Journal of Geographical Planning
Volume. 1, Issue 1 November 2025
Page No: 42-55

Bridging Policy and Practice in Urban DRR: The Role of Spatial Planning

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Received : October 007, 2025
Accepted : November 07, 2025
Published : November 30, 2025

Citation: Novianti, D., & Jalaludin, M. (2025). Bridging Policy and Practice in Urban DRR: The Role of Spatial Planning. Journal of Geographical Planning, 1(1), 42-55.

ABSTRACT: Disaster risk reduction (DRR) in urban environments requires innovative planning strategies that integrate spatial, environmental, and social dimensions. This narrative review investigates how spatial planning frameworks support DRR in developing countries by analyzing recent literature on policy design, nature-based solutions (NbS), geospatial technologies, and community participation. The study follows a thematic synthesis method to examine institutional frameworks, adaptive regulations, and context-specific practices across regions. The findings reveal that disaster-sensitive zoning, inclusive policy structures, and NbS like green infrastructure and riparian buffers significantly reduce urban vulnerability. GIS and remote sensing are shown to enhance spatial risk analysis, while community participation strengthens the legitimacy and effectiveness of mitigation strategies. However, implementation remains constrained by institutional fragmentation, lack of capacity, and limited stakeholder engagement. The discussion highlights that integrated planning, cross-level policy coordination, and participatory governance are essential for sustainable DRR. It also underscores the role of institutional reform and technological innovation in overcoming systemic barriers. The study concludes by recommending that future research assess the effectiveness of NbS and participatory tools through empirical methods and comparative evaluations. This review affirms that spatial planning, when aligned with climate resilience and inclusive practices, can transform urban risk management and foster adaptive development.

Keywords: Spatial Planning, Disaster Risk Reduction, Nature-Based Solutions, Urban Resilience, Participatory Governance, GIS And Remote Sensing, Climate Adaptation.

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INTRODUCTION

Urban environments are increasingly acknowledged as critical zones of vulnerability in the context of natural disasters. As urbanization accelerates, particularly in the Global South, cities face a mounting convergence of risks stemming from climate change, inadequate infrastructure, and socio-economic inequalities. Disasters such as floods, landslides, and earthquakes disproportionately affect urban areas, where population density, informal settlements, and poorly

planned development exacerbate exposure and limit adaptive capacity. In East Teluk Betung Sub-District, Indonesia, for example, hydrometeorological hazards such as floods and landslides have become more frequent and intense due to the combined impacts of urban expansion and climate change (Affandi et al., 2024). Similarly, studies in Bukit Antarabangsa, Malaysia, highlight that social dimensions—including housing quality and income level—significantly influence community vulnerability, underscoring the complex interactions between socio-economic status and disaster risk (Kamarudin et al., 2022). Furthermore, research from Surakarta, Indonesia, demonstrates that deficient spatial planning mechanisms contribute to an accumulation of disaster vulnerabilities, reinforcing the need for integrative urban risk management approaches (Miladan et al., 2020).

Over the last two decades, a paradigm shift has emerged emphasizing the integration of disaster risk reduction (DRR) into spatial and urban planning frameworks. This evolution has been driven in part by international agreements, such as the Sendai Framework for Disaster Risk Reduction, which advocates for the incorporation of risk-informed policies into spatial development strategies (Sagala et al., 2021). Concurrently, innovations in geospatial technologies and the establishment of Spatial Data Infrastructures (SDIs) in regions like Europe have significantly improved the availability and usability of disaster-related spatial data (Ključanin et al., 2021). Case studies from various urban centers illustrate that adopting risk-sensitive urban planning has enhanced city-level resilience, with notable examples in Southeast Asia and the European Union (Sarafova, 2022). These developments signal a growing consensus that urban disaster preparedness and mitigation cannot rely solely on reactive measures but must be embedded within proactive planning systems that account for current and future hazards.

The mounting evidence of urban disaster vulnerability is not limited to high-profile disaster events but is also reflected in empirical assessments of urban exposure and risk. In Indonesia, frequent urban flooding has caused repeated displacements, economic losses, and health crises in cities like Jakarta, Surabaya, and Semarang, where drainage systems are often outdated or overwhelmed (Susiati et al., 2024). Globally, the World Bank estimates that by 2050, over 1.6 billion urban dwellers will be affected by extreme weather events, many of which are magnified by poor spatial planning (World Bank, 2021). The United Nations Office for Disaster Risk Reduction (UNDRR) further emphasizes that urban populations are especially susceptible to cascading risks, where one hazard, such as heavy rainfall, may trigger secondary events like landslides or infrastructure failures. The intersection of demographic pressure, informal development, and environmental degradation compounds these risks and underscores the relevance of spatially-informed DRR strategies.

