



Integrating Disaster Risk Management into Infrastructure Governance: A Framework for Resilient Development in Indonesia

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ABSTRACT

Indonesia is highly vulnerable to disasters, e.g., floods, landslides, earthquakes, and volcanic eruptions; all of which pose serious risks to public infrastructure resilience. Although infrastructure investment continues to increase, disaster risk considerations are not fully integrated into infrastructure planning and governance. This study develops a conceptual framework for integrating Disaster Risk Management (DRM) into public infrastructure governance in Indonesia. Using secondary data from the National Disaster Management Agency, the Ministry of Public Works and Housing, and international development reports, the study applies a qualitative approach to examine policy frameworks, institutional arrangements, and the use of risk information in infrastructure planning. The findings show that infrastructure governance in Indonesia remains largely reactive, with limited use of hazard mapping in spatial planning and weak coordination among relevant institutions. The proposed framework emphasizes cross-sectoral coordination, systematic use of geospatial risk data, and community participation in planning and decision-making. Strengthening these mechanisms can enhance infrastructure resilience, reduce disaster-related losses, and support sustainable public infrastructure investment.

Keywords: Disaster Risk Management; Infrastructure Governance; Resilience

ABSTRAK

Indonesia merupakan negara yang sangat rentan terhadap bencana, seperti banjir, tanah longsor, gempa bumi, dan letusan gunung api, yang semuanya menimbulkan risiko serius terhadap ketahanan infrastruktur publik. Meskipun investasi infrastruktur terus meningkat, pertimbangan risiko bencana belum sepenuhnya terintegrasi ke dalam perencanaan dan tata kelola infrastruktur. Studi ini mengembangkan kerangka konseptual untuk mengintegrasikan Manajemen Risiko Bencana (*Disaster Risk Management*) ke dalam tata kelola infrastruktur publik di Indonesia. Dengan data sekunder dari Badan Nasional Penanggulangan Bencana, Kementerian Pekerjaan Umum dan Perumahan Rakyat, serta laporan pembangunan internasional, studi ini menerapkan pendekatan kualitatif untuk mengkaji kerangka kebijakan, pengaturan kelembagaan, dan pemanfaatan informasi risiko dalam perencanaan infrastruktur. Temuan penelitian menunjukkan bahwa tata kelola infrastruktur di Indonesia masih cenderung bersifat reaktif, ditandai dengan terbatasnya penggunaan peta bahaya dalam perencanaan tata ruang serta lemahnya koordinasi antar lembaga terkait. Kerangka yang diusulkan menekankan pentingnya koordinasi lintas sektor, pemanfaatan data risiko geospasial secara sistematis, serta partisipasi masyarakat dalam proses perencanaan dan pengambilan keputusan. Penguatan mekanisme tersebut dapat meningkatkan ketahanan infrastruktur, mengurangi kerugian akibat bencana, dan mendukung keberlanjutan investasi infrastruktur publik.

Kata Kunci: Ketahanan; Manajemen Risiko Bencana; Tata Kelola Infrastruktur

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INTRODUCTION

Located in the Pacific “Ring of Fire,” Indonesia is vulnerable to a wide range of hazards, including earthquakes, tsunamis, volcanic eruptions, floods, and landslides. In 2023 alone, the National Disaster Management Authority (*Badan Nasional Penanggulangan Bencana*, or BNPB) recorded more than 3,000 disasters, which displaced millions of people from their homes and damaged large areas of public infrastructure. Infrastructure systems, including transportation networks and nodes such as roads, water supply infrastructure, energy generation facilities, public housing, and communication infrastructure, are particularly vulnerable to such threats. This vulnerability is partly due to their intensive material requirements and the fact that a number of infrastructure assets have been constructed in hazard-prone areas, often with limited integration of disaster risk considerations into planning and governance mechanisms (Putra et al., 2021).

National development policy in Indonesia continues to prioritize infrastructure investment. Through the 2025–2029 National Medium-Term Development Plan (*Rencana Pembangunan Jangka Menengah Nasional*, or RPJMN), infrastructure development has been one of the strategic priorities for

strengthening connectivity, economic competitiveness, and resilient infrastructure systems (Bappenas, 2024). However, natural disasters have delayed many projects and demonstrated the need for stronger alignment between Disaster Risk Management (DRM), governance, and planning. Infrastructure is vital for economic growth and connectivity, but its long-term performance depends largely on risk-informed governance and planning that can adequately address disaster risks (Napitupulu & Putra, 2024).

