public value that is both shared and sustainable.

The next section examines the concepts of network governance, collaborative governance, and adaptive governance to better understand the governance system surrounding how open-source platforms like PetaBencana.id operate within Indonesia's climate resilience efforts.

2.1.1 Conceptualization of Network, Collaborative and Adaptive Governance

As stated previously, the concept of governance emerged as a response to challenges in policymaking, regulations, and government effectiveness while the idea of good governance gained prominence through international organizations, which advocated for attributes such as stability, transparency, interaction, and responsiveness, particularly in the context of development. Building on these discussions, scholars introduced the concept of network governance to examine more decentralized and collaborative forms of governing. As noted by Ansell and Torfing (2022), the concept of governance gained significant traction in the 1990s, particularly through the work of British scholars such as Marsh and Rhodes (1992), Rhodes (1997), and Marsh (1998), who critiqued classical corporatism and proposed a more flexible understanding of policy networks. Concurrently, North American scholars, including Provan and Milward (1995) and Agranoff and McGuire (1999), contributed to the discourse by emphasizing policy implementation and service delivery through interorganizational networks (Ansell & Torfing, 2022).

Network governance represents a shift from vertical, top-down approaches to more horizontal forms of decision-making, characterized by systems of affect, communication, knowledge exchange, and dialogue. It has emerged as a key framework for understanding how autonomous yet interdependent actors, such as governments, civil society, and private organizations, collaborate to address complex public challenges in non-hierarchical ways (Ansell & Torfing, 2022). Unlike traditional governance models that rely on centralized authority, network governance emphasizes coordination through both

formal and informal relationships, where trust, flexibility, and mutual learning are central (Kapucu & Hu, 2020). This approach is particularly relevant in contexts marked by uncertainty and complexity, where no single actor possesses the full knowledge or capacity to respond alone. Scholars have explored network governance through multiple theoretical lenses: sociological traditions highlight the role of social ties and relational structures (Borgatti & Halgin, 2011), inter-organizational theory examines how collaboration and resource dependencies influence cooperation under uncertainty, and public administration literature focuses on inclusive participation and legitimacy in policymaking (Agranoff & McGuire, 2003)

While network governance has been conceptualized in various ways, very few works connect these theories with practice. The works of Kapucu and Hu (2020), Meerow et al. (2024), and Maes et al. (2018) offer empirical examples and attempt to fill this gap. As an example, Kapucu and Hu (2020) use cases from the United States to illustrate how network governance operates in high-stakes contexts such as crisis management. They argue that traditional hierarchical models often fall short in complex, rapidly evolving situations, highlighting the need for more flexible, network-based approaches. For example, the response to Hurricane Katrina case in 2005 revealed the limitations of top-down government, which delayed critical information flows and hindered coordination across agencies and levels of government. This case underscores the need for a collaborative network approach, as effective crisis management increasingly relies on coordination among diverse public, private, and civil society actors (Kapucu & Hu, 2020).

Building on these real-world examples, Meerow et al. (2024) explore how network governance plays out in practice by looking at urban flood resilience efforts in four coastal cities. Through a comparative analysis, Meerow et al. (2024) demonstrated how the structure and cohesion of governance networks, influence the strength of local flood resilience policies. Their findings challenge the assumption that more collaboration always leads to better outcomes, emphasizing the importance of both network quality and plan integration. Maes et al. (2018) offer a more critical perspective on network governance through a case study on landslide risk governance in Uganda. Their findings revealed that network structures, while often presented as participatory, can in practice be used by central governments to maintain control, reinforce existing power hierarchies, and shift blame when governance failures occur.

Relevant to the broader discussion of network governance, the concept of collaborative governance rose to prominence in the early 2000s (Gash, 2022; Emerson et al., 2012). Ansell and Gash (2017) played a key role in formalizing the concept, reviewing over 30 empirical cases to develop a widely used framework. They define collaborative governance as "a governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets" (Ansell & Gash, 2017). Complementing this, Ansell and Torfing (2022) describe collaborative governance as a more integrative and deliberative mode of network governance, one that goes beyond coordination to enable shared power, joint decision-making, and the co-creation of public value.

Gash (2022) highlighted a range of real-world examples that show just how differently collaborative governance is practiced depending on political and institutional settings. For instance, In the United States, efforts to bring together stakeholders in environmental management often succeeded in encouraging participation, but many struggled with unclear roles and weak accountability, making long-term progress difficult. Meanwhile, in Australia, attempts to implement collaborative structures in local social policy often ran into resistance from rigid, top-down bureaucracies (Gash, 2022). Moreover, Bianchi et al. (2021) present cases from the Netherlands, China, and New Zealand, showing that success often hinges on strong leadership, shared goals, and systems that can adapt over time. Together, these examples suggest that collaborative governance is best understood not as a universal solution, but as a flexible approach that must be carefully adapted to the political, institutional, and cultural realities on the ground.

Both network and collaborative governance share a common element, which is the importance of learning and reflection in building and maintaining strong relationships between actors. As suggested by Ansell and Torfing (2022), earlier work from Lasker et al. (2001) and Booher (2004) also highlight the relational dimensions of collaboration, emphasizing that successful collaborative governance depends not only on institutional structures but also on trust-building, shared learning, and the ability to generate synergy through diverse stakeholder engagement. However, as Meerow et al. (2024) stated, more collaboration or more network ties do not automatically lead to better outcomes. Without clear coordination, thoughtful planning, and attention to power dynamics, collaborative efforts can fall short.

Adaptive governance builds on the principles of network and collaborative governance but extends further to address the complex demands of global environmental change, including climate change. It emphasizes continuous learning, institutional flexibility, and coordination across multiple governance levels. The concept emerged in the early 2000s, rooted in efforts to understand how institutions could more effectively manage the uncertainty and complexity of social-ecological systems (Brunner et al., 2005; Folke et al., 2005). As Chaffin et al. (2014) noted that traditional top-down governance models are often inadequate in responding to these challenges. In response, adaptive governance promotes more flexible, bottom-up approaches that position citizens, communities, and institutions as active co-producers of governance outcomes. It offers a dynamic and responsive framework for managing the unpredictable and interconnected nature of contemporary environmental issues.

In recent years, the focus of adaptive governance scholarship has shifted from theoretical discussion to identifying and studying real-world examples, particularly cases that highlight learning processes and the role of adaptive capacity (Ansell & Torfing, 2022). For instance, Boyd (2008) described how adaptive governance emerged in the Amazon through the development of multilevel institutional arrangements and flexible policies in response to ongoing deforestation. Nelson et al. (2008) examined drought governance in Australia, where adaptive responses included decentralized decision-making and flexible water allocations that responded to environmental feedback. Similarly, Olsson et al. (2008) analysed the governance of the Great Barrier Reef, where adaptive approach was enabled through knowledge co-production between scientists, policymakers, and local communities. These examples share common features such as learning through experience, stakeholder participation, flexible institutional arrangements, and the ability to adapt and stay resilient to changing ecological conditions; core traits of what define adaptive governance.

2.1.2 Climate Resilience as a Pillar of Governance Transformation

As addressed in earlier paragraphs, building resilience is necessary to transform governance that is strong, capable of solving complex environmental challenges. Thus, to answer the research questions and better understand the governance aspects that support resilience, this chapter also reviews the concept of resilience in relation to climate change and disaster management.

Since the early 2010s, resilience has become an important guiding concept in how cities and communities address the growing risks of climate change (Özerol & Bressers, 2023). Originally associated with strength and resistance, the meaning of resilience has evolved. Today, it is understood as the ability to learn, adapt, and change, especially when applied to areas like disaster management, urban sustainability, and the governance of social-ecological systems (Tyler & Moench, 2012). In other words, resilience involves anticipating, absorbing, and recovering from disruptions, especially under conditions of uncertainty and change (Djalante et al., 2011; Djalante et al., 2012). Research also shows that when different actors, including governments, communities, and civil society, work together and build trust, they are often better positioned to strengthen resilience (Meerow et al., 2024).

To guide this research, resilience is defined following the United Nations International Strategy for Disaster Reduction (UNISDR) as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" (UNISDR, 2009). The term is also considered in relation to the disaster management cycle**,** comprising mitigation, preparedness, response, recovery**,** and prevention following the terminology used by the UNISDR. At its core, resilience refers to the capacity of systems and institutions to function effectively and adapt across all phases of this cycle. Figure 2.1 illustrates the disaster management cycle to show how these stages are interconnected, as visualized by Sharma (2022) using data from UNISDR (2009).

Figure 2.1 Disaster management cycle (Sharma, A., 2022; UNISDR, 2009)

Following the discussion of resilience across the disaster management cycle, an important question arises: how can resilience be effectively assessed? Measuring resilience goes beyond simply evaluating the presence of policies or procedures; it requires frameworks that capture critical dimensions such as adaptability, institutional flexibility, and the capacity for learning.

As postulated by Casiano Flores et al. (2017), Governance Assessment Frameworks are valuable tools for identifying implementation challenges and highlighting areas for improvement. They provide a structured approach to evaluating how governance systems perform under stress, offering insights into their capacity to support resilient and adaptive responses.

2.1.3 Governance Assessment Tool (GAT)

The Governance Assessment Tool (GAT), originally developed in 2011, provides a framework for evaluating governance systems across various sectors and is grounded in Contextual Interaction Theory (CIT) (Bressers et al., 2016). CIT theory emphasizes the importance of understanding interactions among different governance actors and contexts (Özerol & Bressers, 2023). Expanding on this, the theory argues that the success of policy implementation largely depends on the interactions among key actors, particularly their motivations, knowledge, and resources. This perspective challenges traditional top-down

approaches by recognizing that the complex and dynamic relationships between these factors significantly shape policy outcomes. By embracing this complexity, CIT offers a more nuanced and structured approach to analyzing and understanding the multifaceted nature of policy implementation processes (Bressers et al., 2016). Figure 2.2 below illustrates the different layers of context in CIT. They are shown as overlapping circles, each with a direct potential impact on actor characteristics. This means the wider context can influence actors directly, not only through structural or the specific case context. Likewise, while the case process can affect the contexts, this impact is usually limited to the specific context (Bressers et al., 2015).

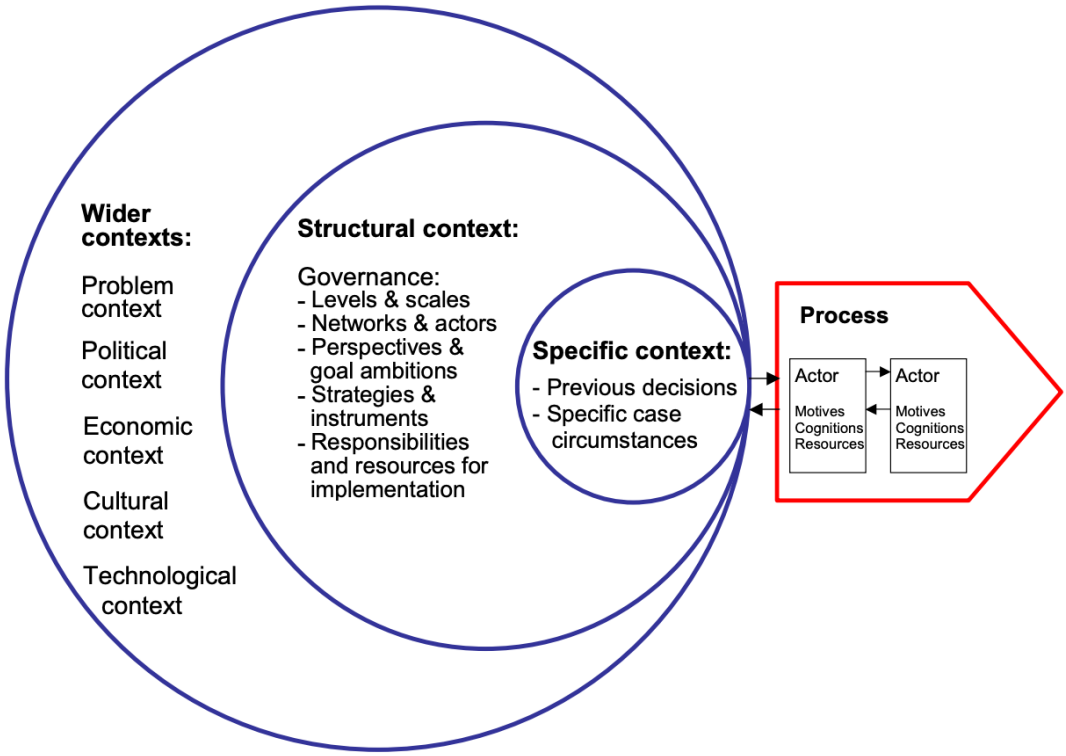

Figure 2.2 Elaboration of the layers of context in Contextual Interaction Theory (Bressers et al., 2016)

Drawing on this, Figure 2.3 below depicts an iterative development cycle where specific context influences the process, which produces results, thereby creating either positive or negative feedback loops for the project progress (de Boer, C., & Bressers, H., 2011).

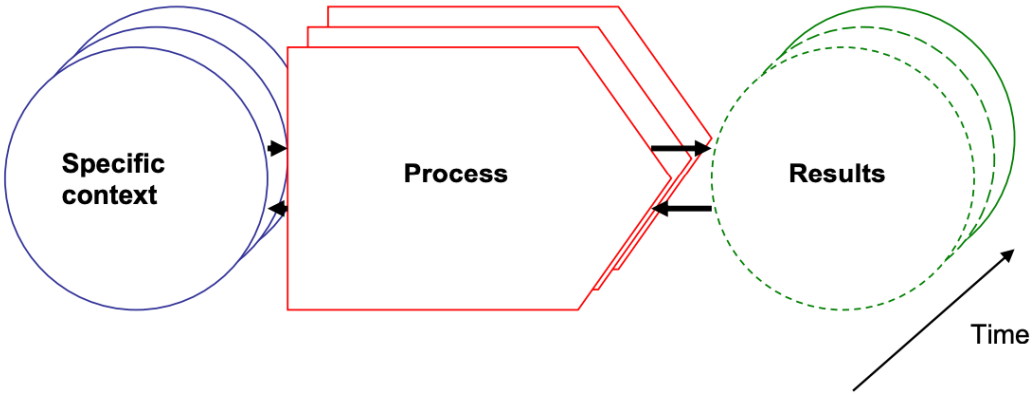

Figure 2.3 Interaction processes influenced simultaneously by various layers of context (de Boer, C., & Bressers, H., 2011)

Although it was originally developed within European context for water governance policy, particularly through the DROP project on drought resilience in northwest Europe (Bressers et al., 2016), it has been referenced in academic works in more than 20 countries (Özero & Bressers, 2023). For instance, applications of the GAT can be found on the governance assessments of urban water transition initiative in the Netherlands (Casiano Flores et al., 2023), water management innovations in Denmark, Germany, and Spain (Rouillard et al., 2016), wastewater governance in Mexico (Casiano Flores et al., 2017), water conservation in Iran (Mirnezami et al., 2019), water governance in Palestine (Judeh et al., 2017) and the reuse of treated wastewater in Palestine (Al-Khatib et al., 2017). Beyond water policy and governance, GAT has been applied in community-based waste management in Indonesia (Latanna, 2023), the adoption of energy-efficient appliances in Nigeria (Gana & Hoppe, 2017), and low-energy green buildings in Delhi and Singapore (Jain et al., 2020). These diverse applications highlight the tool's broad relevance, demonstrating that the GAT is not restricted to a single policy domain but is well-suited for analysing complex and dynamic governance settings.

5 governance dimensions of GAT are explained below, with sample questions (Bressers et al., 2016):

- **Level and scales**: Which administrative levels are involved and how?
- **Actors and networks**: Which actors are involved in the process?

- **Problem perception and goal ambitions**: Which various angles does the debate of public and stakeholders take towards the problem at hand?

- **Strategies and instruments**: Which policy instruments and measures are used to modify the problem situation?

- **Responsibilities and resources**: Which organizations have responsibility for what tasks under the relevant policies and outcomes?

In addition to 5 governance dimensions, 4 quality criteria are also to be considered questions (Bressers et al., 2016):

- **Extent**: Are all elements in the five dimensions, which are relevant being addressed, taken into account?

- **Coherence**: Are the elements in the dimensions of governance supporting, rather than contradicting, each other?

- **Flexibility**: Are multiple roads to the goals, depending on opportunities and threats as they arise, permitted and supported?

- **Intensity**: How strongly do the elements in the dimensions of governance urge changes in the status quo?

