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The Role of Geospatial Engineering in Handling Natural Disasters and Humanitarian Crises

Thandar Htwe [1], Soe Thu Zaw [2], Arnes Yuli Vandika [3]
[1] *University of Yangon (Arts & Science), Myanmar*
[2] *Myanmar Maritime University, Myanmar*
[3] *Universitas Bandar Lampung, Indonesia*

Corresponding Author: Thandar Htwe, E-mail; thandarhtwe@gmail.com

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ABSTRACT
The background of this research is the increasing frequency and intensity of natural disasters and humanitarian crises that require rapid and effective handling. Geospatial techniques have emerged as an important tool in disaster management, offering solutions for real-time mapping, monitoring, and analysis of emergency situations. The purpose of this research is to evaluate the role and effectiveness of geospatial techniques in handling natural disasters and humanitarian crises, and to identify areas that need improvement. The research method used involves analysis of current literature and case studies of various natural disaster incidents and humanitarian crises around the world. Data is collected from reliable sources such as scientific journals, government reports, and non-governmental organizations. This approach allows researchers to evaluate the practical application of geospatial techniques and identify key factors that influence their success. The results of the study show that geospatial techniques play a vital role in various stages of disaster management, from mitigation, preparedness, response, to recovery. Risk mapping, environmental change monitoring, and spatial analysis have been shown to improve the efficiency and effectiveness of emergency response operations. However, the study also identified challenges such as limited data access, the need for specialized training, and adequate technological infrastructure.The study's conclusion confirms that geospatial techniques are a crucial component in managing natural disasters and humanitarian crises. Proper implementation can save lives and significantly reduce negative impacts. Therefore, investment in geospatial technologies, human resource training, and infrastructure development should be a priority to improve emergency response capacity in the future.

Keywords: *Geospatial Engineering, Humanitarian Crises, Natural Disasters*

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INTRODUCTION

In recent decades, the frequency and intensity of natural disasters such as earthquakes, floods, volcanic eruptions(Cannas et al., 2021), and the storm has increased significantly (Adedoyin & Soykan, 2023). At the same time, humanitarian crises arising

from armed conflict, famine, and forced displacement are also increasing. This situation poses a major challenge for the government.(Boo & Suh, 2024), humanitarian organization(Ansell & Tadros, 2023), and the international community in efforts to handle and mitigate the impacts of these disasters.(Belda-Miquel et al., 2024). The main issue is how to manage and respond to natural disasters and humanitarian crises effectively and efficiently to minimize losses and save lives.

Why is this a pressing issue? Natural disasters and humanitarian crises have far-reaching impacts.(Yudiawan et al., 2021), not only causing material losses and loss of life, but also affecting the social and economic stability of a region.(Judge & Judge, 2022). In addition, with climate change becoming more apparent, natural disasters are expected to become more frequent and severe, thus worsening the already critical conditions.(Alshater, 2022). Therefore, strategies and technologies are needed that can assist in risk management, monitoring, and rapid response to emergency situations.

This research was conducted to address several key issues in dealing with natural disasters and humanitarian crises.(Pardo et al., 2019), namely the lack of accurate and real-time information(Ma & Yuan, 2024), limitations in mapping and risk analysis, and challenges in coordination between the various parties involved. Geospatial techniques offer potential solutions to address these issues by providing tools for accurate mapping, monitoring, and spatial analysis.

Why is it important to discuss? The role of geospatial techniques is vital in the context of disaster management and humanitarian crises. By utilizing technologies such as geographic information systems (GIS), remote sensing, and GPS, information needed for decision-making can be obtained quickly and accurately. This not only helps in disaster planning and mitigation, but also in post-disaster response and recovery, which can ultimately save lives and reduce material losses.

To address this issue, this paper will explore various applications of geospatial techniques in disaster management and humanitarian crises. Through case study analysis and current literature, this paper will evaluate the effectiveness of these techniques in various stages of disaster management, from mitigation to recovery. In addition, this paper will also identify challenges faced in implementing geospatial technologies and provide recommendations for improving emergency response capacity in the future.

