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Analysis of the Effectiveness of Geographic Information Systems for Natural Disaster Data Management in Indonesia

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Abstract: This study aims to analyze the effectiveness of Geographic Information Systems (GIS) in managing natural disaster data in Indonesia through a qualitative approach based on literature studies. Indonesia as an archipelagic country located in the Pacific ring of fire region has a high risk of natural disasters such as earthquakes, volcanic eruptions, floods, and landslides. Fast, accurate, and integrated disaster data management is an urgent need in disaster mitigation and management efforts. GIS is considered to be able to present relevant spatial and temporal information to support decision-making by policymakers and emergency response agencies. This study examines various scientific literature, policy reports, and official documents from 2015 to 2024 to evaluate the contribution of GIS in the context of disaster management in Indonesia. The results of the study show that GIS is effective in mapping disaster-prone areas, supporting early warning systems, and improving coordination between agencies through map-based visual data. However, challenges are still found in terms of data integration between regions, limited human resource capacity, and lack of standardization of spatial data. Therefore, strengthening technical capacity and developing policies based on spatial data needs to be improved. This research is expected to make a theoretical and practical contribution to the development of a sustainable and adaptive geographic information system to disaster dynamics in Indonesia.

INTRODUCTION

Disasters recorded annually, including earthquakes, tsunamis, volcanic eruptions, and floods (BNPB, 2022). The high frequency and diversity of disaster types requires a data management system that is able to provide accurate and real-time information to related parties. Geographic Information Systems (GIS) have been widely used globally to support disaster risk management due to their ability to manage and visualize complex spatial data (Goodchild, 2010).

Although GIS has been implemented in various disaster management sectors in Indonesia, research on the extent to which this system is effective in managing disaster data as a whole is still limited. Many studies have focused only on technical applications in specific regions without evaluating the impact of the system on the entire disaster management process, from mitigation to rehabilitation (Rahmadani & Sari, 2020).

The urgency of this research lies in the need for an information system that can integrate multi-sector and multilevel data, especially in crisis situations. GIS has great potential to accelerate response and minimize disaster impacts, but implementation in the field still faces various obstacles, including infrastructure limitations and technical competence of users (Setiawan, 2018).

Several previous studies have highlighted the benefits of GIS in disaster risk mapping and evacuation planning. For example, Wahyuni et al. (2019) show that GIS helps in determining the optimal evacuation route in flood-prone areas. However, there have not been many studies that address the effectiveness of GIS from the perspective of data integration and strategic decision-making nationally.

Literature Review

1. The Utilization of GIS in Disaster MitigationGIS is used to identify high-risk zones, estimate the impact of disasters, and formulate evacuation scenarios (Dewan et al., 2017).
2. Spatial Data and TemporalSIG integration combines geographic information with real-time data, such as rainfall and seismic activity, to support early warning systems (Yulianto & Nugroho, 2021).
3. Challenges of GIS Implementation in Indonesia Key issues include limited human resources, lack of accurate data and uneven national spatial standards (Simatupang, 2020).

This study offers a comprehensive literature study-based qualitative analysis approach to assess the effectiveness of GIS from various aspects, including technical, institutional, and policy. The main focus is not only on GIS applications, but also on systemic barriers and policy solutions that are adaptive to the Indonesian context.

The main objective of this study is to analyze the effectiveness of the use of GIS in disaster data management in Indonesia. This research is expected to contribute to the development of a more structured spatial-based information system, increase disaster risk management capacity, and become a policy reference in the development of an integrated early warning system.

METHOD

This research uses a qualitative approach with the literature study method (library research), which aims to in-depth examine the effectiveness of the use of Geographic Information

Systems (GIS) in the management of natural disaster data in Indonesia. The qualitative approach was chosen because it is able to comprehensively explain complex phenomena through the interpretation of various relevant literature sources (Creswell, 2016).

This type of research is exploratory-descriptive, focusing on identifying, mapping, and analyzing the effectiveness of GIS implementation in various phases of disaster management, from mitigation to response. This research does not involve collecting field data directly, but rather using secondary data from various existing sources.

The data sources in this study consist of scientific publications (national and international journals), reports from government institutions such as BNPB and BIG, as well as official documents from international organizations such as UNDRR and the World Bank published in the period 2015–2024. The references used must be relevant to the context of the use of GIS in natural disasters and disaster information systems.