Governance Dimension	Quality			
	Extent	**Coherence**	**Flexibility**	**Intensity**
Level and scales	How many levels are involved and dealing with an issue? Are there any important gaps or missing levels?	Do these levels work together and do they trust each other between levels? To what degree is the mutual dependence among levels recognized?	Is it possible to move up and down levels (upscaling and downscaling) given the issue at stake?	Is there a strong impact from a certain level towards behavioural change or management reform?
Actors and networks	Are all relevant stakeholders involved? Are there any stakeholders not involved or even excluded?	What is the strength of interactions between stakeholders? In what ways are these interactions institutionalised in stable structures?	Is it possible that new actors are included or that the lead shifts from one actor to another when there are pragmatic reasons for this? Do the actors share in 'social capital' allowing them to support each other's tasks?	Is there a strong pressure from an actor or actor coalition towards behavioural change or management reform?
Problem perception and goal ambitions	To what extent are the various problem perspectives taken into account?	To what extent do the various perspectives and goals support each other, or are they in competition or conflict?	Are there opportunities to re-assess goals? Can multiple goals be optimized in package deals?	How different are the goal ambitions from the status quo or business as usual?
Strategies and instruments	What types of instruments are included in the policy strategy? Are there any excluded types? Are monitoring and enforcement instruments included?	To what extent is the incentive system based on synergy? Are there any overlaps or conflicts of incentives created by the included policy instruments?	Are there opportunities to combine or make use of different types of instruments? Is there a choice?	What is the implied behavioural deviation from current practice and how strongly do the instruments require and enforce this?
Responsibilities and resources	Are all responsibilities clearly assigned and facilitated with resources?	To what extent do the assigned responsibilities create competence struggles or cooperation within or across institutions?	To what extent is it possible to pool the assigned responsibilities and resources as long as accountability and transparency are not compromised?	Is the amount of allocated resources sufficient to implement the measures needed for the intended change?

Table 2.1 GAT matrix with its main evaluative questions (Bressers et al., 2016)

2.2 Open-source Software

According to Schweik & Semenov (2003), open-source programming is an exciting approach that has evolved out of computer science, where principles from open-source projects can be applied beyond technology to tackle complex societal challenges in public policy. The Open-Source Definition, published by the Open-Source Initiative (OSI), outlines 10 rights that a software license must grant to be considered open source. The following outlines the core principles of open-source software, along with brief descriptions of each (Kavanagh, 2004).

- Free Distribution: The license shall not restrict any party from selling or giving away the software as a component of an aggregate software distribution containing programs from several different sources

- Source Code: The program must include source code and must allow distribution in source code as well as compiled form. The license must allow modifications and derived works, and must allow them to be distributed under the same terms as the license of the original software

- Derived Works: The license must allow modifications and derived works, and must allow them to be distributed under the same terms as the license of the original software

- Integrity of Author's Source Code: The license may restrict source-code from being distributed in modified form only if the license allows the distribution of ‘patch files’ with the source code for the purpose of modifying the program at build time. The license must explicitly permit distribution of software built from modified source code. The license may require derived works to carry a different name or version number from the original software

- No Discrimination Against Persons or Groups: The license must not discriminate against any person or group of persons

- No Discrimination Against Fields of Endeavor: The license must not restrict anyone from making use of the program in a specific field of endeavour. For

example, it may not restrict the program from being used in a business, or from being used for genetic research

- Distribution of License: The rights attached to the program must apply to all to whom the program is redistributed without the need for execution of an additional license by those parties

- License Must Not Be Specific to a Product: The rights attached to the program must not depend on the program's being part of a particular software distribution. If the program is extracted from that distribution and used or distributed within the terms of the program's license, all parties to whom the program is redistributed should have the same rights as those that are granted in conjunction with the original software distribution

- License Must Not Restrict Other Software: The license must not place restrictions on other software that is distributed along with the licensed software. For example, the license must not insist that all other programs distributed on the same medium must be open-source software

- License Must Be Technology-Neutral: No provision of the license may be predicated on any individual technology or style of interface

Closely linked to the term 'open-source software' is 'open-source platform', though they have distinct technical meanings. In theory, while open-source software generally refers to individual applications with freely available source code, open-source platforms function as integrated systems that bring together multiple open-source components to support broader functionalities (Kavanagh, 2004). Given that this research focuses on the socio-cultural dimensions of the open-source approach rather than its technical classifications, the terms open-source software and open-source platform is used interchangeably in this paper to reflect their overlapping roles.

As Feller et al. (2005) highlight, open-source development extends beyond merely a technical model; it is also a socio-cultural movement that values transparency and participation. These are elements deeply rooted in academic traditions and hacker culture that promote knowledge sharing, collaboration and decentralization. Unlike proprietary platforms, which are controlled by private companies, open-source platforms operate on

the principle that software should be freely shared as a communal resource rather than restricted by corporate interests.

The success of open-source project relies heavily on its leadership and governance structures. According to Lerner & Tirole (2003), leadership is a decisive factor, as leaders set roadmaps, mediate conflicts, and ensure quality control. Equally important is a transparent governance; projects that establish clear contribution guidelines, well-defined decision-making processes, and strong community norms attract long-term contributors and maintain development momentum. Among the mechanisms for ensuring the long-term sustainability of open-source projects is the establishment of non-profit foundations. Many open-source initiatives rely on these foundations to manage resources, funding, legal rights, and governance structures, providing institutional stability while preserving community-driven development (O'Mahony, 2005; Aigrain, 2005). Without structured leadership, clear governance, and stable financial support, open-source projects risk becoming abandoned (Lerner & Tirole, 2003).

2.2.1 Open-source Platforms for Climate Action

Open-source platforms have become powerful tools in climate action and disaster management, offering transparency, adaptability, and broad participation. The increasing demand for open-source platforms humanitarian efforts is particularly driven by critical challenges during disasters such as lack of coordination (Bharosa et al., 2010; Wickramarachchi & Mahanama, 2019; Currion et al., 2017). By design, they invite contributions from a wide range of stakeholders, including governments, NGOs, local communities, and developers, enabling collective problem-solving and real-time updates. These platforms offer a cost-effective solution during disaster events without the financial burden of proprietary systems, making them especially relevant for developing countries (Currion et al., 2017; Wickramarachchi & Mahanama, 2019).

For instance, in 2004, OpenStreetMap (OSM) was established; an open-source and collaborative mapping platform widely used by organisations for humanitarian purposes, providing adaptable base maps that support a variety of applications beyond disaster management[1]. Additionally, during the 2010 Haiti earthquake, Ushahidi platform utilized the power of crowdsourced data to create crisis maps that generated over 50,000 incident

[1] OpenStreetMap: https://wiki.openstreetmap.org/wiki/History_of_OpenStreetMap

reports (Mulder et al., 2016). In Tanzania and Togo, open-source platforms have been used to model flood scenarios and implement early warning systems, helping mitigate disaster impacts (Cannata et al., 2016). Sahana, another open-source platform, streamlines disaster coordination by managing resources and organizing volunteers (Nielsen & Santos, 2013). Moreover, during the COVID-19 pandemic, developers rapidly created tools for contact tracing and resource allocation with open-source solutions (Wang et al., 2021). While not all open-source tools rely on crowdsourced data, this research focuses on platforms that integrate both open-source technology and crowdsourced data, exploring how real-time public participation shapes disaster response.

2.2.2 Crowdsourcing for Disaster Data Collection

This research specifically examines how crowdsourcing is deployed specifically with open-source technology. Crowdsourcing, a core principle in many open-source platforms, enables real-time data collection, public engagement, and locally-informed decision-making. It serves as the foundation for participatory approaches in disaster management. In summary, crowdsourcing can be defined as an information-gathering method that relies on voluntary online participation to accomplish a specific task in a manner that fosters mutual benefit (Estellés-Arolas & González-Ladrón-de-Guevara, 2012; See, et al., 2016). In particular, real-time data from the public enhances the situational awareness needed for effective disaster response (Song et al., 2020).

Crowdsourced mapping initiatives allow communities to play an active role in disaster response, challenging the limitations of traditional top-down systems that often overlook local knowledge (Klonner et al., 2016). Further complementing this idea, Poblet et al. (2014) illustrate how different types of crowdsourcing roles align with various phases of the disaster management cycle (see Table 2.2 on the next page). For instance, the ‘crowd as sensor’ provides real-time, on-the-ground information by sharing observations via social media or apps. The ‘crowd as reporter’ and ‘crowd as social computer’ interpret, verify, and disseminate information during emergencies, enhancing collective situational awareness. Meanwhile, the ‘crowd as microtasker’ supports structured tasks such as mapping or data classification, which are especially valuable in both preparedness and response phases.

	Crowd as a sensor	Crowd as a social computer	Crowd as a reporter	Crowd as a microtasker
Preparedness	●			●
Response		●	●	●
Recovery		●	●	●
Mitigation	●	●	●	

Table 2.2 Crowdsourcing roles across the disaster management cycle (Source: Poblet et al., 2014)

One crucial subset of crowdsourced data is Volunteered Geographic Information (VGI), which refers to the product of spatially referenced data contributed by individuals. While all VGI is crowdsourced, not all crowdsourced data is VGI, for example, textual reports or social media posts may be crowdsourced but lack geographic attributes. VGI plays a crucial role in disaster response and mapping efforts, as it provides real-time, location-based insights that complement authoritative spatial data produced by government bodies (Klonner et al., 2016). Although there is a technical distinction between the two terms, many scholars use the terms crowdsourcing and VGI interchangeably in practice (Fast and Rinner, 2014). This thesis will also use a similar approach, using both terms interchangeably to refer to spatially user-generated data.

Klonner et al. (2016) developed a framework to classify levels of VGI based on how actively users or volunteers participate in the process, which is visualized in Figure 2.4.

1. Crowdsourcing: Basic participation, where individuals submit raw, unstructured reports (e.g., geotagged images, incident updates)

2. Distributed Intelligence: Volunteers assist in data classification and verification, improving accuracy

3. Participatory Science: Trained volunteers contribute to structured data validation and analysis

4. Extreme Citizen Science: Volunteers collaborate with researchers and policymakers, shaping disaster response strategies

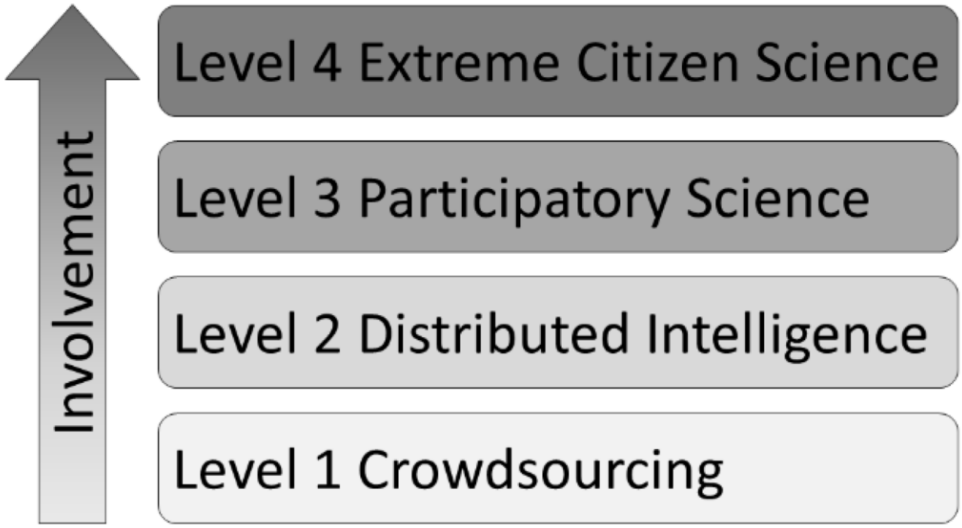

Figure 2.4 Volunteers involvement levels for disaster analysis (Klonner et al., 2016)

While this thesis focuses primarily on crowdsourced data, the framework by Klonner et al. (2016) offers insight into broader patterns of public participation in disaster data collection. A key methodological development in this space is the use of VGI being is increasingly integrated with traditional sources such as government records, satellite imagery, and sensor networks. These conventional sources are typically standardized and institutionally verified, forming the backbone of long-term planning and official disaster response efforts (Hultquist & Cervone, 2020).

In this context, open mapping, in other words, collaborative creation and sharing of VGI, enables the generation of real-time, accessible geospatial data to support urban planning, emergency preparedness, and risk reduction (Johnson & Sieber, 2012). Platforms such as OpenStreetMap, PetaBencana.id, and Ushahidi rely on VGI to create live crisis maps, track flooded areas, and optimize emergency responses. This is especially important in Global South context, where data gaps are often most severe. According to Massa & Campagna (2016), open-source and crowdsourced mapping efforts contribute timely spatial data while actively involving local communities. By engaging residents in mapping and data collection, these initiatives enhance community ownership and support more inclusive, participatory urban and spatial planning processes.

Nonetheless, crowdsourced or VGI data presents challenges, particularly in terms of ensuring accuracy, consistency, and reliability. Olteanu-Raimond et al. (2017) identify further obstacles to VGI adoption, including legal and privacy issues, uncertain

contributor motivations, sustainability challenges, and concerns about job security regarding the devaluation of professional mapping and Geographic Information System (GIS) roles. In contrast, while authoritative spatial data, that is produced by government agencies or certified organisations using standardized methods, advanced technology, and professional expertise, is generally more reliable and formally structured; it can sometimes lack real-time details or community relevance found in crowdsourced data (Maulia, 2018; Du et al., 2016). Nevertheless, VGI shares fundamental characteristics with authoritative spatial data, including geographic references, content, and attributes, allowing it to support the aggregation and comparison of information across different scales and time periods (Capineri, 2016). However, when carefully integrated with institutional sources and supported by clear validation protocols, crowdsourced mapping remains a powerful tool, for enhancing data availability and for democratizing knowledge production in disaster management.

3 Methodology

The research used a qualitative approach, focusing on exploring and understanding phenomena through in-depth analysis (Galletta, 2013). As suggested by Verschuren & Doorewaard (2010), creating a research framework can enhance clarity and transparency in addressing the research objectives, therefore a framework has been developed to guide this research. The framework is structured into 3 phases. The first phase involves the identification of the case study, a literature review, and desk research on relevant policies in Indonesia. The second phase focuses on identifying stakeholders, conducting semi-structured interviews, analysing relevant policies and exploring governance aspects based on the GAT. Then, the findings were analysed and assessed following the GAT matrix referenced in existing scholarship (Bressers et al. 2016; Casiano Flores & Crompvoets, 2020; Jain et al., 2020; Latanna et al., 2023; Kreiner et al., 2023), where recommendations for policy makers on the adoption of open-source platform for climate resilience can be derived. A graphical representation of this adaptation, created by the author, is provided below (see Fig. 3.1) and further elaborated in the subsequent paragraphs. An iterative approach across phases has been employed to enable a dynamic and thorough understanding of the research focus.

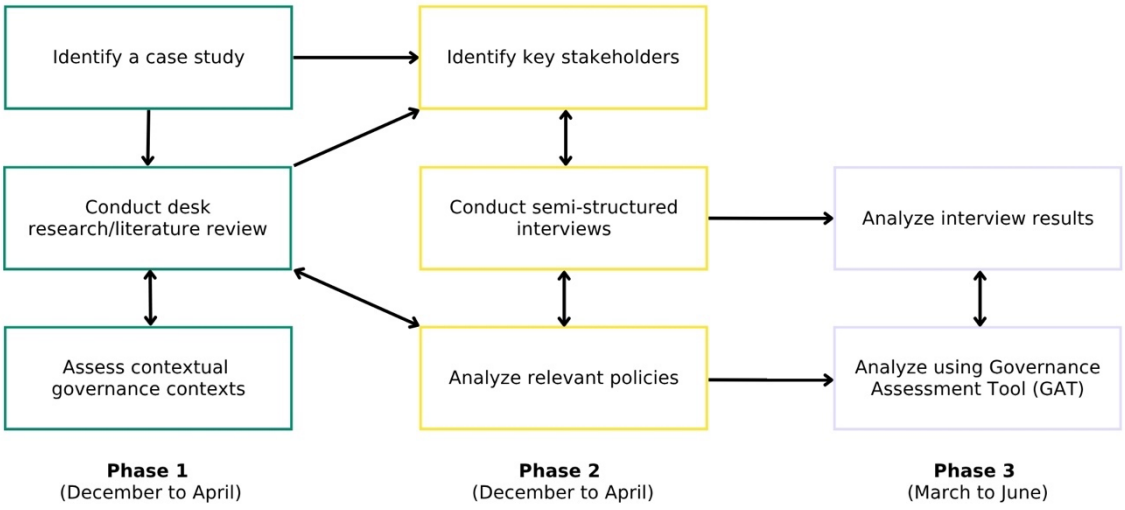

Figure 3.1 Research framework (source: from author)

Specifically, this thesis examines the case study of CogniCity OSS as implemented in Indonesia through the PetaBencana.id platform. This case helps us understand how the platform has evolved over time and how it might be adapted to other settings, such as Pakistan through AafatInfo.pk. As postulated by Yin (2018), a case study approach is

well-suited for investigating contemporary, real-world phenomena, particularly when addressing ‘how’ and ‘why’ questions. The main research question explores how governance contexts influence the adoption of open-source solutions for climate resilience and the lessons that can be drawn for other countries.

