## INTEGRATING GIS FOR RESILIENT HOUSING SOLUTIONS AMONG COASTAL SETTLEMENTS IN DAVAO CITY: A SYSTEMATIC LITERATURE REVIEW

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**ABSTRACT**

Climate change poses substantial and multifaceted threats to coastal informal settlements, exacerbating existing vulnerabilities through various mechanisms such as flooding, rising sea levels, storm surges, and soil liquefaction. These threats significantly impact the livelihoods and safety of residents in these areas, highlighting the urgent need for resilient housing solutions. This systematic literature review scrutinizes the integration of Geographic Information Systems (GIS) and Climate Disaster Risk Assessment (CDRA) methodologies in developing adaptive and sustainable housing strategies for coastal communities, with a specific focus on Davao City. Following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, a total of 56 relevant studies published between 2014 and 2024 were meticulously analyzed. The comprehensive findings illustrate the immense potential of GIS and CDRA tools in effectively mapping vulnerabilities within coastal regions, facilitating informed urban planning decisions, and guiding the formulation of community-driven housing policies aimed at resilience building. Key insights from the literature reveal that GIS can provide critical spatial data that assists stakeholders in visualizing risk zones and assessing the impact of climate change on housing infrastructures. Similarly, CDRA methodologies offer a structured approach for evaluating the potential consequences of environmental hazards, thereby informing proactive measures to enhance community resilience. The review recommends several actionable strategies to strengthen the capacity for adaptive housing solutions. These include promoting participatory governance models that engage local communities in decision-making processes, enhancing the integration of traditional and local knowledge into GIS-based interventions for more context-specific solutions, and reinforcing legislative frameworks that support the implementation of adaptive housing practices. By taking these steps, stakeholders can create a more resilient future for coastal communities grappling with the challenges of climate change.

**Keywords:**

Geographic Information Systems (GIS), urban resilience, flood-prone areas, housing vulnerability, spatial analysis, resilient housing solutions, vulnerability mapping, participatory GIS, climate adaptation strategies

**INTRODUCTION**

**BACKGROUND**

Coastal communities, especially informal settlements, are increasingly vulnerable to climate change-induced hazards such as flooding, storm surges, sea-level rise, and liquefaction. In Davao City, the risks associated with climate change are particularly pronounced due to rapid urbanization, insufficient urban planning, and the lack of formal infrastructure in these informal settlements. These settlements are often situated in low-lying coastal areas, exacerbating their exposure to flooding and other climate hazards. The absence of solid foundations, proper housing designs, and effective governance further intensifies the vulnerability of residents to environmental stressors.

Geographic Information Systems (GIS) and Climate Disaster Risk Assessment (CDRA) are emerging as indispensable tools for assessing vulnerabilities, guiding resilient housing solutions, and informing sustainable urban development strategies in these coastal areas. GIS enables the identification and mapping of risk factors, while CDRA incorporates climate change projections to assess potential future impacts. These approaches allow for the development of data-driven solutions that can effectively address vulnerabilities in informal settlements, particularly through participatory governance models that involve local communities in planning and decision-making.

This review synthesizes current literature on the integration of GIS and CDRA in addressing the vulnerability of coastal communities, focusing on the implications for resilient housing solutions in Davao City. Additionally, it explores the role of local knowledge and participatory approaches in enhancing the relevance and effectiveness of GIS-based interventions in the context of urban flood resilience.

**OBJECTIVES**

This review aims to:

1. Explore how GIS and CDRA can be integrated into the formulation of resilient housing strategies for coastal settlements in Davao City.
2. Analyze the role of participatory governance and local knowledge in improving the effectiveness of GIS-based interventions.
3. Investigate the potential challenges in implementing GIS and CDRA-based solutions and propose strategies to overcome them.

**METHODOLOGY**

**Search Strategy**

A comprehensive and systematic search was carried out across prominent academic databases, which included Scopus, ProQuest, and ScienceDirect. This search utilized a carefully selected set of keywords, such as “Geographic Information Systems (GIS),” “Climate-Driven Risk Adaptation (CDRA),” “resilient housing,” “coastal settlements,” “climate change,” and “flooding.” The primary focus was on identifying and analyzing studies published between 2014 and 2024, thereby ensuring that the review captured the most recent advancements and methodologies relevant to the subject. In the course of this search, great care was taken to exclude gray literature, which often includes reports, theses, and other documents that have not undergone the rigorous peer-review process. This exclusion was crucial in maintaining the integrity and scientific credibility of the sources included in the analysis. By prioritizing peer-reviewed publications, the aim was to ensure a high standard of quality and reliability in the findings and discussions contained within the review.