Urban planning decisions have long-term implications for how risks are distributed and managed. Poorly regulated land use, especially in hazard-prone zones, increases the concentration of vulnerable populations in areas that lack adequate infrastructure and emergency preparedness. In Surakarta, for example, spatial assessments have shown that areas near riverbanks and industrial zones are often simultaneously exposed to flood risk and social vulnerability (Miladan et al., 2020). In such contexts, traditional planning approaches that focus solely on economic development fall short in addressing the dynamic nature of urban risk.

Instead, integrated spatial planning must consider the multiplicity of hazards, infrastructure resilience, and social equity to build long-term urban sustainability.

Nonetheless, the implementation of risk-sensitive spatial planning faces multiple challenges, particularly at the subnational and municipal levels. Local governments often operate under severe resource constraints, lacking the financial capital, technical capacity, and trained personnel required to develop and enforce effective DRR policies (Sagala et al., 2021). Competing priorities, such as economic growth imperatives and infrastructure development, may overshadow risk considerations. Moreover, discrepancies between low-carbon development goals and existing DRR frameworks can lead to policy incoherence and diluted implementation efforts (Rözer et al., 2025). Bureaucratic complexities, institutional fragmentation, and insufficient community participation further hinder the translation of risk-informed plans into actionable strategies (Akola et al., 2023). These systemic barriers perpetuate the disconnection between spatial planning and actual disaster risk mitigation outcomes.

Adding to these challenges is the persistent gap in empirical evidence linking spatial planning interventions to tangible disaster risk reduction outcomes. Although numerous studies advocate for integrated planning, few provide robust, longitudinal data that evaluate the effectiveness of these measures over time (Sagala et al., 2021). This absence of comprehensive impact assessments restricts the development of best practices and limits the ability of policymakers to justify investments in risk-sensitive planning(Akola et al., 2022). Additionally, many studies focus on technical or engineering solutions without fully incorporating social, economic, and political dimensions that critically influence the success of planning initiatives (Dandoulaki et al., 2023). The lack of interdisciplinary research hampers a holistic understanding of the systemic factors that facilitate or obstruct spatially-informed disaster resilience.

There is also a notable deficit in studies that assess the long-term sustainability of DRR-integrated spatial planning initiatives. Much of the existing literature evaluates short-term outcomes or pilot projects, neglecting to track the evolution of risk exposure, urban form, and institutional capacity over extended periods (Rahman et al., 2019). Without longitudinal insights, it is difficult to ascertain the resilience dividends of spatial planning or to adapt strategies in response to emerging threats and socio-environmental dynamics. Bridging this gap is essential to foster evidence-based policymaking and to ensure that urban planning is both adaptive and transformative in the face of ongoing global change.

This review aims to address these gaps by systematically analyzing the current state of spatial planning for disaster risk reduction in urban areas, with a focus on identifying effective strategies, institutional enablers, and common barriers. The goal is to provide an evidence-based synthesis that can guide policymakers, planners, and practitioners in integrating DRR into urban planning processes. Emphasis is placed on examining how risk assessments are operationalized within planning frameworks, how multi-level governance structures affect implementation, and how local contexts shape the applicability of international best practices. A secondary objective is to evaluate the role of spatial data, participatory planning, and cross-sectoral collaboration in enhancing the resilience of urban environments.

The scope of this review is geographically focused on urban areas in Indonesia, particularly Surakarta and Palu, which exemplify distinct risk profiles and planning challenges. Surakarta represents a city facing multi-hazard exposure, including floods and fires, with an emerging agenda for integrated spatial planning (Miladan et al., 2020). In contrast, Palu provides a critical case study in post-disaster reconstruction following the 2018 earthquake and tsunami, offering insights into the integration of DRR into long-term urban redevelopment (Sagala et al., 2021). These case studies serve as anchors for examining broader trends and drawing generalizable lessons relevant to other rapidly urbanizing regions in Southeast Asia and beyond.