3.1 Data Collection

This thesis draws on both primary and secondary sources of data. The primary data consists of semi-structured interviews conducted with key stakeholders, while the secondary data includes desk research and a literature review of existing studies, policy documents, and websites/materials related to CogniCity OSS.

3.1.1 Desk Research

Desk research was conducted through websites and webinars related to CogniCity OSS. Interestingly, practitioners involved in its development in Indonesia actively promoted the platform across various social media channels, which helps in generating more visibility and engagement to the public. The platform also featured in discussions on open data forums, including CivicDataLab[2]. These findings bring light to the identification of potential stakeholders to interview, and the discovery of recurring themes and topics further explored in the literature review.

3.1.2 Literature Review

First, desk research on websites and webinars related to CogniCity[3] and a literature search was carried out using Scopus, Web of Science, Limo, and Google Scholar. To investigate the climate resilience and governance topic, the keywords 'climate resilience', 'governance for climate resilience' and other similar terms were used. To address the context of open-source technology for climate resilience strategies, the keywords 'open-source for disaster management', 'open-source for humanitarian efforts', and 'open-source for sustainable development' were utilised. Samples of the keywords are provided (see Table 3.1). Additionally, when identifying articles related to the thesis topic and research questions, backward and forward literature search methods will be utilised (Gusenbauer, 2024).

[2] CivicDataLab: https://civicdatalab.in/work/urbandevelopment/petabencana/
[3] CogniCity website: https://cognicity.info/

Database	Pre-defined terms	Coverage
Scopus, Web of Science, KU Leuven Limo, and Google Scholar	(Climate* OR Climate resilience* OR sustainable* OR network* OR collaborative* OR adaptive*) AND governance	2000s – present
	Open source for AND (climate* OR disaster* OR sustainable* OR humanitarian*)	

Table 3.1 Examples of keywords used for literature search

For the case study-related research, the keywords 'CogniCity', 'PetaBencana' and 'AafatInfo' have been used.

3.1.3 Interviews

In the first phase of the research, an informal interview was conducted with a former geographic data researcher from Yayasan Peta Bencana (YPB), the NGO responsible in the development of PetaBencana.id platform. This interview, along with desk research on relevant websites and webinars of CogniCity OSS, helped identify additional stakeholders for subsequent interviews.

30 individuals were contacted for interviews, including representatives from YPB, CivicDataLab, Indonesian universities, and the Philippines-based NGO, MapaKalamidad, which implements a similar open-source disaster mapping platform based on the CogniCity OSS. Despite these outreach efforts, several interviews were repeatedly cancelled, or communication ceased without further notice. Notably, multiple attempts were made to engage with the team behind YPB, the NGO responsible for the development and maintenance of PetaBencana.id. Direct emails were sent to the organization's director, followed by efforts to schedule a group interview with key staff members. Although schedules were confirmed on two occasions, one of which was postponed, the interviews were ultimately cancelled due to unexpected funding cuts from the United States Agency for International Development (USAID), a major donor to YPB.

One additional contact, currently affiliated with YPB and formerly with the National Disaster Management Agency (BNPB), agreed to provide insights but chose to speak only about their previous role at BNPB, limiting commentary on their current position at YPB. Additionally, some interviewees had experience moving between various jobs and projects; for example, a developer from the QGIS community had previously contributed

to platforms used by BNPB and has an extensive understanding of how platforms like PetaBencana.id can complement official government systems.

Despite a few setbacks, a total of 20 people were interviewed, including junior to senior level officials from different levels of government agencies: national, provincial, and regency levels (in Jakarta and Central Java regions), as well as representatives from NGOs, academia, and the open-source mapping community; all of whom possess expertise in platforms used for disaster management in Indonesia. The list of interviewees is presented in Table 3.2. These participants were either directly involved in the implementation of the PetaBencana.id platform, had received training on its use, or were familiar with the system. The inclusion of a diverse group of stakeholders reflects the multi-level and multi-sectoral coordination essential to Indonesia's disaster management objective of enhancing national and provincial agencies' capacity to access, share, and act on multi-scale hazard information through integrated platforms. In addition, an interview was conducted with the director of Aafat.info, CogniCity's OSS adaptation in Pakistan. A complete stakeholder mapping to support easy visualization and categorization of stakeholders has also been made, which is elaborated in Results section.

Each interview, conducted via Zoom, lasted approximately one hour. Several interviewees provided supplementary documents that consist of information about their organizations' structures, organization goals related to climate action and disaster management, and the platforms they utilize. During interviews, a snowball technique of asking recommendations of other relevant stakeholders to interview was also implemented. The GAT elements were used as a basis for the questions during these semi-structured, in-depth interviews. As iterated by Bressers et al. (2015), the GAT should serve as a flexible checklist during interviews to ensure all relevant issues are covered without disrupting the conversation flow. Questions must be adapted to each case's local context, targeting appropriate strategies, actors, and levels of analysis. Sample interview questions can be checked in Appendix.

Sector type	Name of organization	Number of interviews
National level	National Disaster Management Agency (BNPB)	3
	Geospatial Information Agency (BIG)	3
Province	Provincial Disaster Management Agency (BPBD)	5
Regency/city	Regency Disaster Management Agency (BPBD)	1
Academia/ research centres	Pacific Disaster Center	3
	University of Indonesia (Disaster Expert Association)	1
Civil society	OpenStreet Map Indonesia	1
	Indonesia QGIS Community	2
Pakistan	Aafatinfo.pk	1

Table 3.2 Affiliations of the stakeholders interviewed

To safeguard informants' privacy, consent was obtained from all participants prior to the interviews. While written consent is standard practice in many research settings, Silverman (2009) argues that highly formalized procedures can, by contrast, create distance between the researcher and participant and may hinder the development of trust. As such, a flexible approach was adopted. All participants were verbally informed of the study's purpose, and verbal consent was obtained to promote comfort and openness. However, written consent was also secured from officials who preferred a formal process. Both forms of consent ensured that ethical standards were upheld while accommodating the preferences of participants. In support of this approach, Silverman (2009), Kvale & Brinkmann (2009) suggest that the strength of qualitative research often lies in the ease and flexibility of the interview process.

3.2 Data Analysis

To begin, results of literature review were summarised and categorised in a spreadsheet to get a thorough understanding of the context of the implementation of open-source and crowdsourcing technologies for climate resilience, and specific case studies, including CogniCity OSS in Indonesia.

This research employs a thematic qualitative analysis, drawing on Creswell and Creswell Báez (2021), combined with a structured approach using the Governance Assessment Tool (GAT) as an a priori framework. The predefined dimensions of the GAT guided the coding process, ensuring that insights from the interviews were systematically organized within established governance categories. This approach allows for a flexible yet structured analysis that accommodates both emergent themes and established governance

criteria. To complement the analysis, a stakeholder map was developed to visually represent relationships, responsibilities, and interactions among key actors, directly reflecting the governance dimensions of the GAT. This will be further explained in Results section.

The coding process followed 8 steps:

1. Transcribing interview data
2. Reviewing transcripts and policy documents for contextual understanding within governance categories
3. Coding text segments
4. Grouping and refining codes under relevant governance themes
5. Refining and eliminating duplicates
6. Developing theme-based passages
7. Mapping stakeholder connections based on predefined categories
8. Constructing a narrative that supports the GAT-based assessment

Interviews were transcribed, translated, and categorized according to the GAT dimensions: level and scales, actors and networks, problem perception and goal ambitions, strategies and instruments, and responsibilities and resources. All audio files were transcribed into text format using an AI transcription service. To ensure accuracy, multiple rounds of rigorous cross-checking were conducted to match the original audio recordings and the transcribed texts. Moreover, policy and regulatory documents, along with internal documents provided and recommended by interviewees, were analyzed to complement and validate the qualitative findings. In particular, information used in the introduction to the case study in Chapter 4, which covers the context of Indonesia's climate landscape, was drawn from these documents.

In the transcript spreadsheet, the keywords and concepts below (see Table 3.4) were tagged during thematic coding to capture relevant patterns and support consistency across transcripts (see Table 3.5).

GAT dimension	Examples of keywords and concepts used
Level and Scales	Coordination across national/provincial/local levels, policy gaps
Actors and Networks	Multi-stakeholder collaboration, silos, trust/distrust issues
Problem Perception & Goals	How actors define disaster risk, use of data, goal clarity, perceived challenges/goals, value of crowdsourced citizen data, data validation, different priorities, leadership perspectives
Strategies and Instruments	Use of various platforms and instruments for disaster management
Responsibilities & Resources	Budget, role clarity, training gaps, mandates, knowledge transfer, donor

Table 3.3 Coding used for transcript

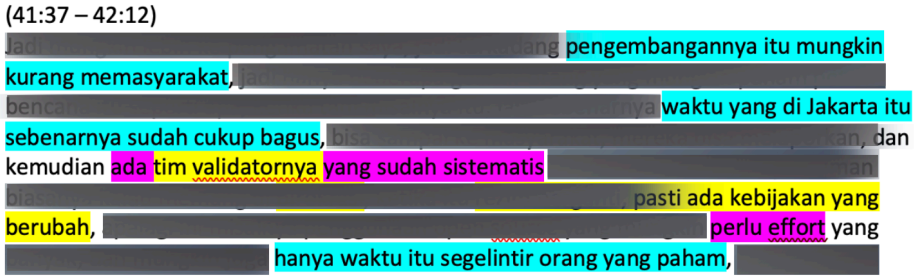

Table 3.4 Example of transcript and manual coding

A summary table based on the GAT matrix is then created, following the structure and design used in prior studies that have applied the GAT assessment (Bressers et al. 2016; Casiano Flores & Crompvoets, 2020; Jain et al., 2020; Latanna et al., 2023; Kreiner et al., 2023). The assessment table also used a colour scale to represent varying levels; ranging from red to signify 'restrictive' to a certain governance to green to signify 'supportive'. Together, these steps provided the foundation for constructing a coherent narrative, the details of which are further explained in the Results section.

3.3 Limitations

This research aims to explore the governance aspects that support and hinder the adoption of open-source and crowdsourcing technology for climate resilience initiatives. However, there are several limitations that concerns with the use of case study method, doing semi-structured interviews and providing assessments based on GAT. Case studies are often criticized for their limited generalizability, as they focus on a single or small set of cases, making broader application difficult. Their subjective nature can also introduce bias, with researchers potentially emphasizing data that supports their hypotheses. Despite these

limitations, case studies remain a powerful tool for exploring complex social phenomena. They provide context-dependent insights shaped by specific social, political, and institutional settings, unlike quantitative methods that seek universal rules. By capturing intricate relationships, power dynamics, and real-world decision-making, case studies can uncover unexpected findings and generate practical insights that bridge research and real-world application. Understanding human behaviour, governance, and decision-making requires situational awareness and practical experience, which case studies uniquely offer (Flyvbjerg, 2006).

In the case of conducting semi-structured interviews, one key limitation is that the quality of the data depends largely on rapport building, how well the interviewer facilitates the conversation and how open the interviewees are in sharing their thoughts (Dicicco-Bloom & Crabtree, 2006). Moreover, since the interviews were done online, it was harder to pick up on non-verbal cues, which can sometimes add important context (Seitz, 2016). In some cases, interviews included 2–3 people from the same organization to accommodate busy schedules, however, this may have influenced responses, with participants potentially holding back their true opinions to align with the group. Relying on self-reported data also comes with challenges, as people may interpret past events differently over time (Althubaiti, 2016). Nonetheless, interviews are essential for capturing rich, nuanced insights into individuals' perspectives and opinions, especially when addressing 'how' questions. Virtual interviews also enabled participation from individuals in geographically distant locations, reducing travel costs and saving time for both interviewers and interviewees.

Another limitation to consider is the approach used to frame interview questions, analyse interview results and findings through GAT. While the GAT provides a recent tool for assessing governance contexts across various policies and initiatives, it is not the only relevant framework. For instance, the Open-Source Adoption Framework (Fitzgerald, 2011), may offer greater insight into the adoption aspects of open-source platforms. Despite its relevance, Open-Source Adoption Framework primarily focuses on the technical aspects, developer communities and evolution of open-source projects, rather than the governance aspects. Other similar tools to the GAT include Governance Assessment Frameworks are the Fit-for-purpose Governance Assessment Framework (Rijke et al., 2012), the OECD Multi-level Governance Framework (Charbit, 2011), the Management Transition Framework (Pahl-Wostl et al., 2010), and the Land Governance

Assessment Framework (Burns et al., 2011). Unlike sector-specific frameworks like the Land Governance Assessment Framework or high-level policy coordination tools like the OECD framework, and in contrast to the Fit-for-Purpose Governance Framework, which lacks standardized indicators and empirical validation; the GAT provides a more comprehensive approach to analysing policies in complex governance settings, particularly in climate and sustainability. Overall, in comparison to other frameworks, the GAT puts an emphasis on multi-stakeholder interactions across complex policy settings, making it well-suited for assessing governance factors surrounding OSS adoption for climate resilience.

4 Case Study: CogniCity OSS Project in Indonesia (PetaBencana.id)

4.1 Wider Context: Indonesia's Climate Landscape

Indonesia is one of the most geographically and ecologically diverse nations in the world, however its very landscape makes it exceptionally vulnerable to environmental and disaster-related challenges. As an archipelago of over 17,000 islands, it is positioned between the Indian and Pacific Oceans, placing it at the centre of major global trade and maritime routes. This geographical advantage, however, comes with significant risks, as Indonesia is located in the Pacific Ring of Fire, where the convergence of the Indo-Australian, Eurasian, and Pacific tectonic plates results in frequent seismic activity. Earthquakes, volcanic eruptions, and tsunamis are persistent threats, with major disasters such as the 2004 Indian Ocean tsunami and the 2018 Palu earthquake.

Beyond its geological vulnerability, Indonesia faces increasing climate-related challenges. Sea level rise, land subsidence, extreme weather, and environmental degradation are intensifying the country's exposure to disaster. For example, Jakarta has one of the fastest rates of land subsidence in the world, between 3–10 cm per year, combined with sea level rise of 0.1–0.6 cm annually between 1961 and 2015. These trends have contributed to more severe and frequent flooding, particularly in low-lying coastal areas such as northern Java.

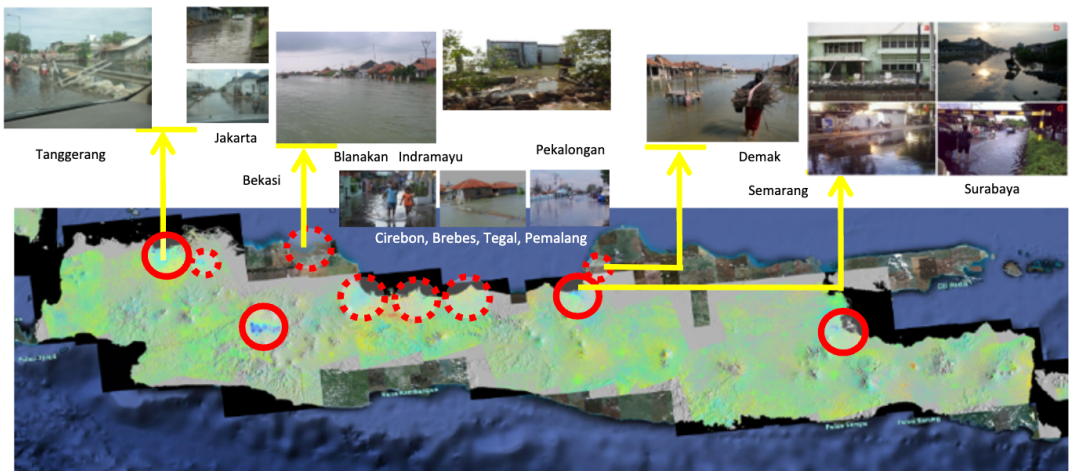

Figure 4.1 Severe and frequent flooding cases along the northern coast of Java, in low-lying urban areas (source: Badan Informasi Geospasial, personal communication, January 19, 2024)

To give context of the mapping references and recurring terms in the Results section, it is first useful to know how Indonesia administrative is structured. Indonesia's administrative structure is generally divided into four levels. The two highest levels are defined in the 1945 Constitution (UUD 1945) and function as autonomous regions, while the two lower levels are outlined in Law No. 23 of 2014[4]. These administrative divisions are as follows:

1. **Province** (*Provinsi*)
2. **Regency and City** (*Kabupaten* and *Kota*)
3. **District** (*Kecamatan*)
4. **Village and Sub-district** (*Desa* and *Kelurahan*)
5. **Community Unit and Neighborhood Unit** (*Rukun Warga* or *RW* and *Rukun Tetangga* or *RT*)

In terms of policies, in response to escalating environmental and climate-related challenges, Indonesia has made disaster risk reduction and climate adaptation national priorities. The country has adopted the Sendai Framework for Disaster Risk Reduction (2015–2030), which emphasizes understanding risk, strengthening governance, investing in resilience, and enhancing preparedness (UNDRR, 2015). National agencies such as the BNPB, Regional Disaster Management Agency (BPBD) at provincial (*Provinsi)* and regency/district (*Kabupaten*/*Kota)* levels, and the Geospatial Information Agency (BIG) have played central roles in implementing these priorities. Through the use of geospatial information systems, they have improved early warning mechanisms, enhanced risk mapping, and supported more informed policy planning aimed at building resilience at both local and national levels (Ogie et al., 2017).