Despite the enactment of laws related to disaster management, such as Law No. 24 of 2007 on Disaster Management, the integration of disaster risk into infrastructure governance remains weak in Indonesia. Various studies have shown fragmented institutional arrangements in the planning and implementation of infrastructure projects (Sagala et al., 2019; Siagian et al., 2021), particularly where coordination among ministries or agencies concerned with disaster risk reduction is still limited. Furthermore, hazard and risk data produced by national institutions are not consistently integrated into infrastructure planning or spatial development processes (Asian Development Bank, 2020). As a result, infrastructure projects often prioritize short-term economic efficiency and construction speed rather than long-term resilience to natural hazards.

The most recent Indonesian government regulation concerning the national disaster management agenda for the 2025–2029 period is the BNPB Regulation No. 1 of 2025 concerning National Disaster Management Planning. This policy emphasizes stronger prevention, mitigation, preparedness, and early warning efforts, as well as improved emergency response and recovery services. It also highlights cross-sectoral collaboration and community involvement, including the participation of people with disabilities, in the disaster management process to ensure inclusive protection (Abdillah et al., 2025). Nevertheless, many infrastructure projects continue to focus on cost efficiency and construction speed, often overlooking long-term resilience. Consequently, disasters not only disrupt public services but also lead to financial losses and humanitarian crises.

With regard to the above situation, this study seeks to: (1) analyze the current state of disaster risk integration within Indonesia's infrastructure governance framework; (2) identify key institutional, technical, and policy gaps that hinder risk-informed infrastructure development; and (3) propose a governance framework to embed DRM into infrastructure planning, implementation, and monitoring.

This research is expected to contribute to the growing body of literature on sustainable infrastructure governance by providing an Indonesia-specific framework that integrates disaster risk considerations (Edjossan-Sossou et al., 2020). This study might be utilized to assist policymakers, development partners, and infrastructure practitioners by offering practical recommendations for strengthening risk-informed infrastructure governance. Beyond Indonesia, the findings may also provide lessons for other low- and middle-income countries facing similar challenges in integrating DRM into infrastructure planning and governance.

In the context of this research, the concept of infrastructure governance is used to refer to the institutional arrangements, policy frameworks, and decision-making processes that guide the process of planning, financing, implementation, and management of infrastructure systems. It is characterized by the participation of multiple actors, including government, the private sector, and local communities; all of whom play a role in shaping the design, operation, and maintenance of infrastructure (Monstadt & Coutard, 2019).

THEORETICAL FRAMEWORK

Effective infrastructure governance ensures that development aligns with broader policy objectives, such as economic growth, social equity, and environmental sustainability. In the DRM context, infrastructure governance also includes the integration of hazard information, risk assessments, and resilience standards into infrastructure planning and implementation processes.

This research examines the incorporation of DRM into infrastructure development through the lens of disaster risk governance. Disaster risk governance focuses on the roles of institutions, the dissemination and utilization of risk information, and the participation of relevant actors in development processes vulnerable to disasters (Tierney, 2012; UNDRR, 2015). In this case, the governance of resilient infrastructure depends on three key elements: (1) institutional coordination among relevant agencies, (2) the systematic use of risk and hazard information in infrastructure planning, and (3) the active participation of stakeholders, including local communities and private sector actors. These dimensions serve as the analytical framework for examining how disaster risk considerations are integrated into infrastructure governance in Indonesia.

Disaster Risk and Infrastructure Vulnerability

Disaster risk is commonly understood as a function of hazard, exposure, and vulnerability (UNDRR, 2015). Because of their fixed location and long-life cycle, infrastructure systems are inherently vulnerable to various types of hazards. Floods can damage bridges and roadways, earthquakes can disrupt power grids and water pipelines, and landslides can cut off communities from access to critical facilities (Moraitis et al., 2020). Infrastructure resilience is therefore central to achieving the Sustainable Development Goals (SDGs), particularly Goal 9 on resilient infrastructure and Goal 11 on sustainable cities and communities (Davies, 2023).