**Inclusion and Exclusion Criteria**

**Inclusion Criteria:**

* Studies focusing on GIS applications for disaster risk reduction in coastal areas.
* Articles addressing housing resilience strategies, particularly in informal settlements.
* Research conducted in or relevant to Southeast Asia, with a focus on Davao City and other coastal cities facing similar challenges.

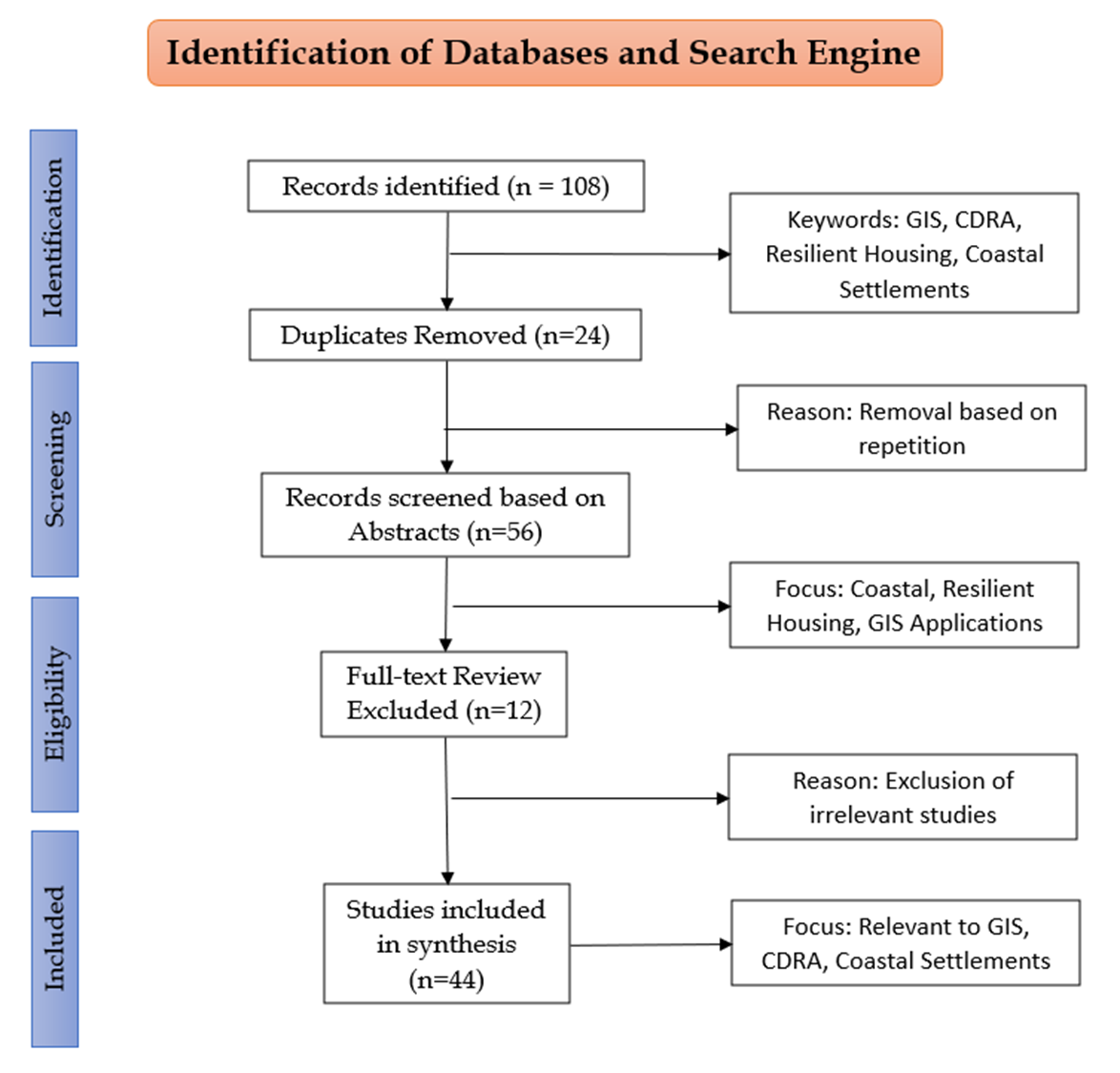
**Exclusion Criteria:**

* Studies not directly related to climate change, GIS, or CDRA applications.
* Non-peer-reviewed articles and conference proceedings.
* Studies lacking empirical data or rigorous methodologies.