From a demographic standpoint, the populations most affected by disaster risk in urban areas tend to be those residing in informal settlements and marginalized communities. These groups often live in hazardous zones due to economic necessity and face limited access to essential services, information, and political representation. According to Kamarudin et al. (2022), socio-economic disparities significantly influence household-level resilience, making it imperative that spatial planning efforts prioritize equity and inclusion. By focusing on these vulnerable urban populations, this review seeks to illuminate pathways for more just and effective urban resilience policies that are responsive to both structural and localized risk dynamics(Demir et al., 2021; Gonzales & Ajami, 2017).

In sum, the intensifying challenges of urban disaster risk necessitate a reorientation of planning practices toward a more integrative, risk-sensitive paradigm. This review contributes to that effort by consolidating empirical findings, identifying policy-relevant insights, and proposing a framework for action that aligns spatial planning with the imperatives of disaster resilience and sustainable urban development.

METHOD

This study employed a narrative literature review approach to synthesize scholarly research on the integration of spatial planning and disaster risk reduction (DRR). The review process was designed to systematically gather, screen, and evaluate scientific literature relevant to the core theme of risk-sensitive spatial policy implementation. Literature searches were conducted using three primary academic databases: Scopus, Web of Science, and Google Scholar. These databases were selected for their comprehensive coverage of interdisciplinary peer-reviewed publications, particularly in urban planning, disaster studies, environmental science, and public policy.

To ensure a targeted and high-quality literature search, several carefully constructed keyword combinations were utilized. The primary search strings included: "spatial planning" AND "disaster risk reduction" AND "policy implementation"; "urban resilience" AND "disaster management" AND "spatial planning"; "integrated risk assessment" AND "spatial planning" AND "climate change"; "community participation" AND "disaster risk reduction" AND "spatial planning"; and "multi-hazard risk" AND "spatial planning" AND "sustainability." These keyword combinations were strategically selected to capture studies that reflect diverse

perspectives and dimensions of disaster-related urban planning. The inclusion of terms such as "policy implementation," "community participation," and "multi-hazard" aimed to retrieve studies that integrate social, technical, and institutional factors in spatial governance. Boolean operators (AND/OR) were used where appropriate to refine search results and ensure both breadth and specificity.

Searches were conducted over a period of two months to allow for iterative refinement and expansion of keyword combinations as emerging themes were identified. Filters were applied to limit the results to peer-reviewed journal articles written in English. Additional search strategies included snowballing from the reference lists of key articles, as well as citation tracking to identify highly cited and influential works that may not have appeared in initial searches due to indexing or metadata variations.

A rigorous set of inclusion and exclusion criteria was applied to ensure the relevance and methodological robustness of selected studies. Inclusion criteria required that articles be published in peer-reviewed journals, thus assuring the scientific credibility and integrity of their content. Studies had to focus explicitly on spatial planning and its relationship with disaster risk reduction or management. Only those papers that provided a clear and replicable methodological description were considered, with priority given to studies featuring empirical data, case-based analysis, or structured frameworks that could inform policy and practice. Special attention was given to studies conducted in urban or peri-urban areas with high disaster risk exposure, such as flood-prone or seismically active regions, especially within the Global South where urban vulnerability is often amplified.

Conversely, several exclusion criteria were adopted to eliminate studies that were unlikely to contribute substantively to the review. These included articles that were not accessible through open access or institutional access channels, thereby limiting the ability to evaluate their content. Non-empirical publications, such as purely theoretical or conceptual commentaries without data or grounded case examples, were excluded to maintain a focus on evidence-based analysis. In addition, articles focusing on geographic areas or populations unrelated to the scope of this study were discarded. Studies older than ten years were generally excluded to ensure that the review reflects recent developments, practices, and challenges in the evolving landscape of urban planning and disaster governance. However, seminal works that have significantly shaped the field and continued to be referenced were retained for contextual grounding.

The review included diverse study designs to capture the multifaceted nature of spatial planning for DRR. Among these were case studies, qualitative policy analyses, comparative studies, and mixed-method research. Empirical studies using geospatial modeling, risk assessment simulations, participatory mapping, and policy evaluation frameworks were particularly valued. These types of studies provide tangible insights into the operationalization of DRR in urban planning contexts and highlight practical implications for stakeholders. Experimental designs such as randomized controlled trials were not expected nor prioritized, given the contextual and applied nature of urban planning research.