In Southeast Asia, poor integration of risk assessment into infrastructure planning has been found to generate significant socio-economic costs (Asian Development Bank, 2020). The 2018 Sulawesi earthquake and tsunami, for example, caused devastating casualties and damaged key infrastructure, thereby delaying recovery efforts (Wakhungu et al., 2021). These examples emphasize the need to integrate disaster risk into infrastructure planning.

Governance Frameworks in DRM

Governance plays a critical role in determining how disaster risks are managed within infrastructure systems. According to Tierney (2012), disaster governance extends beyond government institutions to include networks of stakeholders, such as the private sector, civil society, and international organizations. Effective governance frameworks rely on coordination, transparency, and accountability (Fadillah et al., 2025).

Indonesia has made progress through regulatory instruments such as the Disaster Management Law, Law No. 24/2007, and the

National Disaster Management Plan 2020–2024. However, scholars argue that these frameworks are often not systematically integrated into sectoral infrastructure planning (Siagian et al., 2021). Fragmentation across ministries and agencies results in overlapping responsibilities and limited enforcement of risk-informed standards (Putra et al., 2023).

Risk-Informed Infrastructure Planning and Its International Best Practices

Risk-informed planning requires the use of hazard maps, vulnerability assessments, and predictive modeling in the design and siting of infrastructure. The Sendai Framework for Disaster Risk Reduction 2015–2030 advocates mainstreaming Disaster Risk Reduction (DRR) into development planning, including infrastructure investment. Risk-informed infrastructure not only reduces disaster losses but also enhances long-term sustainability (Putra et al., 2023).

Although previous studies have examined disaster risk and infrastructure resilience in various sectors and regions, limited attention has been given to how disaster risk information is integrated into infrastructure governance and policy frameworks at the national level. In particular, the roles of institutional coordination, cross-sectoral planning mechanisms, and the systematic use of risk data in infrastructure decision-making remain insufficiently explored (Sagala et al., 2019). This disconnect between data and practice hampers resilience.

Comparative studies from Japan, Chile, and New Zealand demonstrate that effective integration of DRM into infrastructure planning and governance requires institutional mechanisms, available financing instruments, and active participation from local communities. Japan, for example, has codified disaster risk considerations into public works through strict building codes

and continuous monitoring (Putra, 2025). Chile has also become an international model for earthquake-resistant design standards, which have evolved over time based on advances in scientific knowledge.

These global cases illustrate the need to mainstream resilience into both technical standards and governance mechanisms. Indonesia could strengthen its infrastructure resilience measures by drawing on these best practices while adapting them to national and local contexts (Putra et al., 2025).

Research Gaps

Although there is an emerging body of literature on DRM in Indonesia, studies that specifically address governance dimension of infrastructure resilience remain limited. Most existing studies focus on technical mitigation measures, such as structural engineering, rather than institutional integration. Besides, little research has examined how national and local risk data can be effectively integrated into infrastructure projects during the design and implementation stages. This gap provides a basis for the present research to propose a governance framework that connects policy, technical planning, and community involvement (Napitupulu & Putra, 2024).

METHODOLOGY

Research Design

This study employs a qualitative descriptive research design using secondary data-based analysis. The research investigates the incorporation of DRM into infrastructure governance in Indonesia (Pathharaprachayakul et al., 2021), focusing on policy frameworks, institutional arrangements, and spatial risk data. The method is exploratory as it seeks to identify gaps and propose a particular governance framework (Rossi et al., 2023).

Data Source

The study relies on multiple sources of secondary data:

1. Government reports: publications from the National Disaster Management Authority (BNPB), the Ministry of Public Works and Housing (PUPR), and the Ministry of National Development Planning/National Development Planning Agency (Bappenas) (Scano et al., 2021).
2. International institutions: reports from the United Nations Office for Disaster Risk Reduction (UNDRR), the Asian Development Bank (ADB), and the World Bank (Putra et al., 2025).
3. Academic literature: peer-reviewed journal articles, policy studies, and case studies on disaster risk reduction and infrastructure governance (Prameswara et al., 2024).
4. Geospatial data: hazard maps, risk assessments, and disaster statistics available from BNPB and the Indonesian Geospatial Information Agency (*Badan Informasi Geospasial*, or BIG).