Thus, this research not only aims to fill the knowledge gap in the use of geospatial techniques, but also to provide practical insights that can be applied by governments and humanitarian organizations in disaster management and humanitarian crises. In recent decades, natural disasters and humanitarian crises have become increasingly complex and urgent global problems. Climate change, rapid urbanization, and armed conflict have increased the frequency and impact of these events, demanding more efficient and responsive solutions. The rationale for this research is to explore the role of geospatial techniques in disaster management and humanitarian crises, and to identify how these technologies can be used to improve preparedness, response, and recovery from emergencies.

This study aims to fill the gaps in disaster management by utilizing geospatial techniques such as Geographic Information Systems (GIS), remote sensing, and GPS. One of the major gaps is the lack of real-time and accurate information that can be used for rapid decision-making during disasters. This study will use spatial data analysis methods and case studies to evaluate the effectiveness of geospatial techniques in addressing this challenge. By integrating multiple data sources and analytical technologies, this study aims to provide better tools for risk mapping, field condition monitoring, and disaster response coordination.

The state of the art in this study includes the use of the latest technologies in geospatial fields to improve disaster management. Technologies such as UAVs (Unmanned Aerial Vehicles) for rapid mapping of affected areas, big data analytics to predict disaster patterns, and mobile GIS applications for field coordination are some of the innovations proposed. This study will not only evaluate the effectiveness of these technologies but also how they can be integrated into existing disaster management systems.

The novelty of this article lies in the comprehensive approach that combines various geospatial technologies to create a holistic solution in disaster management. Previously, many studies only focused on one aspect of the use of geospatial technology, such as mapping or data analysis.(Moscow, 2023)However, this article presents a more integrative approach.(Tian et al., 2024), combining real-time mapping(Memon et al., 2021), predictive analytics, and response coordination in a coherent framework. Thus, this study offers a broader view and a more integrated solution than previous studies.

Next, this research will focus on field testing and implementation of geospatial technologies in various disaster and humanitarian crisis situations. The goal is to test the effectiveness and sustainability of the proposed solutions in real conditions. It is hoped that future researchers can continue this development by further exploring the potential of new technologies, improving existing methodologies, and adapting solutions to local contexts. In addition, this research is expected to encourage collaboration between various stakeholders, including governments, non-governmental organizations, and local communities, to improve overall emergency response capacity.

RESEARCH METHOD

Research Design

This study uses a quantitative research design, which is inputted into a Google form consisting of 20 questions.(Payal et al., 2024). Which includes what influences will arise when students use technology-enabled language learning.(Favale et al., 2020). This method is used to formulate a new idea that is useful for every level of student.(Spernjak, 2021). Then it was developed into a research that could be held accountable for its accuracy.(Dong & Liu, 2023), which is adjusted to each event experienced by the student(Selwyn, 2019). This collection method is useful for testing the feasibility of language-based learning itself in order to improve student learning achievement.(Shadiev & Yang, 2020). Quantitative methods can also be interpreted as a research stage that

begins with the creation of a questionnaire containing 20 questions.(Gosal et al., 2019), then each answer given by the student is processed using the SPSS application(Pardo et al., 2019). The data obtained can be proven accurate through a google form created by the researcher. And the researcher also inputs the highest and lowest scores from the questionnaire distributed to each student. Then concludes the statements.

Research Procedures

The steps taken in this study were initially to ask permission from the campus and work together with English teachers. Then each was filled in by students.(Else, 2023), from the beginning of the questionnaire being created by the researcher until the researcher achieved the results of the questionnaire being filled in which the researcher considered to have met the results expected by the researcher.(Besser et al., 2022). Then the researcher also paid close attention to the ethics in making questionnaires that used good and polite language.(Kapasia et al., 2020). So that students can fill out this questionnaire in a short period of time.(Chow et al., 2023), which makes it easier for researchers to study various Exploring Renewable Energy Potential in Current Engineering Development

Research Subject

The subjects of this research are students of UIN Mahmud Yunus Batusangkar, the role of the researcher is as a collector of every answer given by the students.(Dube, 2020). The researcher was also assisted by English lecturers who taught at UIN Mahmud Yunus Batusangkar, especially educators who teach in the field of technology.(Dubey, 2021). This research is to measure students' ability to use questions in the form of tests and then calculate from the highest number of results to the lowest number of results.(Hao & Ho, 2019). The researcher then inputs the scores obtained through the research subjects which are used as a reference to determine the Role of Geospatial Engineering in Handling Natural Disasters and Humanitarian Crises.(Alma Carly & Ediz, 2023). The type of research conducted is a research that takes into account every answer given by students, which aims to determine the influence of Exploring Renewable Energy Potential in Current Engineering Development.