**Study Selection Process**

Following **PRISMA guidelines**, the study selection involved:

1. **Initial Search:** Identifying 108 studies.
2. **Removal of Duplicates:** Narrowing the pool to 84 articles.
3. **Title and Abstract Screening:** Selecting 56 relevant studies.
4. **Full-Text Review:** Excluding 12 articles that did not meet criteria, resulting in 44 final studies.

Below is the PRISMA flowchart that provides a visual representation of the study selection process:

The flowchart details the progression from initial study identification to the final inclusion of studies, ensuring clarity in the methodology.

**Data Extraction and Analysis**

Data were extracted from the selected studies on:

* Study objectives, methodologies, and findings.
* Geographic and temporal scope of each study.
* GIS and CDRA methodologies were applied.
* Resilient housing outcomes and policy recommendations.

The analysis was thematic, categorizing findings into **climate vulnerability**, **GIS-CDRA integration**, and **governance and policy implications**.

**RESULTS AND DISCUSSION:**

The integration of Geographic Information Systems (GIS) and Climate Disaster Risk Assessment (CDRA) is proving to be a revolutionary method for tackling the vulnerabilities faced by coastal settlements. This study conducts a thorough and systematic review of diverse applications, placing particular emphasis on their implications for fostering resilient housing solutions in Davao City and comparable areas prone to climate-related risks.

Through an in-depth analysis, the research uncovers significant insights into how GIS and CDRA can be utilized effectively for disaster preparedness and response. The findings highlight the importance of participatory approaches, where community involvement is essential in understanding local vulnerabilities and enhancing resilience. Additionally, the study examines various challenges associated with the implementation of GIS-CDRA methodologies, such as data accessibility, technical expertise, and the need for stakeholder collaboration.

Furthermore, the research suggests potential strategies to mitigate these challenges, such as the development of capacity-building programs for local communities, investment in better data management systems, and the promotion of interdisciplinary partnerships. By addressing these barriers, the integration of GIS and CDRA can significantly contribute to more sustainable and climate-resilient housing practices, ultimately leading to improved safety and well-being for coastal populations in Davao City and similar regions.

**Integration of GIS and CDRA**

GIS and CDRA are pivotal in identifying vulnerabilities and informing targeted interventions. De Risi et al. (2013) demonstrated the utility of probabilistic GIS models in mapping flood risks in informal settlements, enabling the design of both structural measures, such as elevated housing, and non-structural solutions, like drainage improvements. Similarly, Rezvani et al. (2023) highlighted how GIS-based decision support systems can adapt to evolving environmental conditions, making them invaluable for long-term housing resilience. GIS allows integration of multi-layered data such as topographical features, climatic patterns, and socio-economic indicators, ensuring a holistic view of risk scenarios.

Additional success stories further emphasize GIS's effectiveness. Makhlouf et al. (2021) demonstrated the use of GIS to identify flood-prone areas in Algiers, Algeria, highlighting its role in urban flood risk analysis and informing effective zoning laws. Similarly, Kourgialas and Karatzas (2011) showcased how GIS methodologies aided flood-hazard assessment in Crete, Greece, facilitating the creation of tailored urban drainage systems. Taylor and Millington (2017) provided qualitative GIS representations that improved flood resilience in urban landscapes by incorporating socio-economic factors into risk assessments.

In Southeast Asia, Nguyen et al. (2018) explored GIS applications in Ho Chi Minh City, Vietnam, where GIS integration reduced urban flood risks by optimizing drainage networks and identifying high-risk zones. Additionally, Lyu et al. (2016) used GIS mapping to monitor flood impacts in Guangzhou, China, offering valuable insights into disaster preparedness. These studies demonstrate how GIS systems not only address current vulnerabilities but also enhance the scalability of risk management strategies across various urban contexts.