Analytical Framework

The analysis is guided by the disaster risk governance framework (Tierney, 2012; UNDRR, 2015), which emphasizes three dimensions:

1. Institutional frameworks, which examines the roles and responsibilities of government agencies in integrating DRM into infrastructure planning (Stantis et al., 2024).
2. Risk information, which assesses the availability and use of hazard data and risk mapping in infrastructure decision-making.

3. Stakeholder participation, which evaluates the extent to which communities, private sector actors, and civil society are engaged in governance processes.

A comparative review of international best practices from Japan, Chile, and New Zealand is also conducted to contextualize Indonesia's position and identify relevant, transferable lessons.

Selection of Case Studies

This paper analyzes three representative hazard types and their related infrastructure vulnerabilities:

1. Floods, particularly in Jakarta metropolitan area, where flooding frequently disrupts infrastructure and housing.
2. Landslides, particularly in West Java and Central Java, where hillside infrastructure projects are vulnerable to slope movement.
3. Earthquakes, particularly in Sulawesi, including the 2018 Palu earthquake and tsunami, which severely damaged critical infrastructure.

These cases were selected because they represent high-frequency and high-impact hazards in Indonesia and provide insights into broader governance challenges.

Data Analysis Procedure

Data analysis was conducted in the following three steps:

1. Content analysis, used to assess the integration of DRM into policy, legal, and institutional frameworks.
2. *Spatial overlay*, used to assess hazard maps in relation to infrastructure development plans in order to identify areas exposed to risk.

3. Comparative benchmarking, used to compare governance practices in Indonesia with international best practices and identify possible areas for improvement.

Limitations

The availability and quality of secondary data constitute a limitation of this research. Although hazard maps and disaster statistics are publicly available (publics & 2019, 2019), they vary significantly in terms of granularity and consistency across regions. In addition, this study does not involve fieldwork or primary data collection, which may have provided a deeper understanding of institutional and community-level conditions. However, reliance on multiple secondary sources and triangulation helps minimize these limitations (Chai et al., 2023).

FINDINGS

Current State of Disaster Risk Integration in Infrastructure Governance

Indonesia has made progress in disaster management policy through such legal instruments as Law No. 24/2007 on Disaster Management and the establishment of the National Disaster Management Authority (BNPB). However, the evidence shows that DRM remains a fragmented and reactive component of infrastructure planning. Infrastructure projects often lack sufficient funding for resilience, and in some cases, construction speed is prioritized over structural robustness.

For example, BNPB has produced hazard maps, but these maps are not yet used as mandatory references in feasibility studies or environmental impact assessments. Consequently, several large infrastructure projects have been developed in hazard-prone areas. The Jakarta flood in 2020 damaged recently rehabilitated road networks and

public transportation facilities, partly due to inadequate risk-based spatial planning.

At the institutional level, coordination among ministries, including the Ministry of Public Works and Housing (PUPR), Bappenas, and the Ministry of Environment and Forestry, remains weak. This results in overlaps and inefficiencies, as each agency tends to develop its own policies and programs. This finding is consistent with the broader literature, which shows that fragmented policy and limited coordination can hinder effective governance (Darmawan et al., 2021).

Case Study Findings

To illustrate the analysis, this study focuses on three representative hazard types and their associated infrastructure vulnerabilities.

1. Flooding in Jakarta

Jakarta is highly vulnerable to flooding. Data from BNPB show that approximately 150 flood incidents are recorded each year. Toll roads, drainage systems, and residential complexes are among the most affected types of infrastructure. Although flood hazard maps are available, the data are rarely processed and incorporated into building permits or urban development plans.

For instance, a 2022 case study showed that flood risks in the Jakarta Mass Rapid Transit (MRT) project were not assessed until after construction had commenced. This resulted in significant additional costs for mitigation measures, such as pumping stations and flood barriers. As a result, the project became more vulnerable to risk and financial loss, as these corrective measures could have increased project costs by up to 30% due to the need to retrofit or reinforce weak points after construction had already begun.