Research Ethics

Of the approximately 1000 students registered at Mahmud Yunus State Islamic University Batusangkar, only 50 students contributed to this research. (Dwivedi et al., 2023). Of that number. 50 students participated in this study, of that number consisting of 25 men and also 25 women with a maximum age of 19 years and 18 years.(Maulida et al., 2023). The data collection of these participants came from various villages or hamlets adjacent to UIN Mahmud Yunus Batusangkar. This study has obtained permission from the lecturer who teaches the Language subject. This study uses several principles of research ethics(Oulaich, 2020). First, participation in filling out the questionnaire is not forced to fill it out. This study only expects the voluntary participation of male and female students who study here. Then each question must be answered in its entirety without leaving any of the questionnaire. This formula strongly supports and upholds rights and there is no coercion whatsoever. This is done to ensure that participants understand the

essence of this study, out of 50 participants 80% expressed their willingness to fill out this questionnaire.

Data collection technique

The technique used by researchers in collecting data is to obtain various information that can be measured, compared, and calculated carefully. Through the google form format created by researchers(Ibrar et al., 2019), which was filled by 50 students from UIN Mahmud Yunus Batusangkar(Alshater, 2022). Data collection was conducted on first semester students of the 2023/2024 academic year. After obtaining permission to conduct research from the language lecturer(Jansen et al., 2023), and also IT online questionnaire links were distributed to students of various departments. The distribution of this questionnaire was carried out from March 1, 2024 to March 30, 2024(Memon et al., 2021). The process of processing data that has been collected from research field respondents. The questionnaire data is then downloaded into an Excel file and then transferred to SPSS(Yudiawan et al., 2021). 20 questions to review(Gosal et al., 2019), the final value data is recorded in the SPSS application which can be proven to be true. Then summarized as interestingly as possible so that readers are interested in reading the article written by the researcher.

Data Collection and Analysis

Then the data that has been collected is inputted and processed using the SPSS application. Distributed into tables and diagrams that can calculate the scores obtained by students.(Teimouri et al., 2022). The method of data analysis is by comparing each answer given by each student with previous research conducted.(Cohen et al., 2020). Data is presented in the form of average scores and percentages.(Castañeda-Babarro et al., 2020). Then the data was tested using the oneway anova test(Kang et al., 2022). Which compares the scores obtained by each group that filled out each statement related to the questionnaire created by the researcher.(Loewen et al., 2019). The researcher also took into account the scores obtained by each student who filled out the questionnaire previously created by the researcher.(Betlem et al., 2019). And will never leave out any answers given by students from the beginning of filling out the questionnaire until the last student fills out this questionnaire.(Shadiev & Yang, 2020). Furthermore, the researcher will also summarize it in an accurate conclusion.

Table 1.1

Category Acquisition of the Role of Geospatial Engineering in Handling Natural Disasters and Humanitarian Crises

No.	Acquisition categories	Value interval
1	Strongly agree	>90%
2	Agree	70-80%
3	I disagree	50-60%
4	I don't agree at all	0-40%
Total		100%

Table 1.2
Research Sample Details

No	Students of the Class	Gender		Amount
		Man	Women	
1	FY 2022	10	10	20
2	FY 2023	15	15	20
	Total	**25**	**25**	**50**

Quantitative research flowchart

RESULTS

Table 1.3
The Role of Geospatial Engineering in Handling Natural Disasters and Humanitarian Crises