However, the implementation of these tools is often constrained by data limitations, as many informal settlements lack detailed and updated geospatial datasets. Addressing this data gap through partnerships and modern technologies like remote sensing can significantly enhance their effectiveness. Studies consistently emphasize the importance of participatory approaches in enhancing the effectiveness of GIS-based interventions. Nshuti (2020) explored the use of participatory GIS in the Sebeya catchment, revealing that local knowledge significantly improves the contextual relevance of flood risk assessments. Participatory approaches, such as workshops and mapping sessions, enable communities to provide critical insights about local vulnerabilities and strengths. Mulligan et al. (2019) reinforced this perspective by demonstrating how community-driven data collection strengthens the technical robustness of flood management plans. These approaches also foster trust and ownership among stakeholders, ensuring long-term commitment to resilience strategies. Despite these benefits, participatory models face challenges, such as the need for extensive technical training and resource allocation to effectively integrate local inputs.

**Challenges in Implementation**

The review highlights several significant barriers that impede the widespread adoption of Geographic Information Systems for Community Disaster Risk Assessment (GIS-CDRA) frameworks. One of the foremost challenges is related to the availability and precision of data, which are particularly problematic in informal settlements. In these areas, comprehensive datasets are often lacking, making it difficult to accurately assess vulnerabilities and plan effective interventions. The absence of reliable data not only hampers the precision of vulnerability assessments but also casts doubt on the effectiveness of disaster response strategies.

In addition to data issues, institutional fragmentation presents a formidable obstacle to the successful implementation of GIS-CDRA frameworks. The lack of cohesive coordination among various agencies involved in disaster management results in inefficiencies, duplication of efforts, and the potential for conflicting strategies. This fragmentation underscores the necessity for improved collaboration and communication across institutions to forge a unified approach to disaster risk management.

Financial constraints play a critical role in hindering progress as well, particularly in developing regions where resources may be limited. A chronic lack of investment in both infrastructure and human capital restricts the capacity to implement and sustain GIS-CDRA initiatives. To address these issues, substantial financial investment is essential, not only to develop the necessary technological infrastructure but also to engage in training programs that build local technical expertise.

Moreover, while the integration of local knowledge into the GIS-CDRA framework shows promise, it necessitates the establishment of formalized processes to effectively align community inputs with scientific data. Nshuti (2020) emphasizes that without these mechanisms in place, the potential benefits of local knowledge may remain untapped. Creating standardized protocols for participatory GIS could serve as a crucial step in bridging this divide, facilitating better data integration and community engagement in disaster risk assessments and planning. This approach would enhance both the relevance and reliability of the data used in decision-making, ultimately leading to more effective disaster management strategies.

**Implications for Policy and Practice**

The findings of the study emphasize the critical need for comprehensive and robust policy frameworks that institutionalize the use of Geographic Information Systems (GIS) and Community Disaster Risk Assessment (CDRA) in urban planning processes. To truly integrate these tools into the fabric of urban development, it is vital to strengthen legislative support, ensuring that there are clear and actionable guidelines that promote the systematic application of GIS and CDRA methodologies. Additionally, fostering participatory governance models is essential to bridge the existing gap between technical assessments and the real-life experiences and needs of the communities affected. For instance, incorporating participatory flood modeling into municipal governance frameworks can not only provide essential data-driven insights but also empower local residents by enhancing their ownership of resilience strategies. This dual approach of integrating technical expertise with community involvement can lead to more effective disaster preparedness and response measures. Policies should also prioritize investments in cutting-edge geospatial technologies to ensure that urban planners and local authorities have access to the most reliable data. It is important to promote equitable access to this data among all stakeholders, ensuring that marginalized communities are not left behind in the planning and implementation processes. Furthermore, facilitating cross-sector collaboration can enhance the sharing of knowledge and resources, creating a more cohesive and effective approach to urban resilience.

Future research must focus on developing adaptive housing designs that can withstand various environmental challenges while improving the integration of diverse data sources. Emerging technologies such as remote sensing, which can provide real-time environmental data, blockchain for data verification to enhance trust and transparency, and advanced geospatial systems, should be explored to optimize the use of information in urban planning.