The National Disaster Management Agency (BNPB) plays a central role in Indonesia's disaster management system, overseeing policy development, cross-sector coordination, and leading disaster response at the national level. Under Law No. 24 of 2007[5], BNPB is responsible for managing all phases of disaster management: mitigation, preparedness, response, recovery, and prevention. To enhance coordination and data governance, BNPB

[4] National Law No. 23 of 2014: https://peraturan.bpk.go.id/Details/38685/uu-no-23-tahun-2014
[5] National Law No. 24 of 2007: https://peraturan.bpk.go.id/Details/39901/uu-no-24-tahun-2007

issued BNPB Regulation No. 1/2023 on Indonesia One Disaster Data (Perban No. 1/2023 Satu Data Bencana)[6] and Implementation Guidelines No. 7 of 2023 (Juklak No. 7/2023)[7], which standardise disaster data reporting and impact assessment across government levels.

At the operational level, BNPB collaborates closely with Regional Disaster Management Agencies (BPBDs), which implement disaster management on the ground across provincial and district levels. Typically, BPBDs are structured into specialised divisions of emergency response, logistics, rehabilitation, and reconstruction, supported by task forces and administrative teams. They are also responsible for collecting disaster data through field assessments, community reports, and volunteer inputs. This information is compiled and sent to BNPB's Pusdalops (Emergency Operations Center) for daily verification, followed by quarterly validation through site visits, virtual meetings, or phone consultations to ensure accuracy. Verified data is then standardised into formats such as datasets and infographics for both internal and public use. BNPB also utilizes several digital platforms for its operation, including InaRISK for disaster awareness designed for public use and InAWARE for real-time hazard monitoring. Furthermore, BNPB also makes use of initiatives like PetaBencana.id platform, which leverages citizen-generated reports to enhance real-time disaster response capabilities.

Supporting both BNPB and BPBD, the Geospatial Information Agency (BIG) ensures that accurate and accessible geospatial data is available to guide decision-making in various fields of urban planning, infrastructure development, environmental management, and disaster management. Mandated by Law No. 4 of 2011[8], that provides the foundational legal framework for management and use of geospatial data in Indonesia, including in disaster-related contexts, BIG leads the implementation of the One Map Policy (Satu Data Indonesia), ensuring geospatial consistency by coordinating mapping activities across government ministries and agencies. All regional spatial plans are required to utilise BIG's base maps, which are accessible through the Satu Data Portal and offer multi-scale geospatial information for both national and local applications. Unlike BNPB and BPBD, which operate across all phases of disaster management, BIG

[6] BNPB Regulation No.1 of 2023: https://peraturan.bpk.go.id/Details/240472/peraturan-bnpb-no-1-tahun-2023
[7] Implementation Guidelines No. 7 of 2023 concerning One Data Indonesia: https://data.bnpb.go.id/dataset/juklak-standar-data-kejadian-dan-dampak-bencana
[8] National Law No. 4 of 2011: https://peraturan.bpk.go.id/Details/39136/uu-no-4-tahun-2011

focuses primarily on pre-disaster activities, particularly mitigation and preparedness, by providing essential data infrastructure and technical support to inform downstream response and recovery operations. Reinforcing its role in advancing integrated geospatial governance, BIG is currently focusing on a long-term project running until 2029, funded by the World Bank. This initiative aims to achieve comprehensive geospatial coverage across Indonesia.

Together, these agencies collaborate with other government partners: the Meteorology, Climatology, and Geophysics Agency (BMKG) for early disaster warnings; the Ministry of Environment and Forestry (KLHK) for forest fire prevention and early warning systems for haze and environmental disasters; and the National Search and Rescue Agency (Basarnas), the Indonesian National Armed Forces (TNI) and National Police (POLRI) to lead emergency response operations. Furthermore, international stakeholders, NGOs and civil society actors that play a vital role in advancing climate resilience initiatives across Indonesia.

An important international partner in Indonesia's disaster management ecosystem is the Pacific Disaster Center (PDC), an applied science and research center managed by the University of Hawaii. Renowned for its advanced risk intelligence platforms, PDC collaborates with BNPB and other stakeholders to enhance disaster preparedness and response. A key outcome of this partnership is InAWARE, a customized version of PDC's DisasterAWARE platform tailored specifically for Indonesia. InAWARE provides real-time hazard monitoring and integrates global data with local risk assessments, supporting decision-makers at both national and provincial levels.

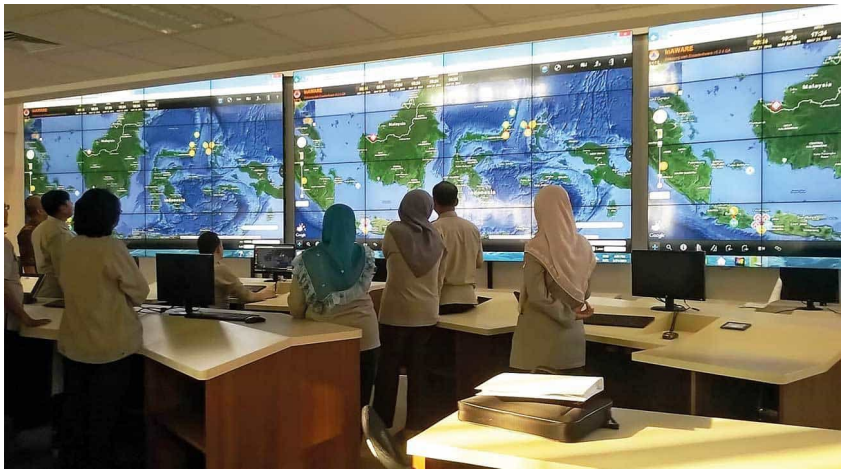

Figure 4.2 Staff monitor real-time hazard data using InAWARE (PDC, 2020)

Another key partner is HOT Indonesia (Humanitarian OpenStreetMap Team Indonesia), which leverages the OpenStreetMap (OSM) platform to carry out spatial mapping to disaster management efforts. It works closely with BNPB, BPBD, and local government offices (*Kelurahan*), collaborating to collect and update administrative boundary data, especially in disaster-prone areas. The scope of these mapping activities typically depends on requests from local BPBD offices. For example, these activities have involved BPBDs in Jakarta, East Java, and Semarang. NGOs and organizations like YPB have also collaborated with HOT Indonesia, using OSM's data to enhance their disaster datasets.

HOT Indonesia's work also involves a broader collaboration with international partners, including USAID, the Pacific Disaster Center (PDC), and the Massachusetts Institute of Technology (MIT). Together, they support BNPB through initiatives such as the development of InAWARE. Specifically, HOT Indonesia contributes by mapping essential data, which is first entered by data specialists and then reviewed by a Quality Assurance team to ensure accuracy.

Beyond mapping, HOT Indonesia also collaborates with BPBDs through training sessions that focus on OpenStreetMap data collection and maintenance, as well as on disaster management operational activities. These sessions cover the practical use of digital tools like InAWARE, PetaBencana (or PetaJakarta), and InaSAFE, helping BPBDs strengthen their on-the-ground disaster response and preparedness.[9]

Complementing HOT Indonesia's mapping efforts is the QGIS community, a global and local network of users and developers dedicated to advancing open-source geospatial tools. Central to their work is QGIS, a widely used open-source GIS software that enables spatial analysis and visualization of geospatial data. In Indonesia, QGIS has become a cornerstone for both disaster management and environmental initiatives, supporting projects from flood risk assessment to land-use mapping for carbon reduction in Bali and mangrove conservation in Sumatra and Kalimantan. Importantly, QGIS serves as the foundation for InaSAFE, a free and open-source tool developed in close collaboration with BNPB. InaSAFE allows users to generate realistic natural hazard impact scenarios

[9] HOT Indonesia collaboration with BPBDs: https://www.hotosm.org/projects/disaster-early-warning-and-capacity-building-inaware

that enhance planning, preparedness, and response efforts, that can be used complementary with other platforms managed by BNPB.

Platform	Main Stakeholders	Type	Purpose
InAWARE	BNPB, PDC, USAID	Government use only, web-based dashboard	Real-time hazard monitoring and interagency coordination
InaSAFE	BNPB, World Bank, QGIS community	Plugin for QGIS, publicly accessible[10]	Disaster impact modelling for planning
InaRISK	BNPB, UNDP	For public use[11], mobile app available	Public risk awareness and self-assessment for disaster preparedness

Table 4.1 Overview of BNPB's disaster management platforms

NGOs have also played a critical role in helping vulnerable and informal communities strengthen their capacity to cope with disaster risks in Indonesia (Djalante et al., 2012). Often working in collaboration with governments, NGOs help implement community-based programs, extend state capacity, and foster participatory approaches to resilience building (Brass, 2022). Among these NGOs, is YPB; the NGO responsible for the development and maintenance of the PetaBencana.id platform to support Indonesia's climate resilience efforts.

4.2 Development of PetaBencana.id: Origins, Mechanism and Evolution

The CogniCity OSS project[12], which led to the creation of the PetaJakarta.id platform (English: Jakarta Map) and was later rebranded in 2019 as PetaBencana.id (English: Disaster Map), began in 2013 as an applied research initiative by the University of Wollongong in Australia. It was developed in collaboration with the MIT Urban Risk Lab, the initiators and developers of PetaJakarta.id, Jakarta's Regional Disaster Management Agency (BPBD DKI Jakarta), and Twitter Inc. (Ogie et al., 2017; Hidayat, 2020; Fadmastuti et al., 2024).

The project emerged as a response to Jakarta's chronic flooding challenges, which have repeatedly disrupted daily life and caused significant economic losses, US$565 million in 2007 and US$775 million in 2013 alone (Fadmastuti et al., 2024). The initiative was designed to deliver a faster, more inclusive, and participatory flood information system

[10] InaSAFE open-source code on GitHub: https://github.com/inasafe/inasafe
[11] InaRISK: inarisk.bnpb.go.id
[12] CogniCity project: https://cognicity.info/

to overcome the limitations of traditional, centralized disaster response mechanisms (Ogie et al., 2019).

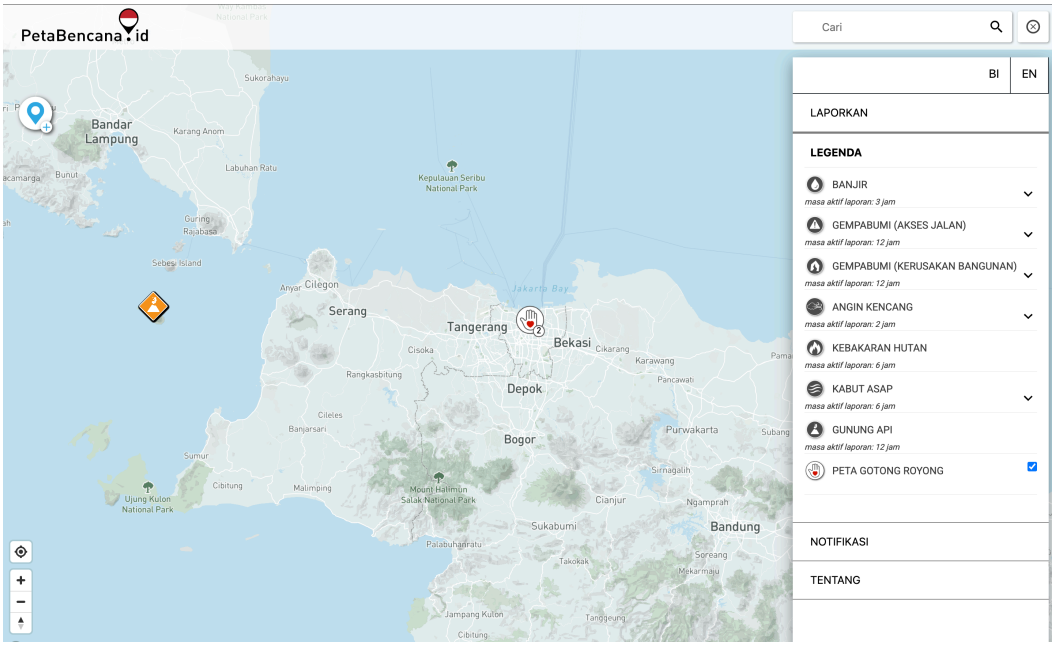

Figure 4.3 PetaBencana.id platform (source: CogniCity website)

The platform works in three main steps: **GATHER**, **SORT**, and **COMMUNICATE** (AHA Centre, 2021). In the **GATHER** phase, the system scans social media platforms such as Twitter and Facebook for keywords like 'flood' or *banjir* (the Indonesian word for flood). Users are encouraged to enable geolocation on their devices when posting, which helps the system accurately map their reports. In the **SORT** phase, humanitarian chatbots respond to these posts, prompting users to confirm whether they are reporting a real-time flood event and to add useful details, such as water depth or photos. The platform then filters and semi-automatically verifies the incoming data. Finally, in the **COMMUNICATE** phase, verified reports are visualized as geotagged markers on a publicly accessible map on PetaBencana.id. This interface combines citizen-generated data with official datasets, such as the locations of pumps, floodgates, and drainage infrastructure, to provide a comprehensive, real-time picture of flood conditions. With its focus on open access, transparency, and ease of use, the platform strengthens communication between the public and government agencies, supporting the co-production of knowledge and fostering trust in disaster response efforts (AHA Centre, 2021; Ogie et al., 2019; Fadmastuti et al., 2024). At present, this operational model is also applied to other disaster contexts beyond flooding, such as forest fires and earthquakes,

and has expanded to cities including Surabaya and Bandung. Though YPB faced challenges replicating the platform due to limited public access from older mobile phone systems and weaker network coverage outside Jakarta, it sought to overcome these obstacles by expanding server capacity (Hidayat, 2020; Widyanarko, 2018).

By transforming everyday citizens into 'human sensors,' the platform strengthens local capacity to respond to crises and fosters a culture of collective responsibility. Although studies have noted some discrepancies in the accuracy of georeferenced social media data, for example, only 64.2% of tweets were geolocated to the correct urban village sub-district (*kelurahan),* the platform continues to be used as a complementary tool in decision-making (Ogie et al., 2017). To address these concerns, BPBD Jakarta came up with a Risk Evaluation Matrix (REM), which allows the staff officials to review, cross-check, and validate incoming reports before updating the public map; an effort that still largely requires human oversight and manual decision-making (Ogie et al., 2019).

Ultimately, YPB's success rests on multi-stakeholder collaboration involving key partners such as government agencies, academic institutions, private tech firms like Twitter Inc., and international research centers, most notably, PDC; major donors such as the USAID, one of the largest funders of YPB (Widyanarko, 2018; Fadmastuti et al., 2024); and media partners (such as CNN Indonesia, The Jakarta Post, Metro TV, and BBC) as well Qlue, private Indonesian tech company that developed a mobile app allowing Jakarta residents to report problems in real time, including flooding, waste, traffic, and infrastructure issues, which has partnered with BPBD DKI Jakarta (Hidayat, 2020).