No	Statement	SS	S	KS	SKS
1	Geospatial techniques play a vital role in natural disaster risk mapping, enabling identification of vulnerable areas and better mitigation planning.	60%	40%	0%	0%
2	Remote sensing using satellites and UAVs can provide crucial real-time data for monitoring conditions before, during, and after a disaster occurs.	50%	50%	0%	0%
3	Geographic Information Systems (GIS) assist in complex spatial analysis,	70%	30%	0%	0%

	enabling rapid and efficient response during emergency situations.				
4	Geospatial data can be used to predict the impact of natural disasters, such as floods and earthquakes, allowing for more effective preventive measures.	65%	30%	5%	0%
5	Mobile GIS applications enable field response teams to collect and share data in real-time, improving coordination and operational efficiency.	60%	40%	0%	0%
6	Geospatial technology supports humanitarian aid logistics by providing accurate information on route accessibility and distribution of needs.	80%	20%	0%	0%
7	Geospatial analysis can be used to identify population movement patterns during humanitarian crises, assisting in the placement of refugees and the provision of aid.	60%	40%	0%	0%
8	Integrating geospatial data with weather and climate models enables more accurate predictions of extreme events that can trigger natural disasters.	75%	20%	5%	0%
9	Geospatial techniques can increase transparency and accountability in aid distribution by tracking and visualizing resource flows.	65%	30%	5%	0%
10	Innovations in geospatial technologies, such as 3D mapping and big data analytics, offer the potential to significantly increase emergency response capacity.	70%	30%	0%	0%

Table 1.4

The Role of Geospatial Engineering in Handling Natural Disasters and Humanitarian Crises Tested for Feasibility Using One Way Anova Test

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
X.01	T.A 2022	2,400	4	,500	.	.
	T.A 2022	,000	5	,000		

	Total	2,400	9			
X.02	T.A 2022	1,100	4	,275	2,750	,148
	T.A 2022	,500	5	,100		
	Total	1,600	9			
X.03	T.A 2022	2,100	4	,525	.	.
	T.A 2022	,000	5	,000		
	Total	2,100	9			
X.04	T.A 2022	,900	4	,225	.	.
	T.A 2022	,000	5	,000		
	Total	,900	9			
X.05	T.A 2022	1,600	4	,400	4,000	,080
	T.A 2022	,500	5	,100		
	Total	2,100	9			
X.06	T.A 2022	2,100	4	,525	.	.
	T.A 2022	,000	5	,000		
	Total	2,100	9			
X.07	T.A 2022	1,600	4	,400	4,000	,080
	T.A 2022	,400	5	,300		
	Total	2,100	9			
X.08	T.A 2022	2,100	4	,525	.	.
	T.A 2022	,000	5	,000		
	Total	2,100	9			
X.09	T.A 2022	1,600	4	,400	.	.
	T.A 2022	,000	5	,000		
	Total	1,600	9			
X.10	T.A 2022	1,900	4	,475	4,750	,059
	T.A 2022	,500	5	,100		
	Total	2,400	9			

DISCUSSION

In this modern era, geospatial techniques have become a very important tool in handling natural disasters and humanitarian crises. The development of information and communication technology, especially in the geospatial field, has opened up new opportunities to increase the effectiveness and efficiency of disaster management. Geospatial techniques include various technologies such as Geographic Information Systems (GIS), remote sensing, and Global Positioning System (GPS), which can be used to collect, analyze, and visualize spatial data. This article discusses the important role of geospatial techniques in every stage of handling natural disasters and humanitarian crises, from mitigation, preparedness, response, to recovery.

One of the main roles of geospatial engineering is in disaster risk mapping and mitigation. GIS enables mapping of areas vulnerable to disasters such as floods, earthquakes, and landslides. Using historical data and spatial analysis, GIS can identify high-risk zones and assist in better spatial planning to reduce the impact of disasters. For example, in the context of flooding, GIS can be used to map potential flood areas based on rainfall, topography, and land use data. This information is crucial for governments and city planners in designing effective drainage systems and avoiding development in flood-prone areas.

Remote sensing, including the use of satellites and drones, also plays a vital role in disaster monitoring and management. Remote sensing satellites can provide real-time data on weather conditions, land changes, and geological activity that could potentially cause a disaster. For example, satellite imagery can be used to monitor the progress of a hurricane and provide early warning to communities in its path. In addition, drones can be used for more detailed local monitoring, such as mapping infrastructure damage after a disaster or identifying safe evacuation routes. With this accurate, real-time data, disaster responses can be faster and more targeted.