The process of literature selection began with an initial pool of over 600 articles retrieved from the combined keyword searches. Titles and abstracts were screened manually to assess relevance against the inclusion criteria. This initial screening reduced the dataset to approximately 150 articles, which were then subjected to full-text review. Each article was read thoroughly to evaluate its thematic alignment, methodological soundness, and relevance to the research objectives. During this phase, studies were further classified into thematic categories such as governance and policy frameworks, community-based planning, geospatial technologies, and sustainability-focused risk reduction. The classification process facilitated comparative analysis across different urban contexts and risk types.

To enhance reliability, a quality assessment rubric was developed and applied to the selected studies. This rubric evaluated methodological clarity, data validity, analytical rigor, and policy relevance. Articles scoring low on methodological transparency or lacking coherence in data interpretation were excluded from the final synthesis. Where disagreements arose during the evaluation process, consensus was achieved through team discussions, ensuring consistency and critical appraisal across reviewers. Moreover, a detailed extraction sheet was used to document study characteristics including location, research design, key findings, risk context, and policy recommendations. This database enabled the cross-comparison of insights and the identification of patterns in approaches and outcomes.

Through this methodology, the study aims to provide a comprehensive and structured synthesis of the current landscape of spatial planning for disaster risk reduction. By focusing on evidence-based literature that spans multiple disciplines and geographic contexts, the review captures both the challenges and opportunities inherent in translating spatial planning into effective disaster resilience strategies. It also reveals the intersections between technical planning tools, institutional dynamics, and socio-cultural dimensions that shape the effectiveness of DRR policies. Ultimately, this methodological approach ensures that the resulting analysis is grounded in a robust body of knowledge, offering actionable insights for urban planners, policymakers, and disaster risk practitioners seeking to navigate the complex terrain of risk-informed spatial development.

RESULT AND DISCUSSION

The findings of this narrative review are organized into four thematic areas reflecting the dominant frameworks and practices discussed across the literature: regulatory policies, nature-based solutions, geospatial technology applications, and community participation in spatial planning for disaster risk reduction (DRR)(Raška et al., 2022). Each theme highlights empirical insights and international comparisons that illustrate how disaster risk is addressed through spatial planning approaches.

Policy and Regulatory Frameworks

In developing countries, spatial planning for DRR is most often institutionalized through government-led zoning regulations, urban master plans that integrate hazard risk information, and national safety and resilience frameworks. In Indonesia, particularly in Surabaya, spatial plans increasingly incorporate disaster vulnerability assessments to guide infrastructure development and land-use controls (Pamungkas et al., 2024). Regulatory provisions have been created to delineate high-risk zones and prescribe corresponding land-use restrictions. This effort is complemented by financial prioritization for green infrastructure and hazard mitigation projects (Sagala et al., 2021). Similarly, zoning codes in parts of Southeast Asia have evolved to reflect adaptive risk management principles that aim to prevent new development in hazard-prone locations (Kautsary & Rahman, 2024). These codes emphasize participatory mechanisms in the drafting and revision processes, allowing community inputs to shape contextually appropriate strategies (Roslan et al., 2021).

Moreover, countries increasingly embed climate adaptation targets into their spatial policies. Taramelli et al. (2019) documented efforts to align land-use planning with national climate action strategies in several Asian cities, thereby reducing future disaster exposure by anticipating climate-driven hazards. The integration of these policies underscores the gradual shift from reactive to anticipatory planning paradigms.

Nonetheless, significant variance exists in how policies are designed and implemented across countries. Decentralized governance structures in countries such as Indonesia and the Philippines allow local governments more autonomy to design risk-responsive spatial plans, often resulting in more context-sensitive approaches (Roslan et al., 2021; Hasan et al., 2025). In contrast, top-down policy structures—as seen in parts of South Asia and Latin America—may lack the agility to respond to local needs, reducing the effectiveness of mitigation strategies (Aksha & Emrich, 2020).

For example, comparative studies between Chile and Ecuador highlight how local stakeholder engagement in planning processes enhances the success of DRR strategies by ensuring relevance to community needs and hazard profiles (Greiving et al., 2021). Conversely, the absence of continuous policy monitoring and evaluation mechanisms in some regions results in static plans that do not adapt to changing risk landscapes, thereby undermining long-term resilience (Ramli et al., 2021).