Additionally, what began as a local innovation in Jakarta has been adapted internationally. In 2020, the CogniCity OSS was implemented in the Philippines as MapaKalamidad.ph platform, supporting flood reporting and risk communication. In 2021, it was localized in Pakistan as AafatInfo platform. These international adaptations illustrate the model's flexibility and relevance, offering a scalable, people-centred approach to disaster management well beyond Indonesia (AHA Centre, 2021).

As part of its project activities, YPB provides training to BNPB, BPBD, and related agencies on how to use the platform effectively. It also processes reports from the platform to complement official systems within BNPB and BPBD offices. However, in

2020, when a request was submitted to provide for more detailed mapping data down from RW level (community unit level) to RT level (smallest neighbourhood unit level), the platform was unable to accommodate this request. Unfortunately, there has been no further collaboration with BPBD Jakarta since then. Combined with challenges such as donor funding cuts, the platform's implementation has faced increasing difficulties in recent years, which will be further examined in the Results and Discussion sections.

5 Result

In this chapter, the results of the study are presented through two key components: a stakeholder map and GAT assessment. These results aim to evaluate the governance context surrounding the adoption of the PetaBencana.id platform in Indonesia's climate resilience efforts.

5.1 Stakeholder Map

The stakeholder landscape around PetaBencana.id platform adoption is multi-layered and diverse, involving a complex mix of government institutions, universities, NGOs, and local communities, which involves more than 30 different actors (Hidayat, 2020). Government agencies directly involved include BNPB and BPBD DKI Jakarta, while BIG, BMKG, and KLHK provide indirect support. International partners such as MIT Urban Risk Lab and the Pacific Disaster Center (affiliated with the University of Hawaii) contribute technical expertise. USAID, the platform's major donor, has played a critical role in its development, supported by additional grants from Australian Aid and the Information Society Innovation Fund (ISIF) Asia. The private sector includes Twitter Inc. and media partners like CNN Indonesia, Metro TV, The Jakarta Post, and BBC (Hidayat, 2020). From academia and civil society, University of Indonesia and the QGIS community offer indirect support through research and open-source contributions. While over 30 actors are connected to the platform, the visual highlights key stakeholders, ensuring clear representation across sectors. The inclusion of AafatInfo in Pakistan, built on the same OSS infrastructure, further illustrates the model's potential for replication. Figure 5.1 on the following page presents the stakeholder map.

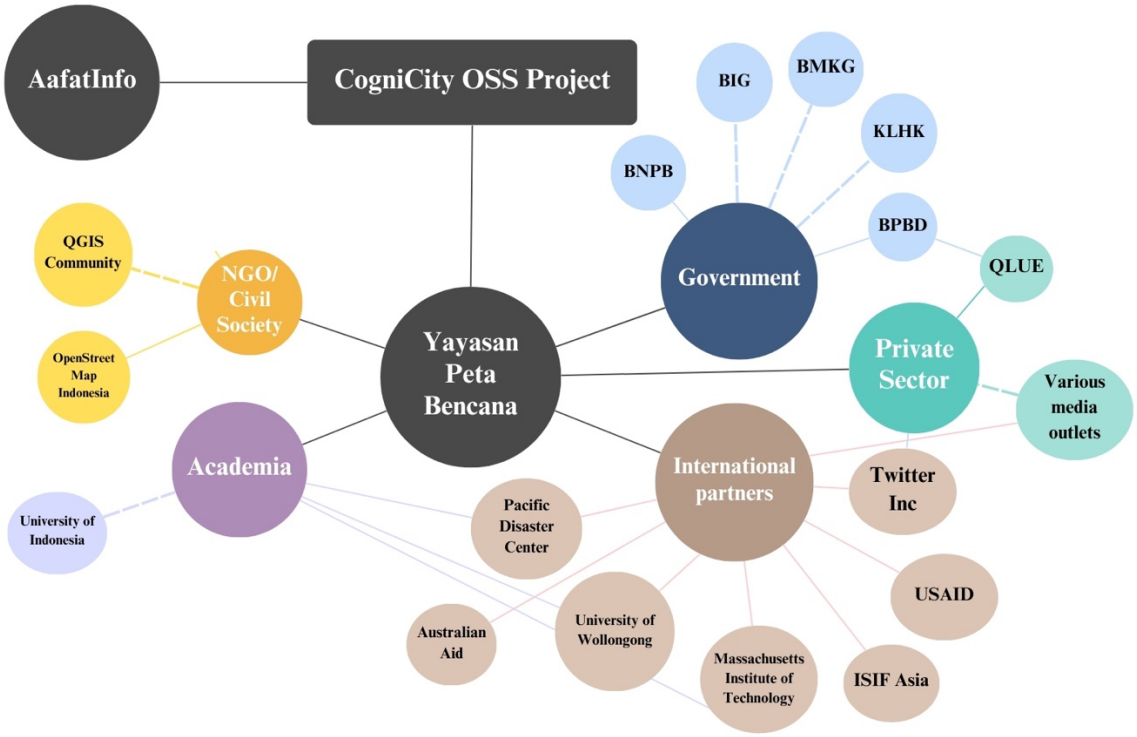

Figure 5.1 Stakeholder map (source: from author)

5.2 GAT Assessment of PetaBencana.id Platform Adoption

It is important to note that governance contexts are inherently dynamic, particularly for the adoption and implementation of digital platforms like PetaBencana.id, which evolve in response to technological advances and changing institutional landscapes. This thesis sets the focus on the period of 2019–2025, capturing the platform's transition from merely a Jakarta-based initiative to a national-scale disaster management tool. This period reflects a distinct phase of growth, institutional collaboration, and key challenges, such as the suspension of collaboration with Jakarta in 2020, when BPBD DKI Jakarta's request for more detailed mapping data down to the RT (smallest local administrative unit) level could not be accommodated, and the USAID funding cuts in 2025. By narrowing the scope to this period, the assessment offers the supportive and restrictive governance aspects at a stage of operational maturity, while recognizing that governance dynamics will continue to evolve as Indonesia advances its disaster management strategy.

5.2.1 Level and Scales

Extent: Moderate to Supportive

The government levels involved in the project are: national (BNPB), provincial, and district (BPBD) levels. Each of government agency levels plays a distinct role, with the BNPB at the national level overseeing strategy, and the BPBD handling operational response. While this structure supports broad inclusion, the actual engagement with platforms like PetaBencana.id varies greatly across regions. In more developed areas such as Jakarta, PetaBencana.id was integrated into official systems, but only on a temporary basis. BPBD Jakarta also participated in the platform's verification process during its early implementation. In contrast, awareness and use of the platform in other regions remain limited. A regency-level officer stated, "We've heard of [PetaBencana], but we haven't received any training or instructions to use it." Overall, the extent of participation is moderate, with adoption largely dependent on local capacity and leadership.

Coherence: Moderate

Government actors generally strive to engage in collaborative efforts, though the process remains complex and inconsistent. Coordination between BNPB and BPBDs is established in principle, such as through routine data verification and the use of national platforms. Regular updates are exchanged through long-distance communication channels, including telephone calls and WhatsApp groups, which facilitate daily interaction with local agencies. While these mechanisms function effectively for core disaster management tasks, they do not systematically integrate external platforms like PetaBencana.id into formal disaster response structures.

Overall, trust and collaboration between national and local levels exist, but the levels tend to vary across regions. Several interviewees highlighted ongoing challenges related to data sharing and institutional trust within the routine operations of disaster management. As one interviewee explained, "In some cases, institutions are reluctant to share data due to a sense of ownership and fear their work will be exploited. This ego-driven mentality hinders collaboration."

Flexibility: Moderate

There is some ability to move between levels, but flexibility is limited by fragmented coordination and uneven capacities across government tiers. Local agencies are able to incorporate external platforms such as PetaBencana.id into their workflows, however, this tends to be short-lived and is not embedded into regular routines. In reality, data from PetaBencana.id can be used in a complementary way but is not formally verified by BPBDs or BNPB, which limits its influence on official decision-making. Early ambitions for scalable coordination, driven by BNPB and YPB, did not fully materialize. As one interviewee explained, "[The initial] idea when PetaJakarta was developed was that BPBD would verify reports and issue the hazard... In fact, it was rolled out for Jakarta... but it never fully scaled." This highlights that, in reality, there is no formal process for adopting and integrating the PetaBencana.id platform, and flexibility to shift responsibilities between national and local actors remains limited.

Intensity: Restrictive to Moderate

Although BNPB sets national disaster policy and promotes the use of digital platforms like PetaBencana.id, its influence on local governance reform and behavioral change remains relatively weak. There is little evidence that national-level initiatives have led to sustained adoption or meaningful shifts in local practices. While BPBDs may participate in training sessions on implementing PetaBencana.id platform, actual use of the platform is minimal. As one BPBD official explained, "We've attended training on PetaBencana, but in practice, we haven't really used it during actual disasters. We're familiar with it, but mostly just tried it out." It is important to note that this may vary depending on the specific BPBD region. Nonetheless, this indicates that, despite national encouragement, local agencies retain substantial autonomy and often continue relying on their existing systems. Top-down pressure is more advisory than directive.

5.2.2 Actors and Networks

Extent: Supportive

The implementation of PetaBencana.id is supported by an inclusive and multi-sectoral governance ecosystem, with broad engagement across national, provincial, and district levels. In addition to government actors, the platform has attracted participation from

international NGOs, academic institutions, and diverse civil society groups. This wide constellation of stakeholders contributes to a governance environment rich in expertise and adaptable in its collaborative structures. Several interviewees noted a general openness among these actors to engage in co-productive disaster governance, particularly regarding the adoption and use of PetaBencana.id. One interviewee reflected this spirit, stating, "Our [Indonesian] culture is really based on *gotong royong* (mutual cooperation). We have a strong spirit of working together."

While the depth of engagement varies by region, the presence of these actors forms a strong foundation for collaborative governance. Even in areas where BPBD involvement has been limited, the current network offers potential for future expansion and deeper institutionalization. This evolving network is especially valuable as climate-related disasters become more frequent and complex. Notably, no major stakeholder groups appear to be excluded.

Coherence: Moderate

Broadly, collaboration relies more on informal relationships than on established institutional mechanisms. During disaster events, collaborative interactions are often temporarily activated that enable multi-sector coordination among local government agencies, NGOs, and community volunteers. As one BPBD officer noted, "In disaster response, we form multi-sector coordination through post-commando units, involving local government agencies, external partners, and volunteers." These arrangements are typically effective in the short term, driven by urgency and a shared operational focus. However, such collaboration is rarely sustained beyond the immediate crisis. Outside of emergency situations, the absence of formal structures or long-term coordination frameworks means that inter-agency engagement often fades, and actors return to working in silos.

This pattern presents a significant challenge for PetaBencana.id platform adoption, which depend on sustained institutional commitment for consistent data sharing, verification, and integration into official workflows. While interpersonal trust and a willingness to collaborate are evident, these dynamics are not consistently embedded in institutional routines. As a result, the platform's adoption and implementation remain largely ad hoc,

relying on the initiative of individual actors rather than being guided by formalised protocols.

Flexibility: Moderate to Supportive

There is clear evidence that new actors, particularly non-governmental organizations, have been included in the governance ecosystem when their expertise or resources are needed. These actors often step in to provide technical training, support data management, or lead public engagement efforts. Their involvement demonstrates a degree of adaptability in the governance system, where roles can be shared or temporarily reassigned in response to practical challenges or capacity gaps.

However, within government agencies, hierarchical structures and rigid administrative norms limit the ability to reassign leadership or decision-making authority when circumstances demand it. Several interviewees pointed to barriers, such as the need for constant upward approval and a lack of autonomy among frontline staff. As one interviewee noted, “If the leadership is open and understands the issue, collaboration becomes easier. But government structures are still very rigid, and staff often defer decisions by saying they have to ask their boss.” This rigidity makes it difficult to adapt quickly or delegate responsibility, even in urgent scenarios.

Despite efforts to build internal capacity through training, knowledge retention is often poor due to frequent staff rotations. One respondent recounted, “Training was given, but then the person was transferred, and the knowledge couldn’t be used anymore in their new position.” These personnel changes not only disrupt program continuity but also prevent the embedding of new practices or innovations within government systems. However, while there are significant constraints, the broader governance ecosystem has shown a commendable ability to adapt by mobilizing external partners.

Intensity: Moderate

While certain stakeholders are actively pushing for change, the level and reach of their influence vary across institutional settings. Initially, BNPB has publicly endorsed digital innovation and platforms like PetaBencana.id. However, its capacity to enforce or operationalize these innovations at the local level remains limited. In contrast, non-governmental actors, including, YPB, have played a more proactive role in promoting the

platform, encouraging behavioural change, and increasing awareness. As one interviewee noted, “Success depends on gaining the confidence of decision-makers… If they can win over BNPB or showcase results in [a specific region], the rest could follow.” This suggests that while there is visible pressure from some actors, its intensity is uneven and contingent on local relationships and informal influence rather than structural authority.

5.2.3 Problem Perception and Goal Ambitions

Extent: Moderate

The extent to which diverse perspectives are taken into account remains moderate. For instance, BNPB often endorses policies on data centralization, platform integration during all disaster phases, and formal reporting structures, while local BPBDs are more focused on immediate response and operational readiness. One interviewee noted, “Usually, with BNPB’s national systems, we experience access difficulties. Sometimes the system is slow or not fully ready, or it’s developed without really considering our local needs. At the local level, we often have special requirements that aren’t accommodated, so we end up developing our own tools.”

Moreover, while NGOs and international partners advocate for inclusive, community-centred approaches, their perspectives are not always fully integrated into formal planning. For example, the value of crowdsourced citizen data is recognized by some but still questioned by others who emphasize verification. This results in inconsistent inclusion of bottom-up insights. Overall, diverse views are not always equally reflected in problem framing or goal-setting, suggesting that participation is present, but unevenly influential in shaping the governance agenda. Although, there is a general agreement that real-time disaster information is crucial among different stakeholders.

Coherence: Moderate

Although a variety of actors contribute to disaster governance, their strategic goals and interpretations of key issues often lack alignment. One interviewee noted that, “Coordination is challenging when everyone has different priorities and agendas”, highlighting the fragmented nature of goal-setting. Conflicts also emerge over the perceived value of citizen-generated data, some stakeholders see it as empowering and timely, while others dismiss it as unreliable unless institutionally verified.

Flexibility: Moderate

There is room for goals to shift over time, particularly in response to changing risks or technological developments. YPB, in particular, has demonstrated flexibility by expanding the platform beyond Jakarta to other cities and by adapting to cover broader disaster types beyond flooding. However, in the government setting, the process of reassessing and adjusting goals is not especially systematic or proactive; instead, changes tend to occur reactively, typically following shifts in leadership. As one government official explained, "Every leader has their own policy. When leadership changes, the policy and focus change too… If you look at it, every time we change presidents, it is rare for policies to stay consistent. These problems within government bureaucracy remain a major challenge." This suggests that while flexibility exists in principle, it is often unpredictable and inconsistent, with shifts in priorities shaped more by leadership turnover than by deliberate, ongoing evaluation. As a result, this dynamic creates uncertainty for YPB's long-term collaboration with government, as sustaining and scaling the platform depends heavily on stable institutional support.

Intensity: Moderate

Several stakeholders are pushing for new and creative approaches to disaster management. These include using crowdsourced data, testing AI-based validation, and promoting open-source platforms. One interviewee mentioned the potential to "automate validation once they have a methodology," which could really speed up and improve the reliability of citizen-reported disaster information.

However, within government institutions, the drive for big changes is often held back by political shifts, limited resources, and a cautious mindset. While there is growing awareness of the need to modernize and a general agreement on the importance of having real-time disaster information, only a few consistently push for major reforms. Overall, the ambitions show a moderate level of intensity, the governments are open to innovation in principle but still slow to break away from established routines.

5.2.4 Strategies and Instruments

Extent: Restrictive to Moderate

Government actors use a combination of regulatory tools (such as contingency plans and formal standard operating procedures or SOPs), technical instruments (including platforms like InAWARE), and social measures (such as community awareness campaigns) to encourage platform adoption and engagement. While these instruments provide a solid foundation, their practical application is uneven. PetaBencana.id platform is widely praised for their usability and public engagement, but formal adoption and integration level varies accross regions. In particular, the verification of crowdsourced data from PetaBencana is crucial to ensure reliability. As one interviewee emphasized, "They really need to ensure proper verification, because coordination with BPBD is crucial to make sure that incidents are accurately reported. For example, if floodwaters only last 10 or 20 minutes, it shouldn't be categorized as a flood, but simply as temporary waterlogging." This highlights a key gap: although the necessary tools and technical processes exist to support PetaBencana.id's adoption, weak enforcement and unclear mandates continue to limit their effectiveness and reliable use across regions.