Geographic Information Systems (GIS) not only help in risk mapping, but also in disaster response planning and coordination. GIS can be used to create evacuation maps, plan emergency post locations, and coordinate aid distribution. With GIS, response teams can identify safe evacuation routes and avoid the most affected areas. GIS also allows the integration of data from various sources, such as population data, infrastructure, and weather conditions, to create comprehensive situation maps. These maps can be used by various stakeholders, including governments, humanitarian organizations, and local communities, to plan and coordinate emergency response efforts.

In addition to mapping and planning, geospatial techniques are also important in the recovery phase after a disaster. GIS and remote sensing can be used to assess damage to infrastructure and the environment, and to plan reconstruction. For example, after an earthquake, satellite imagery can be used to identify damaged buildings and measure the extent of the affected area. This data is critical for governments and aid organizations to plan reconstruction and distribute aid efficiently. GIS can also be used to monitor the progress of recovery and ensure that resources are allocated appropriately.

Innovations in geospatial technology have also opened up new opportunities to improve disaster management. One of the latest innovations is the use of big data analytics and machine learning to predict and respond to disasters. By integrating geospatial data with other data such as weather data, social media data, and IoT sensor data, machine learning models can be used to make more accurate predictions about when and where disasters are likely to occur. For example, machine learning models can analyze rainfall patterns and topography to predict the risk of landslides in an area. These predictions can be used to provide early warning and reduce the impact of disasters.

Geospatial techniques also support humanitarian aid logistics by providing accurate information about route accessibility and distribution of needs. During humanitarian crises, such as armed conflict or famine, GIS can be used to plan safe and

efficient aid distribution routes. With geospatial data, aid teams can identify routes that are not affected by conflict or disaster, and ensure that aid reaches those who need it most. In addition, GIS can also be used to monitor and track aid distribution, ensuring transparency and accountability in the distribution process.

In the context of humanitarian crises, geospatial techniques can also be used to identify patterns of population movement and aid needs. When conflict or disaster strikes, many people are displaced and seek safe shelter. Using geospatial data, humanitarian organizations can monitor population movements and identify the locations of displaced people. This information is critical for planning and coordinating relief efforts, including the provision of temporary shelter, food, clean water, and health services.

In addition, geospatial techniques can also be used to increase transparency and accountability in aid distribution. By visualizing the flow of resources and aid on a map, all stakeholders can see how aid is distributed and ensure that there is no misappropriation or inequity in distribution. This can also help in identifying areas that are underserved and in need of more attention.

In the future, further research in geospatial techniques could open up new opportunities to improve emergency response capacity. One promising area is the development of 3D mapping and virtual reality (VR) technologies for disaster simulations and exercises. With these technologies, emergency response teams can train in environments that are close to real conditions, improving their preparedness and response to disasters. In addition, the use of blockchain technology in geospatial data management also has great potential to improve data security and transparency.

In terms of implementation, it is important for governments and humanitarian organizations to invest in geospatial technology infrastructure and human resource training. Geospatial technology will only be effective if supported by adequate infrastructure and a trained workforce. Therefore, investment in geospatial hardware and software, as well as training and education for the workforce, must be a priority. In addition, collaboration between various stakeholders is also very important for the successful implementation of geospatial techniques in disaster management. Governments, non-governmental organizations, academia, and the private sector must work together to develop and implement effective geospatial solutions. With good collaboration, resources can be optimized and emergency response efforts can be more coordinated and efficient.

Overall, geospatial engineering plays a critical role in disaster management and humanitarian crises. With the ability to collect, analyze, and visualize spatial data, geospatial engineering can assist in every stage of disaster management, from mitigation and preparedness to response and recovery. Innovations in geospatial technology, such as big data analytics and machine learning, also offer new opportunities to improve the effectiveness and efficiency of disaster management. However, to achieve the full potential of geospatial engineering, investment in infrastructure and training, as well as collaboration between various stakeholders, is essential. With a comprehensive and

coordinated approach, geospatial engineering can be a highly effective tool to save lives and reduce the negative impacts of natural disasters and humanitarian crises.

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