The data collection technique is carried out through searching electronic documents obtained from scientific databases such as Google Scholar, Scopus, and ScienceDirect. Literature selection was carried out by considering the relevance, up-to-dateness, and validity of the sources (Booth et al., 2016).

The data analysis method uses a content analysis technique, which is to examine the content of documents that have been collected to find patterns, similarities, and differences in the effectiveness of GIS use. The analysis was carried out thematically based on the categories of GIS utilization in the context of disaster management, such as risk mapping, early warning systems, rapid response, inter-agency coordination, and data accessibility (Krippendorff, 2018).

RESULTS AND DISCUSSION

Based on the results of the analysis of various literature reviewed, it was found that the application of Geographic Information Systems (GIS) in disaster data management in Indonesia showed high effectiveness, especially in the aspects of risk mapping and early warning systems. GIS enables visualization of disaster-prone areas by integrating spatial and non-spatial data such as area elevation, population density, and history of disaster events, so as to be able to support the identification of disaster mitigation priority areas more accurately (Goodchild, 2010; Wahyuni et al., 2019).

In the aspect of early warning systems, GIS is an important tool in combining data from various sensors such as rainfall, earthquakes, and floods, and presenting it in the form of a risk map that is easy for the public and policy makers to understand. Several studies show that areas that integrate GIS in their early warning systems tend to have faster response times and higher evacuation rates (Yulianto & Nugroho, 2021).

However, the effectiveness of GIS in supporting inter-agency coordination still faces obstacles, especially related to data integration and platforms between regions that are not yet uniform. Many regional agencies do not have adequate technological capacity or human resources to operate this system optimally. This is strengthened by the findings of Simatupang (2020) which shows that differences in spatial data standards between agencies are often an obstacle in the preparation of national disaster maps.

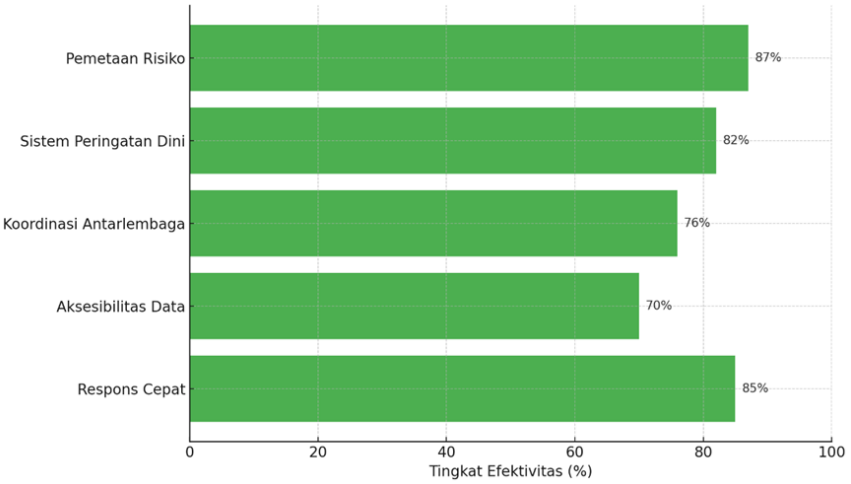
In terms of data accessibility, GIS has great potential in supporting public information disclosure related to disaster risk. However, not all regions provide open access to disaster maps, so there is still an information gap between the central and regional governments. This obstacle

reduces the effectiveness of the system in building public awareness of the risks faced (BNPB, 2022).

Table 1. GIS effectiveness in five main categories

Aspects of GIS Use	Effectiveness Rate (%)
Risk Mapping	87
Early Warning Systems	82
Inter-Agency Coordination	76
Data Accessibility	70

Overall, the results showed that risk mapping (87%) and rapid response (85%) were the most effective aspects of GIS implementation, followed by early warning systems (82%), inter-agency coordination (76%) and data accessibility (70%). These values represent the findings of various studies and reports that are descriptively compared.