Coherence: Restrictive to Moderate

Multiple platforms such as PetaBencana.id, InAWARE, InaSAFE, and InaRISK operate side by side but are not fully integrated, leading to duplication, data silos, and parallel workflows. For example, PetaBencana data has been automatically sent to InAWARE via API, but this process is not fully institutionalized or consistently used in formal decision-making. These gaps create conflicting incentives and fragmented coordination. As one interviewee noted, "Even within one institution, there are too many tools developed, and departments don't always know what others are using." Much of the overlap stems from leadership turnover, which often leads to changes in preferred systems without a long-term strategy. Efforts to improve synergy or to make systems interoperable are considered, but not yet standardized or enforced.

Flexibility: Moderate

There is room to combine policy instruments creatively within Indonesia's disaster governance system, though this potential remains underused. The governance framework

allows local actors to adapt and mix tools based on situational needs. For instance, WhatsApp and social media alongside platforms like PetaBencana.id are used to report and verify disaster information, creating a hybrid system that blends official and community-based inputs. As one interviewee stated, "[In BNPB], most disaster information comes in through WhatsApp, which is Indonesia's main communication tool. Reports include coordinates and location details, but the data is often fragmented and takes time to compile and verify before it can be used for official decision-making." This demonstrates that technical and social tools are often combined in practice. While there is flexibility to adapt instruments creatively, more structured coordination and institutional support are needed to ensure these integrations are formalized and consistently applied across regions.

Intensity: Moderate

The platform itself provides a clear incentive for public participation, as users can see their reports visualized instantly on a public map, which creates a sense of ownership and usefulness. This design encourages reporting and increases engagement: "We can immediately see our report… that visualization helps people feel their data matters," said one interviewee. However, the strength of institutional support varies. While the system has mechanisms for integration into tools like InAWARE and has been used effectively during past events, these are not enforced through formal mandates. Success often relies on personal leadership and external donor support, rather than institutionalized policies.

5.2.5 Responsibilities and Resources

Extent: Restrictive to Moderate

While responsibilities are defined on paper, resource allocation is often uneven, where human resources and technical capacity can be stretched thin. While many actors are willing to contribute during disasters, the real challenge lies in coordinating these efforts effectively. One official noted, "As an agency, we are still 'feeling our way through' when it comes to fully understanding and managing the scope of responsibilities and resources." While platforms like PetaBencana.id are available and integrated into some workflows, funding and support for long-term training and maintenance are inconsistent.

Coherence: Moderate

While roles and responsibilities in disaster governance are formally defined across agencies, coherence in their execution is moderate. Coordination efforts such as the TRC units (Rapid Response Teams) are in place to verify and respond to disasters promptly. However, interviewees noted that during off-hours or fast-evolving crises, not all agencies respond consistently or in a timely manner, leading to operational gaps. As one local official observed, "BPBD works 24/7, but other departments don't always respond outside working hours." This underscores a gap in cross-agency commitment during emergencies. Although the formal structure promotes inter-agency cooperation, practical challenges, such as uneven engagement and limited resources, hinder smooth, coordinated action.

Flexibility: Restrictive to Moderate

Pooling responsibilities and resources is possible without compromising transparency and accountability, as long as strong governance and technical standards are in place. Indonesia's One Data policy provides a solid foundation for data consistency across agencies. As one official explained, "The key is interoperability, sharing data through APIs where the metadata and standards are aligned. It doesn't matter which application is used, as long as the data stays consistent and follows the One Data policy."

That said, challenges remain in practice. Interviewees pointed out that frequent staff rotation, where skilled staff are often moved to other departments or sectors, makes it difficult to maintain continuity and institutional knowledge, which can weaken accountability over time.

Intensity: Restrictive

Resources vary between agencies, and stakeholders widely agree they are insufficient to drive meaningful change. While roles are formally defined, inconsistent follow-through, leadership turnover, and frequent staff rotations disrupt continuity and weaken institutional capacity. Long-term planning and stable funding remain limited. As one official noted, "We have the structure on paper, but when it comes to execution, resources and commitment just don't match the needs on the ground." Weak institutional support and shrinking resources, worsened by donor funding cuts, such as USAID's withdrawal,

have further hampered the long-term sustainability of PetaBencana.id's platform adoption.

Governance Dimension	**Quality**			
	Extent	Coherence	Flexibility	Intensity
Level and scales	Moderate to Supportive	Moderate	Moderate	Restrictive to Moderate
Actors	Supportive	Moderate	Moderate to Supportive	Moderate
Problem perception and goal ambitions	Moderate	Moderate	Moderate	Moderate
Strategies and instruments	Restrictive to Moderate	Restrictive to Moderate	Moderate	Moderate
Responsibilities and resources	Restrictive to Moderate	Moderate	Restrictive to Moderate	Restrictive

Table 5.1 GAT assessment results

The table below presents an overall assessment exclusively of the governance dimensions, showing mostly moderate ratings with some declining trends over time, except for actors, which demonstrate a moderate to supportive improvement, while responsibilities and resources are rated more restrictively.

Governance Dimension	**Overall Assessment**
Level and scales	Moderate ▼
Actors	Moderate to Supportive ▲
Problem perception and goal ambitions	Moderate ▼
Strategies and instruments	Moderate ▼
Responsibilities and resources	Restrictive to Moderate ▼

Table 5.2 Overall assessment of GAT dimensions

On the other hand, the governance quality assessment shows moderate scores overall, accompanied by a downward arrow, indicating a declining trend.

Governance Quality	**Overall Assessment**
Extent	Moderate ▼
Coherence	Moderate ▼
Flexibility	Moderate ▼
Intensity	Moderate ▼

Table 5.3 Overall assessment of GAT qualities

6 Discussion

This section further discusses the findings from the interviews and interprets the results of the GAT analysis, following the structure around the thesis's research objectives:

- **Objective 1**: To explore the governance challenges and opportunities surrounding the PetaBencana.id platform

  → Addressing Research Question 1: How do different governance aspects support or hinder the adoption of an open-source platform for climate resilience initiatives in Indonesia?

  → Addressing Sub-research Question: How do different government agencies perceive crowdsourced data within open-source platforms be utilized for climate resilience efforts?

- **Objective 2 & 3**: To identify lessons from Indonesia that can support the replication of similar platforms in other Global South contexts

  → Addressing Research Question 2: What lessons can be derived from Indonesia's case to support Pakistan in scaling its open-source climate resilience platform?

  → Addressing Sub-research Question*:* What lessons from Indonesia and Pakistan can guide the adoption of open-source climate resilience platforms in other countries?

6.1 Enablers and Hindrances to PetaBencana.id Platform Adoption

This section will discuss the different governance aspects across the GAT qualities and dimensions. To recall, the GAT assessment revealed a complex governance landscape surrounding the PetaBencana.id platform in Indonesia. Its initial success during Jakarta's 2015 floods showcased its potential, but sustaining engagement proved difficult, despite outreach initiatives by YPB through university collaborations, roadshows, and public campaigns. Interestingly, the platform was first envisioned as part of a tiered verification system involving:

- **Citizen-generated reports** submitted through PetaBencana.id

- **Local BPBDs** manually verifying these reports, by calling residents, dispatching field teams, or observing report patterns

- **BPBDs escalating verified data** to BNPB and other official systems, integrating it into national disaster management platforms

Although this model was piloted in Jakarta, it was never fully institutionalized. Over time, operational constraints, lack of standard procedures, and staffing shortages led BPBDs to step back from verification task, resulting in PetaBencana's data largely unverified and used informally. As the platform expanded to other cities, technical limitations, most notably the inability to deliver RT-level mapping requested by BPBD Jakarta in 2020, strained institutional collaboration. These challenges were intensified by the withdrawal of USAID support in 2025, which had been crucial to the platform's development. Today, while some agencies still use its crowdsourced data from the platform to supplement their disaster response, the future of YPB and PetaBecana.id platform remains uncertain. However, as one official noted, USAID is not the only potential source of support; if YPB secures new funding and partnerships, there remains a pathway for renewed progress. The sentiment from stakeholders interviewed suggests that, although YPB personnel declined interview requests, it is evident they continue to hold scheduled meetings with government officials, such as with BNPB, maintain contact with international stakeholders, and organize public events.

Before unpacking the governance quality analysis, it is useful to briefly recall what each quality represents within this assessment. The **Extent** quality evaluates whether all relevant elements, across five key governance dimensions such as actors, resources, and processes, are adequately addressed and integrated. **Coherence** assesses the degree to which these governance elements support and reinforce each other, rather than working at cross purposes. **Flexibility** considers whether the governance system allows for multiple pathways to reach its goals, adapting to emerging opportunities or threats as they arise. Finally, **Intensity** measures how strongly the governance elements push for meaningful change, gauging the system's capacity to challenge and shift the status quo. In the case of PetaBencana.id platform adoption, all four governance qualities were assessed as moderate; however, each shows a clear downward trend. This means that there is significant room for improvement across all governance aspects to better support the adoption of the platform for Indonesia's climate resilience efforts and policies.

To look more closely, in terms of **Extent** and **Coherence**, while different actor groups are considered a part of the system, their actual engagement and coordination have been uneven. Local-level implementation often falls short due to resource limitations, outdated equipment, and a lack of technical training. In many districts, staff have limited awareness or experience with the platform, highlighting a significant gap between formal inclusion and actual practice. Even when local authorities are aware of the platform, technical barriers, such as limited access to APIs or challenges in verifying public flood reports, further constrain its use. This is especially true in less-developed regions, where funding and digital infrastructure are weaker. The situation has been exacerbated by the withdrawal of key donor support, USAID.

Regarding **Flexibility**, there is a considerable room for improvement the governance system surrounding the platform adoption to allow for multiple pathways to reach Indonesia's climate resilience goals. In terms of PetaBencana.id platform's design, it is built for adaptability, made to work with various tools and functioning to inform various disaster contexts on a nationwide scale. However, governance flexibility has not kept pace. Institutional processes and policy frameworks have often proven too rigid to accommodate evolving needs or to quickly implement improvements. For example, efforts to enhance core features of the platform have stalled due to a combination of limited technical resources, slow decision-making processes, and the absence of clear policy mandates. In some cases, collaborations have been paused when data-sharing standards were not met, reflecting broader challenges in aligning governance policies and practices across stakeholders.

In terms of **Intensity**, PetaBencana.id platform began as a pioneer of crowdsourced disaster information in Indonesia (Song et al., 2020), gaining strong momentum during the 2015 Jakarta floods through its innovative use of real-time social media data to integrate citizen reports into official disaster response, PetaBencana.id successfully challenged and shifted the status quo in Indonesia's disaster governance landscape. As described in interviews, the traditional reporting process was lengthy and hierarchical: residents would first report to the neighbourhood (RT) chief, who would inform the community chief (RW), who would then pass the report to the village office (*Kelurahan*), which in turn would escalate it to the sub-district office (*Kecamatan*). This chain of communication caused critical delays in response. By bypassing these layers, PetaBencana.id offered a more immediate, participatory model of crisis information

sharing. However, over time, the platform's transformative momentum has weakened. Sustained commitment from institutional stakeholders has diminished, and the absence of strong coalitions and durable governance structures has made it difficult to maintain the reforms it initially catalysed.

The next paragraphs will discuss in more depth the governance dimensions based on the GAT that have shaped the platform's adoption, in this sense, deriving both the most supportive and the most restrictive factors.

6.1.1 Most Supportive Dimension: Actors and Networks

Compared to other governance dimensions in the GAT, the 'actors and networks' dimension emerges as the most supportive for the adoption and scaling of the PetaBencana.id platform. There are several reasons to this. First, from the early stages of the platform adoption, a wide range of actors, including government agencies, NGOs, international organizations, have been actively involved. The strength of these networks has enabled smooth communication and knowledge sharing across actors. A particularly effective strategy was the integration of Twitter, which significantly boosted visibility and engagement, especially in Jakarta, where residents are among the most active Twitter users globally. Citizens frequently shared real-time flood information with their communities, and feedback on the platform's usefulness was overwhelmingly positive. Collaboration with the government agencies further strengthened institutional trust and led to the platform being officially recognized as the city's primary digital flood reporting tool. The platform's leaders also actively promoted it through newspaper articles, radio interviews, and public forums, helping to build legitimacy and awareness (Ogie et al., 2019).

Additionally, when viewed at a broader scale beyond just the use of PetaBencana.id platform, the interactions among key disaster management agencies, such as BNPB, and BPBD, appear to be well institutionalized, with regular coordination occurring on a daily basis. Interviews further suggest that several stakeholders have actively advocated for the adoption of open-source solutions, including PetaBencana.id, due to their cost-effectiveness and scalability.

Several interviewees emphasized that citizen-driven, crowdsourced data is especially valuable during disasters, as those most affected are often best positioned to report real-

time conditions. This perspective aligns with Widyanarko (2018), who describes residents as the 'best sensors of the city'. The government agencies also currently collaborate with external stakeholders, such as PDC, and various civil society communities, on a case-by-case basis, particularly when specialized expertise or support is required. This spirit of cooperation was reflected in one interviewee's call to strengthen disaster management through a more integrated and collaborative 'multi-helix' approach, involving government, academia, industry, and civil society.

Interview findings suggest that YPB is open to expanding its collaborations with other stakeholders, both within Indonesia and internationally. For instance, YPB has been actively supporting AafatInfo in Pakistan by providing technical guidance and networking support. The YPB Director has also been notably proactive in participating in conferences, talks, and forums related to open-source solutions for humanitarian and disaster management, both in Indonesia and internationally. These engagements serve to promote the platform, foster cross-border partnerships, and broaden its reach. Interviews further indicate that YPB continues to meet with government agencies to explore new partnership opportunities. Despite recent funding cuts, the outlook for future collaborations remains positive. Many stakeholders recognize the strategic value of PetaBencana.id, not only as a real-time disaster response tool but also as a source of crowdsourced data that can inform long-term planning and mitigation, such as infrastructure development. In this way, the platform holds significant potential to evolve into a comprehensive climate resilience tool, supporting decision-making across all stages of disaster management.

6.1.2 Most Restrictive Dimension: Responsibilities and Resources

Of all the governance dimensions assessed using the GAT, 'responsibilities and resources' stands out as the most restrictive in the adoption and long-term sustainability of PetaBencana.id platform. The most significant challenge in this area is funding, as discontinued support from USAID has had a noticeable impact on operations. In 2024 alone, Indonesia received the highest allocation of overall USAID among Southeast Asian nations, amounting to US$791.4 million. However, recent reductions in USAID funding have begun to impact the operational capacity of many local NGOs across Southeast Asia. These cuts have led to program delays, downsizing, and the suspension of certain partnerships (Board & Mahmund, 2025). This current situation clearly reflects Kamstra

& Schulpen's (2014) observation that many NGOs in Indonesia rely heavily on international donors, whose priorities often take precedence over local needs, making it hard to achieve real citizen participation and lasting ownership.

Another restrictive governance dimension, beyond funding, relates to technical infrastructure and data integration capacity. Broadly speaking, interviewees from BPBDs highlighted persistent challenges in accessing and integrating data from official disaster management platforms. In many cases, data is available only through web-based formats with limited access via APIs, making it difficult to incorporate this information into local dashboards or real-time decision-making systems. As a result of these challenges, some BPBD offices have opted to develop their own localized platforms, due to the perception that platforms developed by national agencies such as BNPB do not fully accommodate the specific needs and capacities of local governments. Specifically, in the case of the PetaBencana.id platform, these technical constraints, such as BPBDs requesting more detailed data but failed to accommodate it, significantly reduce the platform's operational value. Another common concern is the difficulty of verifying crowdsourced data, especially where agencies lack sufficient resources or standardized protocols for field validation. This situation highlights a broader challenge: ensuring that national-scale open-source platforms remain adaptable and aligned with the practical capacities and expectations of local disaster management actors.

Lack of clarity around certain organizational roles also pose a challenge. This challenge becomes more pronounced within broader institutional settings, as interview findings revealed that, agencies like BIG often operate with ambiguous mandates due to frequent leadership changes, which result in shifting priorities and responsibilities, making it difficult to maintain consistency in institutional roles over time.