2. Landslides in West and Central Java

West and Central Java, where hilly terrain is common, frequently experience landslides. Infrastructure projects such as rural roads, bridges, and housing developments are often located on unstable slopes, making them vulnerable to slope movement. Spatial comparison between BNPB landslide-prone areas and road and port infrastructure maps indicates that more than 20% of rural infrastructure in Central Java intersects with landslide-prone areas.

Weak enforcement of slope stabilization guidelines reflects limited institutional control. In many cases, local governments lack the technical expertise and financial resources needed to implement detailed mitigation plans. This indicates that the problem is not only an engineering issue but also a governance issue.

3. Earthquake in Sulawesi

Critical infrastructure, including bridges, ports, and power facilities, was destroyed by the 2018 Palu earthquake and tsunami. According to post-disaster assessments, many buildings failed to comply with earthquake-resistant design codes. In addition, land-use planning did not adequately consider liquefaction-prone areas, which resulted in widespread damage to properties and public facilities.

The above cases illustrate a gap in regulatory enforcement. Although building codes exist, compliance monitoring remains weak. Interviews and reports by BNPB (2019) show that oversight agencies do not have sufficient capacity to inspect all construction activities in a timely manner. At the same time, contractors often prioritize cost minimization over resilience.

Based on the aforementioned findings, three important governance gaps can be identified:

1. Institutional fragmentation: ministries and agencies often operate in silos, leading to weak coordination and duplication of efforts.
2. Limited application of risk information: although hazard maps and risk assessment are available, they are not systematically used in infrastructure planning and design.
3. Weak enforcement of regulatory frameworks: limited oversight capacity causes building codes and disaster risk reduction standards to be widely ignored in practice.

International Best Practices

The benefits of mainstreaming disaster risk at every stage of infrastructure development can be seen in countries such as Japan, Chile, and New Zealand.

1. Japan integrates disaster risk management into comprehensive urban planning through strict enforcement of building codes and continuous risk education for engineers and contractors.
2. Chile applies comprehensive building codes supported by seismic risk assessments, which are regularly updated based on new scientific knowledge and post-disaster learning.
3. New Zealand has adopted risk-sharing governance, involving local governments, communities, and private developers in resilience planning.

In contrast, Indonesia’s system remains largely project-based and reactive rather than systemic and preventive. This comparison highlights the need for institutional reform and stronger engagement with key stakeholders.

Table 1. Comparative practices of DRM in infrastructure governance

Country	Policy Integration	Institutional Coordination	Regulatory Enforcement
Indonesia	Partially integrated; DRM is mentioned in spatial and infrastructure policy	Fragmented; overlapping ministries and local agencies	Often weak; compliance gaps remain in building and infrastructure codes
Japan	Fully integrated into national development planning	Strong national-local coordination; central disaster agency	Strict enforcement of building and safety standards
Chile	Embedded in land-use planning and building codes	Decentralized but with clear municipal roles	Seismic codes are rigorously enforced after major earthquakes
New Zealand	Mandated through civil defence and risk reduction acts	Well-defined roles across government levels, with strong community links	Mandatory compliance with resilience standards

Towards a Governance Framework for Risk-Informed Infrastructure

Based on the case findings and the international best practices (in Japan, Chile, and New Zealand), this study proposes a

governance framework for incorporating Disaster Risk Management (DRM) into infrastructure development, as illustrated in Figure 1. The framework consists of five main components:

1. Policy integration: making hazard maps and risk assessments as mandatory references in all infrastructure-related planning documents.
2. Institutional coordination: establishing an inter-ministerial task force on risk-informed infrastructure to reduce fragmentation.
3. Capacity building: strengthening the capacity of local government officials and project implementers in risk-based planning and monitoring.
4. Community engagement: involving communities in identifying local risks and co-creating mitigation strategies.
5. Financial mechanisms: establishing dedicated resilience funds and incentives for developers whose projects comply with designated resilience standards.