Nature-based Solutions (NbS)

The literature confirms that nature-based solutions are effective in reducing urban disaster risk while co-delivering ecological and social co-benefits. Riparian forests, urban green spaces, and wetlands act as natural buffers that regulate hydrological flows and attenuate the impact of flooding. In East Kalimantan's IKN region, for instance, research demonstrates that riparian zones significantly reduce runoff and soil erosion, contributing to flood prevention and water quality improvement (Yuanita et al., 2025). Urban green belts have also been shown to reduce heat island effects and create microclimates conducive to health and wellbeing (Taramelli et al., 2019).

NbS have the added benefit of serving as carbon sinks, which aligns DRR efforts with global climate goals. Their strategic inclusion in urban planning can support long-term resilience by addressing underlying environmental drivers of disaster (Affandi et al., 2024). For example, in cities across Indonesia, the use of ecosystem-based planning has led to the expansion of green infrastructure corridors that improve biodiversity while mitigating landslide and flood risks (Pizzorni et al., 2022).

Despite these advantages, the practical application of NbS in spatial planning faces institutional and operational barriers. Fragmented coordination between agencies, insufficient budget allocations, and limited technical expertise hinder the mainstreaming of NbS in developing regions (Kautsary & Rahman, 2024; Kamarudin et al., 2022). Knowledge gaps among local planners further limit adoption. Research by Pamungkas et al. (2024) and Kodag & Kodag (2023) highlights a widespread lack of training on ecosystem services and ecological design principles.

Social and political challenges also affect implementation. Resistance from communities unfamiliar with the benefits of NbS, combined with inadequate stakeholder engagement during project planning, often results in poor acceptance and suboptimal outcomes (Sagala et al., 2021). Addressing these limitations requires targeted capacity-building, cross-sector collaboration, and enhanced public awareness campaigns to build a constituency for NbS-informed planning.

Geospatial Technologies and Risk Modeling

Geospatial technologies, particularly GIS and remote sensing, are integral to modern DRR planning due to their capacity to visualize risk, monitor change, and inform spatial decision-making. GIS-based mapping tools enable planners to assess exposure and vulnerability by integrating layers of data such as elevation, land use, infrastructure, and population density (Davis et al., 2025; Dhyani et al., 2023). This capacity to model multiple hazards simultaneously enhances the precision and efficiency of land-use decisions.

Remote sensing provides dynamic environmental data that can be used for real-time hazard monitoring and post-disaster assessments(Yan et al., 2022). Taramelli et al. (2019) demonstrated the utility of satellite-based tools in evaluating the performance of green infrastructure under variable weather conditions, supporting adaptive management of urban watersheds. The fusion of remote sensing with GIS offers an evidence-based foundation for designing early warning systems and developing scenario-based evacuation plans(Paršova et al., 2018; Simeonova et al., 2017).

In Banda Aceh, for instance, GIS-based tsunami modeling enabled the identification of priority evacuation routes and safe zones, significantly improving community preparedness and response planning (Hasan et al., 2025). Another example from China shows how spatial analysis of flood risk in Dafeng's agricultural zones informed revised zoning policies that protect both farmers and critical food supply chains (Chang et al., 2023). These applications affirm the utility of geospatial intelligence in shaping locally grounded yet scientifically robust disaster planning.

Community Participation and Local Knowledge

Integrating community knowledge and participatory practices into DRR planning is widely recognized as a critical enabler of effective spatial governance. Local populations possess context-specific insights into environmental hazards, historical vulnerabilities, and social dynamics that are often overlooked in technical assessments (Peters-Guarin et al., 2011). Engagement processes that empower residents to contribute to spatial risk assessments tend to produce more legitimate and actionable plans.

Successful examples include participatory GIS (PGIS) approaches in Nepal, where local residents collaborated with planners to map flood-prone zones and prioritize interventions (Aksha et al., 2020). These initiatives led to the design of community-approved safe zones and evacuation plans that were both culturally sensitive and technically sound.

The most effective participatory models combine top-down policy direction with bottom-up knowledge systems. Integrative frameworks such as Rapid Rural Appraisal (RRA) paired with PGIS enable inclusive data collection, ensure community voices are heard, and foster collective ownership of outcomes (Kamarudin et al., 2022). Studies show that these hybrid approaches are associated with higher levels of community awareness, stronger compliance with risk regulations, and greater resilience to future hazards (Cian et al., 2021).