6.2 Policy and Practical Recommendations

This section presents policy and practical recommendations, divided into 2 parts:

1) for Indonesia, which is at a more mature, operational stage and faces challenges around sustainability and integration of CogniCity OSS (or in other words, PetaBencana.id platform) for climate resilience efforts

2) for Pakistan which is still in the early development or beta-testing phase

By outlining relevant policies and recommendations, this section also reflects how government agencies in Indonesia perceive the use of crowdsourced data within open-source platforms and its role in advancing climate resilience efforts. While this section focus is on Indonesia and Pakistan, the lessons are broadly applicable. Practitioners from other countries can learn from these insights to suit their own phase of platform adoption and specific local needs.

6.2.1 Indonesia

Establish Institutional Policies and Ensure Leadership Continuity

A foundational step toward ensuring the long-term sustainability of the PetaBencana.id platform is its formal integration into Indonesia's national disaster governance framework through clear regulatory mandates. Without formal recognition, its adoption remains fragmented and dependent on the discretion of individual agencies. To maximize its utility and ensure its continuity, the Indonesian government, particularly BNPB and BPBDs, should formally designate PetaBencana.id as part of the country's core digital disaster infrastructure. Crucially, this does not require the government to take over ownership of the platform. Instead, the recommended model is to maintain YPB's leadership and development role while institutionalizing a long-term public–civil society partnership. This approach preserves the platform's open-source, community-driven foundation while embedding it within the national disaster management architecture.

This formalization can be achieved by embedding the platform into national and local disaster response SOPs, allocating dedicated budget lines within BNPB and BPBD annual funding cycles, and establishing memoranda of understanding (MoUs) or partnership agreements with YPB. These mechanisms would clarify roles and responsibilities, define cost-sharing arrangements, and strengthen operational coordination. A practical step would be for BNPB to issue a circular encouraging local governments to adopt and integrate PetaBencana.id platform into their disaster communication systems, ensuring more consistent and systematic use across administrative levels.

Beyond regulatory inclusion, this thesis also recommends efforts to foster a cultural shift in how open-source platforms, especially combined crowdsourcing technologies, are perceived within public institutions. Currently, disaster data is manually compiled and analysed by BNPB teams, a process described as highly time-consuming. This challenge

is especially pronounced in regions outside Java, where administrative units such as sub-districts (*desa*) or urban villages (*kelurahan*) cover large areas. Often, the impact of a disaster happens in just a small area, but official reports usually refer to the entire administrative unit. This makes it hard to know exactly where the damage occurred and how serious it is without accurate location data (e.g. X and Y coordinates). In this context, crowdsourcing technology emerges as a transformative solution. By enabling individuals on the ground to act as 'crowd as sensors,' platforms like PetaBencana drastically reduce the time needed to collect and visualise real-time data. Instead of navigating bureaucratic layers, affected communities can instantly report on a shared platform.

Interviewees highlighted that open-source tools are often undervalued in Indonesia due to a perception that 'free' means unstable or unsupported. Concerns over version compatibility, lack of technical support, and limited after-sales service contribute to this scepticism. However, the use of open-source tools is already embedded in national disaster systems. QGIS, for example, forms the foundation of InaSAFE, a tool co-developed with BNPB. This indicates a precedent for the successful use of open-source technology in formal disaster management. One interviewee, drawing from their experiences in Germany, shared that open-source platforms there are not only widely adopted but also supported through active government involvement.

Drawing on European cases, Olteanu-Raimond et al. (2017) observed that national mapping agencies or other types of government bodies have increasingly adopted VGI and open-source platforms, recognizing their strategic value and integrating them into institutional workflows through collaborative frameworks. Adopting similar principles in Indonesia, such as providing financial support, establishing structured partnerships, and offering formal government endorsement, could foster long-term investment in open digital public goods. This aligns with Haklay et al. (2014), who emphasize the need to encourage greater integration of VGI into authoritative data, noting that actual implementation remains limited in practice.

Finally, leadership continuity is essential. Several interviewees emphasized that political and bureaucratic turnover often disrupts digital initiatives. Shifting policy priorities, staff reassignments, and weak institutional memory create barriers to long-term planning and implementation. This fragility undermines digital innovation in the public sector. As Lerner and Tirole (2002) argue, consistent leadership is a decisive factor in the successful

institutionalization of open-source solutions. While flexibility exists within Indonesia's public institutions, it is often reactive and shaped more by political cycles than by strategic, long-term planning. Additionally, regular monitoring and assessment of the platform's implementation, particularly in relation to Indonesia's broader climate resilience goals, should also be established as part of a long-term governance strategy.

Institutionalizing the adoption of PetaBencana.id platform therefore requires more than formal policy inclusion. It calls for sustained leadership commitment, coordinated cross-agency governance, and a broader shift toward valuing open, citizen-driven digital systems. A strong regulatory and administrative foundation would not only standardize the platform's use across all levels of government but complement the existing BNPB's disaster management systems, such as InAWARE. With these institutional agreements, the next priority should be improving data quality and ensuring system interoperability.

Ensure Interoperability between Different Systems

Ensuring seamless data exchange through open APIs and shared technical protocols is therefore a critical next step for the platform and insufficiently integrated into the workflows of key government systems. Establishing direct API bridges between PetaBencana.id and government systems would allow real-time crowdsourced information to complement institutional data during both preparedness and response phases. This need was reflected by several interviewees and is also supported by PDC's supplementary document, on recommendations for improving data interoperability across platforms for Indonesia's disaster management (PDC, 2020).

Improve Crowdsourced Data Reliability

Beyond system interoperability, improving data reliability is also a central concern. Several interviewees emphasized that limited manpower and technical capability within agencies such as BNPB and BPBDs pose a major challenge to verifying incoming reports. To address this, governments should invest in developing automated or hybrid verification tools, supported by AI or machine learning, to validate crowdsourced reports in real time. These technologies can help detect anomalies such as duplicate entries or outlier patterns. In turn, this would allow human moderators to focus on most critical cases. Supporting research and development in this area would allow BNPB and BPBDs to deploy more scalable and efficient solutions in the face of growing data demands.

Alongside technological innovation, governments should adopt blended approaches that combine traditional data metrics with methods better suited to dynamic, user-generated data. For example, crowdsourced reports can be cross-validated against official sources such as satellite imagery or administrative maps. Including metadata at the point of submission, such as GPS-tagged photos, timestamps, or short descriptions, can further support both automated filtering and manual review (Mulia, 2018).

Community-based moderation also plays a crucial role in improving data reliability Currently, YPB activates the main crowdsourcing role of 'crowd as sensor', by enabling citizens to submit real-time hazard reports. This thesis recommends that YPB further strengthen the 'crowd as reporter/social computer' role (Poblet et al., 2014), through community-based moderation features. This can be done through enabling users to confirm, rate, or flag the contributions of others introduces a valuable layer of peer review. For example, when a user reports a flood or landslide, nearby residents can dispute the claim in real time, adding collective verification to the system. This not only helps distribute the validation workload but also encourages a sense of civic responsibility and active participation in disaster response efforts (Mulia, 2018).

Secure Alternative Funding Sources

A clear and pressing threat to the sustainability of the PetaBencana.id platform is the difficulty of securing stable, long-term funding. As postulated by O'Mahony (2005), non-profit foundations are often formed to handle legal, financial, and governance responsibilities in open-source projects, offering stability while preserving community-driven development. YPB was established with this exact purpose. However, like many similar initiatives, it has faced challenges securing long-term donor support. Aigrain (2005) similarly highlights that structural weaknesses in policy and funding ecosystems have historically undermined open-source initiatives.

This challenge is not unique to YPB. Across Southeast Asia, even around the world, many NGOs are facing similar difficulties, forced to reduce their activities or even shut down entirely following cuts in donor support. The decline in USAID funding, in particular, has left a major gap, and domestic sources of funding are often limited or unavailable (Tyler & Trinh, 2025; See, 2025). Additionally, several officials interviewed noted

challenges related to limitations in Indonesia's state budget (APBN), which constrained the capacity to support and sustain disaster management initiatives.

To address this, YPB should actively pursue alternative funding sources that support climate resilience initiatives, in parallel to formalizing partnership agreements with government agencies, particularly BNPB and relevant BPBDs. This approach would not only strengthen institutional support but also enable these agencies to facilitate new funding partnerships or contribute directly to the platform's sustainability. More importantly, this would also enhance financial transparency within Petabencana.id, an issue identified as a significant concern by Hidayat (2020).

In addition, as Kamstra & Schulpen (2015) suggest, it is important to reduce dependency on international donors by fostering greater local ownership and diversified funding. This does not imply abandoning international funding sources, but rather exploring new funding opportunities, by seeking support from other international initiatives apart from USAID and building partnerships with the private sector.

Seek Strategic Public–Private Partnerships

Hidayat (2020) highlighted the limited involvement of the private sector as a shortcoming in the development of Petabencana.id. Expanding strategic partnerships with private sector actors offers a valuable opportunity to increase both the reach and resilience of the PetaBencana.id platform. Interview findings revealed that integrating the platform with widely used apps such as Gojek could enhance visibility, user engagement, and real-time data application. As one of Indonesia's most popular ride-hailing and mobility platforms, Gojek has a vast user base and technological infrastructure that could be leveraged during disaster events. By embedding real-time hazard alerts, sourced from PetaBencana.id, into the Gojek app, drivers and users could be warned to avoid flood-affected routes, while users would receive updates on disruptions or travel risks in their area. This would not only improve public safety but also allow Gojek to optimize its routing systems during emergencies.

As interviewees have pointed out, the effectiveness of the platform depends on the volume and quality of incoming data. If data remains sparse, the platform may appear inactive or underused, potentially reducing trust and engagement. Establishing

collaborations with partners who can contribute or promote information sharing will be key to maintaining an active and visible platform.

Enhance Public Engagement

A crucial element in the success of platforms like PetaBencana.id is the sustained engagement of contributors. As Olteanu-Raimond et al. (2017) postulated, most citizens are not primarily motivated by financial rewards or prizes. Instead, they are driven by the opportunity to contribute information from their local environment, see it reflected on public maps, and receive feedback from institutions, creating a sense of direct impact and relevance.

Following formal adoption, government agencies explore incentive schemes and gamification techniques such as community recognition titles or digital badges for frequent contributors. Collaborating with YPB to co-design these mechanisms would not reinforce civic trust and a sense of shared responsibility for disaster preparedness. This idea was also reflected in the interviewees. Nonetheless, it is important that when implementing reward systems, these rewards should not encourage contributors to favour quantity over quality in their contributions. Sustainable success depends on first building widespread awareness, and then fostering active, meaningful participation through thoughtful recognition and reward systems (Olteanu-Raimond et al., 2017).

YPB is already making strong strides in public engagement by visiting schools and universities and participating in public events. These efforts have laid a solid foundation for building awareness and participation. However, with greater support from government agencies, these initiatives could be significantly scaled up to reach a broader audience. To further strengthen engagement, coordinated public education campaigns should be launched to promote digital literacy and risk awareness. These campaigns should clearly explain how citizens can use and contribute to PetaBencana.id platform, helping people understand the platform's purpose and potential impact. Empowering the public in this way will be essential for sustaining long-term participation.

6.2.2 Pakistan

Customize Platform Design and Features

AafatInfo is currently in its early development phase, and like YPB, it has the aim of building a nationwide, crowdsourced disaster management platform for Pakistan. The initiative draws inspiration from Indonesia's PetaBencana.id and the Philippines' MapaKalamidad, but the development team quickly recognized that a direct replication would not be feasible. Significant cultural and developmental differences, such as lower literacy rates and wider digital divides in Pakistan, required a more localized and context-sensitive approach.

In response to user feedback, AafatInfo adopted a more vibrant and locally resonant visual style, moving away from the minimalist, monochrome interface of PetaBencana.id, which many users in Pakistan found unappealing. The platform was also functionally adapted to reflect Pakistan-specific hazards that are less prominent in Southeast Asia. These include open sinkholes, exposed electrical wires, and a heightened risk of electrocution during urban flooding. By integrating these threats into the reporting system, AafatInfo enabled users to share more relevant and comprehensive information based on their local experiences. While core features such as location-based reporting, water depth indicators, and photo uploads were retained, the team also tested additional functionalities aimed at improving usability. One example was a gender-based height indicator for flood depth, which was later removed due to user confusion, underscoring the platform's commitment to iterative, feedback-driven development.

Complementing this process, the team also conducted social media analysis and news monitoring to identify key challenges faced by communities during floods. For example, flooded roads with hidden construction pits and poor drainage infrastructure continue to pose serious risks, with underpasses in Karachi frequently submerged. These types of hazards are not typically encountered in the same way in Indonesia or the Philippines, reinforcing the need for localized platform development. Based on these insights, it is recommended that AafatInfo continue investing in user-centered, iterative design approaches, actively testing and adapting both visual and functional features to reflect the lived realities of users.

Build Technical Capacity and Operational Sustainability

While AafatInfo has not yet formalized as a registered NGO, the team has established strong partnerships with universities, civil society groups, media outlets, and corporate actors to support platform testing and public outreach. Guidance from YPB in Indonesia has been instrumental in shaping the platform's early development, particularly through the exchange of open-source tools and strategic advice. Interestingly, during interviews, YPB expressed a more cautious view of the future, citing concerns about reduced international funding such as USAID support. In contrast, AafatInfo's interviewee conveyed a sense of optimism and confidence in the platform's ongoing progress. While AafatInfo has clearly benefited from YPB's early support, it is now showing signs of increased independence and a desire to chart its own course.

Looking ahead, AafatInfo can learn valuable lessons from PetaBencana's experience, not only in terms of design and engagement strategies, but also in preparing for long-term sustainability. As YPB's funding challenges illustrate, reliance on a narrow range of external donors can undermine stability. It is therefore recommended that AafatInfo strengthen its internal technical and organizational capacity by building a full-time core team, formalizing operational roles, and proactively identifying alternative and diversified sources of funding. Doing so will help ensure the platform's long-term viability, reduce vulnerability to future funding disruptions and reduce support dependence on YPB.

Initiate Government Collaboration and Institutional Integration

As AafatInfo platform transitions out of its early development phase, initiating formal relationships with government agencies will be essential for long-term impact and national scalability. This thesis recommends that AafatInfo initiate engagement with national and local disaster management agencies to explore opportunities for collaboration, data integration, and institutional alignment. Starting this process will strengthen the platform's sustainability and support its broader adoption across the country.

Based on interview findings, it can be derived that one of the key lessons learned during AafatInfo's early development was the importance of structured pre-planning. In the initial phase, the team often worked on multiple tasks simultaneously without a clear

sequence, and with most staff working remotely. This lack of coordination led to inefficiencies and the need to revisit or redo earlier work. In hindsight, a step-by-step implementation plan would have provided better clarity and coordination, which enabled more efficient resource allocation. For other countries considering the adoption of a similar citizen-driven disaster management platform, this underscores the value of a comprehensive roadmap, one that aligns technical development with stakeholder engagement, and is adapted to the platform's evolving capacity and local context. Starting off with more in-person meetings, where possible, could also support clearer communication from the start and can help avoid unnecessary delays.

6.3 Academic Contributions

This thesis contributes to growing scholarship at the intersection of governance and climate resilience, particularly within the context of the Global South. The first and most significant contribution of this thesis is its contribution to the advancement of existing governance theories by generating findings that align with and build upon prior research using similar frameworks. It applies the use of GAT in a novel context, evaluating the governance dynamics of an open-source, crowdsourced disaster resilience platform in Indonesia and Pakistan. By doing so, it extends the empirical application of GAT beyond traditional environmental governance settings, demonstrating its utility for assessing complex, multi-actor digital governance ecosystems. As GAT has already been referenced in academic work across more than 20 countries (Özerol & Bressers, 2023), this research further affirms its value in analysing complex and dynamic governance settings. Importantly, the findings also highlight that building resilience is a key driver of governance transformation, enabling institutions to better respond to complex environmental challenges through inclusive and coordinated action. In this context, GAT offers a practical framework for assessing the governance dimensions that support resilience, helping to make the concept more operational in efforts to strengthen and transform governance systems.

As a further contribution, the thesis offers a comparative perspective by analysing the early-stage development of the CogniCity OSS platform through the case of AafatInfo in Pakistan, which, to the best of the author's knowledge, has not yet been examined in academic literature. This is contrasted with the more mature and operational implementation of the same platform through PetaBencana.id in Indonesia. The

comparison illustrates how similar digital tools must be adapted to fit vastly different institutional and social contexts, insights relevant to other cities and countries adopting similar platforms.