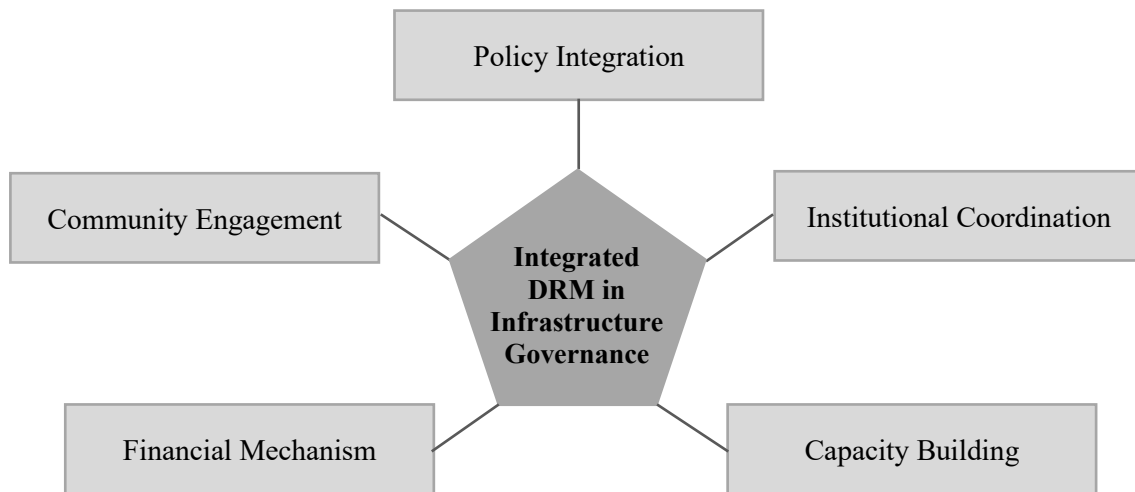


Figure 1. Proposed framework of integrated DRM in infrastructure governance

Implications for Sustainable Development

Integrating disaster risk into infrastructure governance is not only a technical aspect but also a strategic necessity for sustainable development. Infrastructure resilience

directly influences economic stability, social welfare, and environmental sustainability. Through a risk-informed approach, Indonesia can reduce the long-term costs of disaster recovery, safeguard public investment, and strengthen trust in governance institutions.

Dimension	Key Challenges	Opportunities
Policy Integration	DRM remains sectoral; weak mainstreaming across infrastructure sectors	Ongoing revision of infrastructure masterplans to include resilience
Institutional Coordination	Overlapping mandates; limited central-local coordination	Potential role of BNPB as the central coordinating agency
Data Utilization	Hazard maps are underutilized; real-time data sharing is limited	Advances in GIS and digital platforms for multi-hazard data
Regulatory Enforcement	Weak compliance monitoring; limited sanctioning capacity	Growing post-disaster awareness and stronger civil society oversight
Financing Mechanism	Dependence on donor funding; limited use of risk transfer instruments	Emerging PPP frameworks for resilience bonds and insurance schemes

Table 2. Key challenges and opportunities in Indonesia’s DRM integration

DISCUSSION

Fragmentation of Institutional Roles

The findings reveal that disaster risk integration in Indonesia's infrastructure governance is hindered by fragmented institutional responsibilities. Ministries and agencies such as PUPR, Bappenas, and BNPB operate with overlapping mandates, resulting in policy silos and weak cross-sectoral collaboration. This finding aligns with Tierney's (2012) disaster governance theory, which argues that risk management requires multi-actor coordination rather than single-agency intervention.

The absence of a central coordinating body for infrastructure resilience exacerbates duplication and inefficiency. For instance, BNPB provides hazard maps, yet their systematic use in infrastructure design is rarely mandated by PUPR. Such institutional misalignment weakens the effectiveness of existing regulations, making infrastructure projects vulnerable to hazards despite the presence of legal frameworks.

Although hazard and risk data are available, their application in decision-making remains limited. This reflects a broader knowledge-to-action gap as scientific and technical data are not effectively translated into planning processes. According to Sagala et al. (2019), Indonesia's risk maps are often treated as supplementary information rather than as core planning tools.

This gap illustrates a disconnect between technical capacity and governance enforcement. Unlike Japan, where seismic data are embedded into national building codes, Indonesia's hazard information remains underutilized. This prevents the mainstreaming of DRM into feasibility studies, environmental impact assessments, and public procurement standards.