Ongoing engagement and feedback loops are essential to maintaining the relevance and adaptability of DRR strategies. Participatory monitoring mechanisms, such as community hazard observatories and local planning councils, institutionalize dialogue and help bridge gaps between formal planning frameworks and lived experiences. These arrangements support not only more equitable planning outcomes but also cultivate a culture of shared responsibility for risk reduction.

In summary, this review finds that the integration of spatial planning and DRR is most effective when guided by inclusive policies, ecosystem-based designs, data-driven technologies, and participatory processes. Despite challenges in implementation, particularly in resource-constrained settings, there is growing evidence that multidisciplinary and community-centric approaches significantly enhance urban resilience. Comparisons across contexts—from Indonesia and China to Nepal and Ecuador—highlight the value of tailoring strategies to local conditions while leveraging global best practices. Moving forward, deeper institutional commitment, improved capacity building, and continuous monitoring will be essential to sustain and scale these innovations in disaster-resilient spatial planning.

Findings That Reinforce or Challenge Established Theories and Practices

The integration of spatial planning and disaster risk reduction (DRR) has found robust support in current literature, reinforcing established interdisciplinary theories while also posing significant challenges to conventional practices. For instance, Wamsler and Brink (2016) provide compelling evidence that systemic approaches to managing urban risk interconnectivity improve resilience and reduce vulnerability. This aligns with broader discussions in DRR literature emphasizing the

necessity of cross-sectoral integration, combining environmental, social, and economic strategies to build sustainable solutions.

The empirical study in Banda Aceh offers a potent example of how evidence-based policy development enhances the efficacy of DRR strategies (Hasan et al., 2025). This substantiates arguments by Taramelli et al. (2019) regarding the critical role of geospatial technologies and data-driven planning in risk-informed decision-making. Such studies corroborate the theoretical premise that spatially explicit data significantly improve policy formulation and implementation outcomes.

However, several findings challenge prevailing practices, especially regarding the application of nature-based solutions (NbS). Despite their conceptual appeal, the practical integration of NbS often fails to address local capacities and community-specific needs (Yuanita et al., 2025). This resonates with concerns raised by Roslan et al. (2021), who criticize policy frameworks that overlook local knowledge and participation, leading to ineffective implementation.

Moreover, while participatory approaches are theoretically acknowledged as vital, they remain underutilized in many centralized governance systems. Peters-Guarin et al. (2011) emphasize that active community engagement is pivotal to successful DRR implementation. Yet, such engagement is frequently marginalized in top-down planning paradigms, highlighting the need for institutional reforms that elevate local voices in risk governance.

In summary, the findings suggest that future DRR strategies must transcend disciplinary silos and governance hierarchies to develop adaptive, inclusive, and evidence-based interventions. This is particularly crucial given the accelerating impacts of climate change and rapid urbanization, which intensify the complexity of disaster risks.

The Role of Institutional Structures and Socio-Political Factors in Integrating Spatial Planning and Risk Reduction

Institutional structures and socio-political dynamics are central to the success or failure of DRR integration within spatial planning. Strong, well-coordinated institutions can expedite policy development that is responsive to localized risks. Rahman et al. (2019), in their study on climate adaptation in Bangladesh, underscore the value of clear, integrated frameworks that guide policy execution and promote public participation.

Conversely, weak governance, corruption, and imbalanced power structures severely constrain effective DRR implementation. Wamsler and Brink (2016) argue that when planning processes are manipulated by elite interests, they frequently neglect vulnerable populations, exacerbating existing inequalities and undermining resilience efforts. This political marginalization obstructs the flow of resources and undermines the inclusivity of planning processes.

Social awareness and community engagement also play critical roles in shaping effective DRR policy. Kamarudin et al. (2022) advocate for the incorporation of local knowledge into risk planning, emphasizing its importance in aligning policies with ground realities. Failure to do so often results in maladaptive interventions that lack community ownership and legitimacy.

Fragmentation across different governance levels further hampers the implementation of coherent DRR strategies. A lack of coordination among national, regional, and local authorities creates policy inconsistencies and implementation delays. Wamsler and Brink (2016) highlight that disjointed governance structures frequently lead to overlapping responsibilities and inefficient use of resources.