Another significant contribution is that this thesis brings together different governance theories (such as network, collaborative, and adaptive governance), and connect them in ways that go beyond abstract description to interpret real-world cases. Through this approach, the thesis helps make complex governance concepts more tangible and relevant for understanding and improving the institutional dynamics that shape disaster management. Furthermore, it connects these theoretical viewpoints to the role of crowdsourced data in open-source platforms, demonstrating how citizen participation in data collection and decision-making contributes to the evolution of modern governance theories. It also builds upon Hidayat (2020)'s study of PetaBencana.id, which was only limited to the lens of collaborative governance framework, by expanding the analysis to include a broader range of governance forms. This integrative governance perspective is supported by empirical insights drawn from an in-depth case of thorough PetaBencana.id case study and 20 stakeholder interviews. As discussed in various governance theories, successful governance is built on trust, shared learning, and the ability to bring together different groups to work toward a common goal. This connection was especially relevant in the case of PetaBencana.id, where strong actor networks were identified as the most supportive governance factor. Together, these contributions advance both governance theory and practice, providing actionable insights for policymakers and scholars interested in the evolving intersection of open-source technology, citizen engagement, and climate resilience governance.

6.4 Suggestions for Future Research

The findings of this research raise several important questions for further exploration that could enhance government acceptance of crowdsourced data. One key area involves the adaptation and effectiveness of crowdsourced data verification tools. Future studies could focus on how verification methodologies can be empirically tested. This includes testing recommendations from this thesis, such as community-based moderation features, and developing robust methodologies for their evaluation., or to use AI-based tools to automate verifying crowdsourced data. Additionally, policy and practical

recommendations presented in this thesis should be empirically assessed to determine their impact.

Another promising research avenue involves exploring new funding and governance models in the wake of USAID funding cuts affecting platforms like PetaBencana.id and AafatInfo.pk. This broader inquiry could inform adaptations of CogniCity OSS across different countries and provide insights to support NGOs and initiatives facing similar challenges.

While this thesis provides an initial comparison between Indonesia and Pakistan, broader comparative research that includes cases like the Philippines (through MapaKalamidad.ph platform), would offer deeper insights into how digital disaster tools are adapted and institutionalized across varied contexts. Examining shared challenges and context-specific differences, including inter-agency coordination and policy frameworks, could help identify patterns, gaps, and best practices in platform integration. These comparative insights would contribute to more nuanced guidance for governments and developers seeking to implement similar platforms elsewhere.

7 Conclusion

This thesis set out to investigate how governance dynamics influence the adoption of an open-source platform for climate resilience, using PetaBencana.id as a case study. To understand how governance shapes the effectiveness of such a platform, the research applied a broader governance lens, incorporating concepts from network governance, collaborative governance, and adaptive governance, to derive emerging themes of governance dynamics essential in times of global complexity. The application of the Governance Assessment Tool (GAT), based on insights from 20 stakeholders, revealed moderate governance performance overall, with persistent challenges in 'responsibilities and resources' allocation. However, the 'actors and networks' dimension stood out positively, reflecting growing collaboration across sectors. This is particularly evident in the involvement of numerous international partners supporting the platform. On the perception of crowdsourced data within government systems, findings suggest that successful integration largely depends on whether leaders support it. Nonetheless, most stakeholders acknowledged that traditional disaster reporting methods are often bureaucratic and slow, and that crowdsourced information enables faster response, thereby denoting the need for formal policies to validate and institutionalize such practices.

Drawing on these insights, the study turns to AafatInfo, Pakistan's adaptation of CogniCity open-source software (OSS), or in other words, same infrastructure PetaBencana was built on. Although initially modelled after PetaBencana, AafatInfo's development diverged significantly due to differences in climate risks, socio-political dynamics, and citizen needs. These contextual differences led to meaningful changes to AafatInfo platform's design and functionality. This demonstrates that replicating the same OSS is not sufficient on its own, successful implementation also depends on local context and governance conditions. Even so, AafatInfo was able to leverage the networks and experience established by PetaBencana, illustrating the value of transnational learning and cooperation.

Interestingly, this research also underscores the vital role of international donors in supporting early-stage innovation, as seen with USAID, which served as the major funder of PetaBencana. Yet the future of such platforms remains vulnerable, as current cuts to USAID funding highlight the fragility of global aid infrastructures at a time when climate-

related disasters and humanitarian crises are becoming more frequent and severe. In today's increasingly volatile landscape, there is an urgent need to build more resilient, locally grounded, and diversified support systems to sustain citizen-led digital solutions.

Although the thesis successfully met its objectives, several limitations are to be considered. More comprehensive insights might have emerged from direct interviews with Yayasan Peta Bencana (YPB) staff. Methodologically, relying solely on the GAT may have introduced bias and a limited analytical perspective. A comparative study between Indonesia and Pakistan would have further enriched the analysis; however, this was not possible given AafatInfo's beta-stage development. The Philippines (through the case of MapaKalamidad platform), which was in a more mature and operational phase comparable to PetaBencana, was also considered, but stakeholder interviews were declined. These constraints point to potential avenues for future comparative research.

Additionally, several promising trajectories for future research include enhancing government's receptivity toward crowdsourced data. Future studies may consider the operationalization and testing features such as community-based moderation and validation using AI tools for crowdsourced data to ensure data reliability, particularly in contexts where government resources are limited. Another valuable direction involves exploring both theoretical and practical models for alternative funding and governance, particularly in light of diminishing international support, which could shape the sustainable evolution of platforms like PetaBencana and AafatInfo. Moreover, further research is needed into private sector engagement with NGOs and government, particularly in designing viable business or partnership models that incentivize long-term, cross-sector collaboration.

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Appendix

A Interview Invitation Letter Template (Indonesian)

Terkait: Permohonan Wawancara untuk Penelitian Terkait Manajemen Bencana

Kepada Yth:
XXXXX

Dengan Hormat,

Perkenalkan saya, nama Dhiya Khairina, saat ini saya tercatat sebagai mahasiswi dari Erasmus Mundus (Master of Science Public Sector Innovation and eGovernance). Saya menghubungi XXXXX atas rekomendasi dari XXXXX, terkait dengan penelitian yang sedang saya lakukan sebagai tugas akhir, dengan topik:

"Identifikasi Tantangan dan Peluang dalam Meningkatkan Implementasi Teknologi Open Source/Crowdsouring untuk Manajemen Bencana"

Sejauh ini, saya telah melakukan wawancara dengan pihak terkait, seperti XXXXX. Dalam rangka melengkapi penelitian ini, saya ingin mengundang XXXXX yang relevan untuk berbagi wawasan dan pengalaman terkait topik tersebut.

Sebagai usulan, wawancara dapat dijadwalkan pada:

- **Hari/ Tanggal : XXXXX**
- **Jam : XXXXX** (sekitar 1 jam)
- **Tempat : Zoom Meeting**

Namun bila pada tanggal dan waktu tersebut tidak dimungkinkan, saya sangat terbuka untuk disesuaikan dengan waktu yang lebih cocok, namun saya sangat berharap agar wawancara dapat dilakukan dalam waktu dekat.

Demikian disampaikan atas perhatian dan kerjasamanya diucapkan terima kasih.

Salam hormat,
Dhiya Khairina
Public Sector Innovation and eGovernance (Erasmus Mundus Program)
KU Leuven | University of Munster | Tallinn University of Technology
Public Governance Institute, Parkstraat 45, Leuven, Belgium

pioneer

Co-funded by the European Union

B Interview Guide Template for Interviewees (English)

Vision, Mission, & Role of XXXXX

- Could you please explain the role and responsibilities of XXXXX?
- Could you also elaborate on the vision and mission of XXXXX in disaster management in Indonesia?
- What are the main priorities of XXXXX in strengthening national disaster resilience, both in the short and long term?
- What are the main products and services provided by XXXXX related to disaster management?
- With current technological advancements, what is your perspective on the role of XXXXX in building a more innovative and technology-based disaster management system?

Coordination & Collaboration in Disaster Management, System Interoperability, and Perspectives on PetaBencana.id

- What are the main challenges and opportunities in disaster management tasks in Indonesia?
- How does XXXXX coordinate with related parties such as XXXXX and other stakeholders in disaster management?
- What are the main challenges in building coordination among institutions in the pre-disaster, disaster response, and post-disaster phases?
- What are the main challenges in coordinating the various existing disaster management platforms? How does your organization ensure effective interoperability between these different systems?
- What are the main challenges in integrating PetaBencana.id with official disaster management systems? How does XXXXX validate crowdsourced data collected on PetaBencana.id?
- Based on XXXXX's experience, what are the main challenges in implementing open-source technology and crowdsourcing in disaster systems, and what steps has XXXXX taken to address these challenges?
- What improvements could be made to PetaBencana.id to enhance its functionality in managing disaster responses?

The Future of Disaster Management in Indonesia

- How does XXXXX view the role of the private sector, academia, and communities in early warning systems and disaster management?
- Finally, what is your view on the future of disaster management in Indonesia, and what is the future vision and mission of XXXXX, particularly in efforts to strengthen inter-agency coordination?

Note: We would greatly appreciate it if you could also share any supporting data or links that we can access regarding the information you have provided.

C Interview Guide Template for Interviewees (Indonesian)

Visi, Misi, & Peran XXXXX

- Mohon kiranya Bapak/Ibu dapat menjelaskan peran dan tanggung jawab di XXXXX?
- Mungkin dapat dijelaskan, apakah visi dan misi XXXXX dalam manajeman bencana di Indonesia?
- Apa prioritas utama yang dilakukan XXXXX dalam memperkuat ketahanan bencana nasional, baik jangka pendek maupun jangka panjang?
- Apa saja produk dan layanan utama XXXXX terkait kebencanaan?
- Dengan perkembangan teknologi saat ini, bagaimana menurut pandangan Bapak/Ibu terkait peran XXXXX dalam membangun sistem kebencanaan yang lebih inovatif dan berbasis tehnologi?

Koordinasi & Kolaborasi dalam Manajemen Bencana, Interoperabilitas antara Berbagai Sistem dan Perspektif tentang PetaBencana.id

- Apa tantangan dan peluang utama dalam tugas manajemen bencana di Indonesia?
- Bagaimana pola koordinasi XXXXX dengan pihak terkait seperti XXXXX, serta pemangku kepentingan lainnya dalam penangan manajemen bencana?
- Apa tantangan utama dalam membangun koordinasi antar lembaga dalam pengelolaan pada tahap pra, sedang, dan pasca bencana?
- Apa tantangan utama dalam mengkoordinasikan berbagai platform manajemen bencana yang ada? Bagaimana cara organisasi memastikan interoperabilitas yang efektif antara berbagai sistem manajemen bencana?
- Apa tantangan utama dalam mengintegrasikan PetaBencana.id dengan sistem resmi manajemen kebancanaan? Bagaimana XXXXX memvalidasi data crowdsourcing yang dikumpulkan melalui PetaBencana.id?
- Berdasarkan pengalaman XXXXX selama ini, apa tatangan utama dalam penerapan teknologi open-source dan crowdsourcing dalam sistem kebencanaan dan apa yang dilakukan XXXXX untuk mengatasi hal tersebut?
- Apa yang bisa ditingkatkan pada PetaBencana.id untuk memperbaiki fungsinya dalam mengelola respons bencana?

Masa Depan Manajemen Bencana di Indonesia

- Bagaimana XXXXX melihat peran sektor swasta, akademisi, dan komunitas dalam sistem peringatan dini serta manajemen bencana?
- Terakhir, bagaimana pandangan Bapak/Ibu mengenai masa depan manajeman bencana di Indonesia, serta visi dan misi XXXXX kedepan khususnya dalam upaya untuk memperkuat koordinasi antar lembaga terkait?

Note: Kami sangat senang, bila Bapak/Ibu juga dapat menyampakan data dukung atau link yang dapat kami akses atas keterangan yang sudah Bapak/Ibu sampaikan

D Interview Guide Template for Interviewees (English)

Vision, Mission & Role of AafatInfo

- Can you describe your current role and responsibilities at AafatInfo?
- What are AafatInfo's main priorities, both short and long-term, in supporting climate resilience and disaster management?
- What key products or services does AafatInfo offer, and how do they help fill gaps in existing disaster response systems?

Coordination, Collaboration & Perception of Crowdsourced Data

- To what extent does AafatInfo collaborate with government agencies or align with national and local disaster management systems?
- How do different levels of government (national, provincial, local) engage with or respond to the platform?
- What are the main opportunities and barriers to building partnerships with public authorities, particularly in validating and using crowdsourced data?
- How is AafatInfo perceived by government agencies in terms of reliability and integration into formal disaster workflows?
- In your view, how does AafatInfo's approach differ from or align with the efforts of Yayasan Peta Bencana in Indonesia?
- How do you assess multi-stakeholder collaboration for AafatInfo?

Governance Challenges & Open-Source Adoption

- What have been the biggest challenges in promoting open-source software like CogniCity OSS in Pakistan's disaster management landscape?
- How do public authorities generally view the role of open-source platforms in disaster response and preparedness?
- What kind of support (funding, technical, policy) has AafatInfo received from donors or international institutions?
- What further conditions, whether institutional, technical, or social, are needed to improve AafatInfo's impact and scalability?

Future Prospects

- What might other Global South countries need to consider if they were to adopt a similar open-source platform?
- Have you come across examples or policies from other countries that use open-source disaster mapping tools? What lessons could be drawn from them?
- What are your main recommendations for strengthening collaboration between AafatInfo, government bodies, communities, and other stakeholders?

Note: We would greatly appreciate it if you could also share any supporting data or links that we can access regarding the information you have provided.

E Interview Consent Form

Please read this informed consent document carefully. Make sure to pose all your clarifying questions about the research before participation.

Information about the research project

Title: Governance Assessment for Climate Resilience: Insights from an Open-source Platform Adoption in Indonesia and Implications for Pakistan

Period: Academic year 2024-2025

Institution: KU Leuven, University of Münster, Tallinn University of Technology

Researcher: Dhiya Khairina (dhiya.khairina@student.kuleuven.be)

Supervisor: Prof. Vasilis Kostakis (vasileios.kostakis@taltech.ee)
Tutor: Alex Pazaitis (alex.pazaitis@gmail.com)

Research objectives and methodology
The main research question is:
"How do different governance aspects support or hinder the adoption of an open-source platform for climate resilience initiatives in Indonesia?"

To answer the main research question, we will employ a semi-structured interview methodology, involving a single review session per respondent. These interviews will be conducted online, with a specific emphasis on posing open-ended questions.

Research intervention
In the light of this research, we ask you to participate in an interview that will take approximately 60 minutes of your time. In the interview, you will be questioned about the governance aspects that support and hinder the adoption of open-source platform for disaster management and climate resilience strategies.
The interview will be audio and/or video recorded to facilitate data processing and analysis. Taking part in this study does not involve risks or inconveniences.

Voluntary participation
Participation in this study is voluntary. Participants are allowed to discontinue their participation at any time. They do not have to provide a reason for this and will not suffer any disadvantages.

General Data Protection Regulation (GDPR)
Under the GDPR, the data collected during the study will be processed on the grounds of public interest. This implies that when you withdraw from the study, any previously collected data can still be lawfully processed and do not need to be deleted. In case the study is commissioned by an agency or company, it can be requested at any time to have the processing of the data stopped and, where appropriate, have the collected data deleted.

Confidentiality
Research data and findings will be used for scientific purposes and may be published. Anonymity and confidentiality are guaranteed at every stage of the research project. Names of individual respondents will therefore not be published. Complete datasets are only made available to the research community when anonymized.

Contact details
For any questions, concerns, or to exercise your rights (access to or the correction of data, etc.) after participating in the study, you can contact:

a. The student researcher *(see contact details above)*
b. The supervisor or advisor *(see contact details above)*

I have read and understood the information above. I received answers to all my questions regarding this study. I agree to participate in this study under the conditions set out in this document.

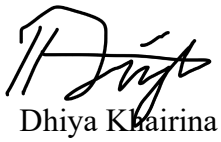
[DATE]

---	---
XXXXX	*Dhiya Khairina*

Declaration of Authorship

I hereby declare that, to the best of my knowledge and belief, this Master Thesis titled "Governance Assessment for Climate Resilience: Insights from an Open-source Platform Adoption in Indonesia and Implications for Pakistan" is my own work. I confirm that each significant contribution to and quotation in this thesis that originates from the work or works of others is indicated by proper use of citation and references.

Tallinn, 1 June 2025



Dhiya Khairina

Consent Form

for the use of plagiarism detection software to check my thesis

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Course of Study: Public Sector Innovation and eGovernance

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I confirm that I have read and understood the information in this document. I agree to the outlined procedure for plagiarism assessment and potential sanctioning.

Tallinn, 1 June 2025

Dhiya Khairina