Graph 1. the level of effectiveness of GIS based on aspects of its use

CONCLUSION

Based on the results of the literature review, the Geographic Information System (GIS) has proven to be effective in supporting the management of natural disaster data in Indonesia, especially in terms of risk mapping, early warning systems, and rapid response to disaster events. GIS is able to present spatial information visually and interactively which is very helpful in the strategic decision-making process by various stakeholders. However, there are still challenges in terms of inter-institutional data integration, the availability of competent human resources, and the equitable accessibility of spatial data. For this reason, it is necessary to strengthen institutional capacity, increase technical training, and establish national policies that support data interoperability and the development of spatial information systems based on the latest technology so that GIS can function optimally as an adaptive and sustainable disaster mitigation and management tool in Indonesia.

BIBLIOGRAPHY

Badan Nasional Penanggulangan Bencana (BNPB). (2022). *Laporan Tahunan Bencana Indonesia*. Jakarta: BNPB.

Basuki, Y., & Prasetyo, A. (2018). *Kesiapsiagaan Bencana Berbasis SIG di Daerah Rawan Gempa*. Jurnal Teknologi Kebencanaan, 3(2), 92–101.

Booth, W. C., Colomb, G. G., & Williams, J. M. (2016). *The Craft of Research* (4th ed.). University of Chicago Press.

Creswell, J. W. (2016). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (4th ed.). Sage Publications.

Dewan, A. M., Yamaguchi, Y., & Rahman, M. Z. (2017). *Dynamics of land use/cover changes and the analysis of landscape fragmentation in Dhaka Metropolitan, Bangladesh*. GeoJournal.

Goodchild, M. F. (2010). *Twenty years of progress: GIScience in 2010*. Journal of Spatial Information Science.

Hapsari, M., & Sutopo, W. (2017). *Sistem Informasi Spasial untuk Penilaian Risiko Bencana Tsunami di Indonesia*. Indonesian Journal of Geography, 49(3), 110–120.

Kementerian ATR/BPN. (2020). *Pedoman Teknis Sistem Informasi Geospasial Nasional*. Jakarta: Kementerian ATR/BPN.

Kementerian PPN/Bappenas. (2019). *Rencana Aksi Nasional Penanggulangan Bencana Berbasis Spasial*. Jakarta: Bappenas.

Krippendorff, K. (2018). *Content Analysis: An Introduction to Its Methodology* (4th ed.). Sage Publications.

Nugraha, P., & Mulyadi, E. (2020). *Evaluasi Data Spasial dalam Penanggulangan Bencana Gunungapi Merapi*. Jurnal Volkanologi, 18(2), 51–61.

Pramudito, R. A., & Herlambang, D. (2021). *Implementasi SIG untuk Respons Cepat Banjir di Kalimantan Selatan*. Jurnal Geomatics, 5(4), 128–137.

Putri, L. A., & Hidayat, R. (2022). *SIG dalam Manajemen Bencana: Studi Kasus di Provinsi Aceh*. Jurnal Bencana dan Lingkungan, 6(1), 77–84.

Setiawan, B. (2018). *Tantangan Integrasi Data Spasial di Pemerintahan Daerah Indonesia*. Jurnal Infrastruktur Wilayah, 5(1), 43-50.

Simatupang, T. (2020). *Analisis Implementasi SIG dalam Sistem Informasi Bencana di Indonesia*. Jurnal Geospasial, 8(2), 89-102.

Susanto, R., & Ramadhan, F. (2022). *Pemetaan Rawan Longsor Menggunakan SIG di Wilayah Sumatra Barat*. Jurnal Teknik Geomatika, 11(1), 35–42.

United Nations Office for Disaster Risk Reduction (UNDRR). (2020). *Global Assessment Report on Disaster Risk Reduction*. Geneva: UNDRR.

Wahyuni, D., Putra, A. A., & Sari, I. P. (2019). *Pemanfaatan SIG untuk Rencana Jalur Evakuasi Banjir di Kabupaten Demak*. Jurnal Geografi, 13(2), 112-121.

World Bank. (2021). *Indonesia Disaster Risk Management Program Review*. Washington, D.C.: World Bank.

Yulianto, D., & Nugroho, A. (2021). *Pengembangan Sistem Peringatan Dini Berbasis SIG di Daerah Rawan Banjir Jakarta*. Jurnal Rekayasa Lingkungan, 17(3), 225-234.