Importantly, policies need to establish clear timelines and accountability measures to ensure not only their effectiveness but also their adoption by relevant authorities. By setting specific goals and performance indicators, policymakers can create a framework that encourages accountability and motivates various stakeholders to engage meaningfully in the urban planning process, ultimately leading to more resilient and sustainable communities.

**GIS-CDRA’s Impact on Urban Economies**

GIS and CDRA systems significantly influence urban economies by reducing the financial impacts of disasters, optimizing resource allocation, and fostering long-term economic resilience. By identifying high-risk areas and informing targeted interventions, GIS-CDRA systems help cities avoid the high costs of unplanned disaster responses. For example, flood mitigation measures designed using GIS data can prevent damages to infrastructure, businesses, and homes, reducing economic losses and protecting livelihoods.

Moreover, GIS-CDRA enhances urban planning by guiding investments in resilient infrastructure, such as flood-resistant buildings and efficient drainage systems. These proactive measures attract investors by reducing uncertainties and ensuring a safer environment for economic activities. In cities like Ho Chi Minh and Guangzhou, GIS-based urban planning has optimized public expenditures by prioritizing infrastructure investments in high-risk zones, thereby increasing overall cost-effectiveness.

Additionally, GIS-CDRA fosters job creation and skills development. The implementation of these systems requires geospatial analysts, urban planners, and technicians, contributing to workforce diversification in cities. Furthermore, the improved resilience of urban economies enhances their ability to recover quickly from disasters, maintaining economic stability and minimizing disruptions to trade and services.

Davao City, in particular, stands to benefit economically from the integration of GIS-CDRA by safeguarding its critical infrastructure, such as ports and transportation hubs, which are vital for its local economy and regional trade. With reduced disaster-related disruptions, urban areas can focus on sustainable growth, fostering a resilient economic environment for businesses and communities.

**RECOMMENDATIONS**

To enhance the integration of Geographic Information Systems (GIS) and Coastal Disaster Risk Assessment (CDRA) in addressing the vulnerabilities faced by coastal settlements, the following detailed recommendations are proposed:

1. **Foster Community Involvement:** It is crucial to actively engage local communities in the processes of disaster risk assessments and urban planning to ensure that their unique perspectives and knowledge are incorporated. This can be achieved by providing training sessions for community members on how to utilize participatory GIS tools effectively. Through hands-on workshops and collaborative projects, community members can learn to gather and analyze local geospatial data, which will contribute to more accurate and contextually relevant GIS-based interventions. Additionally, establishing channels for regular communication between community members and decision-makers will ensure that the insights gathered during these assessments are valued and integrated into broader planning frameworks.
2. **Strengthen Data Collection and Sharing Frameworks:** Improving the accuracy, availability, and accessibility of geospatial data is fundamental to effective disaster risk management. To this end, it is essential to develop robust mechanisms that support the collection, analysis, and dissemination of high-quality geospatial data. Investing in advanced technologies such as remote sensing, high-resolution satellite imagery, and cloud-based GIS platforms will enhance data precision and timeliness. Furthermore, fostering strong partnerships among government agencies, academic institutions, and private sector entities can facilitate the sharing of these datasets, ultimately creating a more comprehensive and interconnected data ecosystem. This collaborative approach will enable stakeholders to leverage shared resources and expertise, leading to more informed decision-making processes.
3. **Institutionalize Participatory Governance Models:** Embedding participatory governance into policy frameworks is necessary to ensure that community involvement is not only encouraged but also formalized within urban planning and disaster risk management strategies. Establishing local disaster resilience committees made up of community members, local government representatives, and other stakeholders can enhance coordination and communication among all parties involved. These committees can serve as vital platforms for discussing and prioritizing the community's needs, preferences, and experiences. By institutionalizing these governance models, communities will have a structured means of influencing policy and ensuring their voices are heard, ultimately leading to more sustainable and resilient coastal settlements.

By implementing these recommendations, we can create a more integrated and effective approach to disaster risk management in coastal areas, building resilience and empowering communities to face future challenges confidently.