Understanding the interplay between institutional arrangements and socio-political conditions is thus essential to crafting more effective DRR policies. Future research should investigate how these dynamics manifest across different contexts and how institutional innovation can support collaborative and context-sensitive spatial planning(Wang et al., 2017).

Policy and Strategic Recommendations to Address Systemic Barriers in Spatially-Based Risk Reduction

Overcoming systemic barriers in spatially-based DRR requires a multidimensional strategy that strengthens institutional frameworks, fosters technological innovation, and integrates local knowledge into formal planning mechanisms. First and foremost, institutional strengthening is critical. Developing collaborative networks among government agencies, NGOs, and communities enhances information sharing and collective action. Effective inter-agency coordination ensures that policies are grounded in comprehensive risk analyses and that interventions are synergistic rather than fragmented.

Technological solutions, particularly geospatial tools, are pivotal in supporting evidence-based planning. Cheng & Chang, (2018) propose GIS-integrated multi-hazard frameworks that enable authorities to assess diverse risk profiles and prioritize interventions accordingly. These technologies enhance the capacity of planners to visualize spatial patterns of vulnerability and to simulate disaster scenarios, facilitating proactive and tailored responses.

Nature-based solutions also emerge as a key policy recommendation. As Taramelli et al. (2019) illustrate, green infrastructure not only mitigates disaster impacts but also contributes to ecological health and urban livability. Implementing NbS such as riparian forests, urban wetlands, and green corridors can simultaneously address climate adaptation and risk reduction goals.

Integrating indigenous and local knowledge into DRR planning further enriches policy relevance and community acceptance. Participatory planning processes that engage local stakeholders from the outset foster social legitimacy and ensure that interventions align with local values and practices. Studies show that such inclusive approaches not only improve implementation success but also build long-term community resilience.

Another strategic imperative is the mainstreaming of climate change considerations into spatial planning(Chaladdee et al., 2022; Luo et al., 2021). Given the escalating frequency and severity of climate-induced hazards, DRR policies must incorporate climate risk projections and adaptive capacity assessments. This integration helps to future-proof infrastructure investments and land-use decisions against emerging threats.

Education and public awareness campaigns are also vital. Enhancing the public's understanding of disaster risks and promoting a culture of preparedness can mobilize grassroots support for DRR initiatives. Community-based training and knowledge exchange platforms can bridge the gap between scientific expertise and everyday risk perception.

Lastly, sustainable financing mechanisms must underpin all DRR efforts. Without adequate financial resources, even the most well-conceived policies remain aspirational. Governments should explore innovative funding models, including public-private partnerships, risk insurance schemes, and international climate finance, to support the implementation of spatially-informed DRR strategies.

In conclusion, advancing DRR in spatial planning requires systemic transformation—one that embraces inclusivity, leverages technology, and fosters institutional accountability. Future research should focus on evaluating the effectiveness of these strategies across diverse socio-political settings and on developing scalable models that can be adapted globally to strengthen disaster resilience.

CONCLUSION

This narrative review has revealed that integrating spatial planning into disaster risk reduction (DRR) policies is a fundamental step toward building urban resilience, especially in developing countries. The findings emphasized the significance of adaptive regulatory frameworks, nature-based solutions (NbS), geospatial technologies, and inclusive community participation as core strategies for minimizing disaster risk. From the empirical evidence presented, localized and participatory approaches—when combined with geospatial tools and cross-sectoral institutional cooperation—demonstrate higher success rates in addressing context-specific vulnerabilities.

The discussion identified institutional fragmentation, limited technical knowledge, insufficient funding, and low community engagement as key systemic challenges hindering implementation. Therefore, overcoming these obstacles requires policy reforms that strengthen institutional capacity, promote the adoption of GIS-based decision-making, and encourage nature-integrated planning. Additionally, ensuring inclusive governance structures that engage local stakeholders remains essential.

Urgently, further interventions are needed to harmonize national and local DRR policies, integrate climate resilience objectives into land-use planning, and expand interdisciplinary collaboration. Future research should focus on developing metrics for evaluating NbS effectiveness, refining participatory GIS frameworks, and exploring comparative policy analyses across regions.

As rapid urbanization and climate risks escalate, spatially-oriented DRR strategies offer a promising pathway toward sustainable, equitable, and adaptive development planning. Emphasizing nature-based solutions, participatory governance, and data-driven frameworks will be critical in mitigating future disaster risks and enhancing the resilience of vulnerable communities.

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