Regulatory Enforcement Challenges

The Sulawesi earthquake case highlights weak enforcement of building codes. Although Indonesia has technical standards for earthquake-resistant structures, compliance is still inconsistent due to limited monitoring capacity. Contractors and local governments often prioritize cost-saving over resilience, which reflects focus on short-term economic incentives rather than on long-term sustainability.

The gap is not only a technical problem but also governance-related issue. Weak oversight, corruption risks, and resource limitations undermine institutional capacity to enforce standards. The issue demonstrates that disaster resilience is not solely an engineering matter but also a governance challenge that requires transparency, accountability, and appropriate incentives.

Lessons from International Best Practices

International comparisons reinforce the importance of institutionalized DRM. Japan shows how strict enforcement of building codes and the integration of hazard data into every planning stage can create a culture of resilience. Meanwhile, Chile shows that regularly updating technical standards based on new seismic data reduces vulnerability to earthquakes. Furthermore, New Zealand provides an inclusive governance model, in which local governments and communities share responsibility for resilience, thereby creating accountability and ownership.

For Indonesia, the key lesson is that resilience requires a systemic and preventive approach rather than ad-hoc interventions. This implies the need to rethink infrastructure governance as a continuous process of adaptation, informed by science and supported by robust institutions.

Risk-Informed Governance Framework

The proposed framework, as illustrated in Figure 1, shows how DRM can be embedded into infrastructure governance through five interrelated pillars:

1. Policy integration ensures that hazard data are used as compulsory references in planning.
2. Institutional coordination reduces fragmentation by establishing inter-ministerial collaboration.
3. Capacity building equips local governments with technical expertise.
4. Community engagement ensures that local risks are recognized and addressed.
5. Financial mechanisms provide resources and incentives for compliance with resilience standards.

By combining these five elements, the framework transforms DRM from a reactive measure into a proactive governance system. The implementation of this framework has several implications:

1. Economic efficiency: Investing in resilience at the planning stage is more cost-efficient than recovering from disasters after they occur.
2. Social equity: Community engagement prevents at-risk groups from being neglected in resilience planning.
3. Environmental sustainability: Integrating risk-informed approaches into infrastructure planning helps protect natural assets and conserve biodiversity.
4. Governance legitimacy: Transparent enforcement of resilience standards improves public confidence in institutions.

CONCLUSION

This study aims to explore and support DRM governance in Indonesia's infrastructure sector through stronger institutional coordination, better data utilization, more effective regulatory enforcement, and the adoption of relevant international best practices. The findings show that Indonesia has made significant progress in producing hazard maps, technical standards, and legal frameworks as part of its national disaster risk reduction strategy. Yet, institutional fragmentation, inadequate use of risk data, and weak regulatory enforcement continue to undermine the resilience of public infrastructure.

The comparison with Japan, Chile, and New Zealand shows that embedding DRM into governance processes is not only a technical matter but also a question of governance structure. Resilience depends on strong institutions, transparent enforcement, and adequate mechanisms for participation. These countries demonstrate that resilience is achieved not through reactive measures but through proactive, risk-informed governance frameworks.

The proposed conceptual framework in Figure 1 identifies five interrelated pillars: policy integration, institutional coordination, capacity building, community engagement, and financial mechanisms. These pillars serve as key pathways for mainstreaming DRM into infrastructure governance. This integrated approach enables Indonesia to move from fragmented measures toward a comprehensive resilience strategy focused on systemic prevention.

In short, strengthening DRM in infrastructure governance generates multiple benefits. It contributes to economic efficiency by reducing recovery costs, promotes social equity through participation, supports

environmental sustainability, and strengthens institutional legitimacy. This study reminds policymakers, practitioners, and researchers that disaster resilience must be treated as a governance priority in infrastructure planning, financing, and implementation.

If successfully implemented, this approach will not only mitigate disaster risks but also support Indonesia's long-term aspiration for sustainable and resilient infrastructure development.

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infrastructure development. He has published several papers on water infrastructure, environmental engineering, and policy studies in national and international journals. Together with M. Ridho Ulya and Zainal Alim, he is currently conducting research on the integration of disaster risk management into infrastructure planning and governance in Indonesia. He can be contacted via email at Muhammad.sedo@tka.itera.ac.id.

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