1. **Invest in Capacity Building:** It is essential to implement targeted training programs for local government units, community leaders, and other key stakeholders in the effective use of Geographic Information Systems (GIS) and Community Disaster Risk Assessment (CDRA) tools. These capacity-building initiatives should encompass comprehensive workshops, hands-on training sessions, and ongoing support to enhance participants' technical skills and confidence in utilizing these systems. By ensuring that stakeholders are well-versed in GIS and CDRA methodologies, we can empower them to not only implement but also sustain these systems over time, ultimately leading to more informed decision-making in disaster management and urban planning.
2. **Strengthen Legislative Support:** To foster a supportive environment for the integration of GIS and CDRA in urban planning and disaster risk management, it is crucial to advocate for the development and enactment of robust policies. These policies should explicitly mandate the adoption of GIS and CDRA practices within local and regional planning processes, ensuring that they become standard operating procedures. Furthermore, legislation should promote participatory approaches that involve community input and feedback, thereby enhancing the relevance and effectiveness of urban planning initiatives. Additionally, adequate funding must be allocated to support the construction of resilient infrastructure in at-risk communities, ensuring that investments are made where they are needed most.
3. **Promote Multisectoral Collaboration:** Building partnerships among various sectors—including government agencies, non-governmental organizations (NGOs), academic institutions, and the private sector—is vital for the successful implementation of GIS and CDRA projects. These collaborations can facilitate the pooling of financial resources, sharing of expertise, and leveraging of diverse perspectives to address complex challenges. By fostering an environment of cooperation and mutual support, stakeholders can enhance the sustainability and effectiveness of GIS-CDRA initiatives, ensuring that they remain relevant and beneficial to vulnerable communities over the long term. Engaging in joint projects, research, and knowledge-sharing platforms can further amplify the collective impact of these efforts.

**Benefits for Davao City**

Davao City stands to gain significantly from the integration of Geographic Information Systems (GIS) and Climate Disaster Risk Assessment (CDRA) in its urban planning and disaster resilience strategies. These benefits are particularly critical given the city's vulnerability to climate-induced hazards such as flooding, sea-level rise, and liquefaction:

1. **Enhanced Vulnerability Mapping:** GIS enables high-resolution mapping of at-risk areas, providing Davao City with precise data to identify vulnerable communities, particularly those in low-lying coastal areas. This helps in prioritizing interventions and resource allocation.
2. **Informed Urban Planning:** By integrating GIS-CDRA tools, Davao City can design adaptive urban plans that account for future climate scenarios. This includes zoning regulations, resilient housing designs, and infrastructure improvements tailored to mitigate specific risks such as flooding and storm surges.
3. **Community Empowerment:** Participatory GIS approaches empower local communities in Davao City by involving them in data collection and decision-making processes. This fosters ownership of resilience strategies and ensures that interventions are culturally and contextually relevant.
4. **Improved Emergency Preparedness:** Real-time data from GIS and CDRA tools enhances the city's ability to respond to disasters effectively. Early warning systems informed by these tools can save lives and reduce property damage during emergencies.
5. **Policy Support and Governance:** The integration of these technologies strengthens the city’s governance frameworks by providing data-driven insights to support legislation and funding for resilience initiatives. Policies informed by GIS-CDRA can institutionalize best practices in urban resilience.
6. **Economic Resilience:** By reducing the impact of disasters through targeted interventions, Davao City can protect its economic assets, including key infrastructure and livelihoods dependent on the coastal areas. Resilient urban planning can also attract investments and promote sustainable growth.
7. **Sustainability and Scalability:** GIS and CDRA frameworks provide a scalable solution that Davao City can expand to other regions within its jurisdiction. This ensures long-term sustainability of disaster risk management practices and promotes knowledge-sharing with neighboring cities facing similar challenges.

**CONCLUSION**

The integration of GIS and CDRA holds immense potential for enhancing the resilience of coastal settlements against climate-induced hazards. This review highlights the transformative role of these tools in vulnerability mapping, informed decision-making, and adaptive housing design. Key insights include the importance of participatory approaches, the critical need for accurate data, and the challenges posed by institutional fragmentation and financial constraints.

For Davao City and similar urban contexts, the findings suggest that fostering community engagement, strengthening governance frameworks, and investing in geospatial technologies are critical for achieving long-term resilience. By institutionalizing GIS-CDRA applications and promoting inclusive policy-making, stakeholders can address vulnerabilities while ensuring sustainability and scalability of interventions. Future efforts should also focus on bridging data gaps and integrating advanced technologies to enhance the precision and effectiveness of disaster risk management frameworks.

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