SWOT Analysis of Flood Disasters in the Mountainous Region of Mandailing Natal: Identifying Strengths, Weaknesses, Opportunities, and Threats in Disaster Risk Management

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Abstract

The Mandailing Natal mountain range, a region rich in natural resources in North Sumatra, Indonesia, has experienced frequent flooding in recent years. The primary contributing factor is the high rainfall, which causes river flows to overflow from the steep mountains into the lowlands. Land use changes, such as deforestation, have worsened this condition by reducing the soil's ability to absorb rainwater, leading to increased frequency and intensity of floods in the area. This research aims to analyze the factors influencing flood disasters in the Mandailing Natal mountains using a SWOT (Strengths, Weaknesses, Opportunities, Threats) approach. Based on literature studies and interviews with local communities and disaster management officers, the main strengths identified are the community's traditional knowledge and the rapid response capability of the disaster management teams. Weaknesses include inadequate infrastructure and low community participation. Opportunities consist of developing reforestation programs and collaborating with the private sector, while the primary threats are climate change and ongoing deforestation. The recommended strategies include utilizing traditional knowledge for reforestation programs, increasing community participation, implementing early detection technology, and improving infrastructure as well as public awareness to address these challenges. The implementation of these strategies is expected to enhance the effectiveness of flood risk management and reduce the impact of disasters in the Mandailing Natal mountains.

***Keywords**:* Mandailing Natal, SWOT, Flooding

Introduction

The Mandailing Natal mountain range, located in the province of North Sumatra, Indonesia, is a region rich in natural resources and biodiversity [1]. This area is known for its dense rainforests, diverse flora and fauna, and fertile soil, all of which contribute to the local economy through the agriculture, forestry, and tourism sectors [2]. However, this region is also prone to various natural disasters, including floods.

The occurrence of floods in this region has become more frequent in recent years, causing significant losses for the local community. High rainfall is the primary factor contributing to flooding in this area [3]. During the rainy season, rainfall intensity can reach its peak, resulting in rapid water flow from the mountains to the lowlands [4]. The steep and sloped mountainous topography causes rainwater to flow quickly into rivers, which often cannot accommodate the large volume of water, leading to overflow and flooding.

In addition, uncontrolled land-use changes have worsened the situation. Deforestation and the conversion of forest land into agricultural or residential areas have diminished the soil's natural capacity to absorb rainwater [5]. Deforestation for plantations and illegal logging increases the risk of soil erosion, which then settles in rivers and reduces their water-carrying capacity. This makes the rivers more prone to overflowing during heavy rainfall.

Global climate change also contributes to the increasing intensity and frequency of floods. Data from the Meteorology, Climatology, and Geophysics Agency (BMKG) indicates that extreme rainfall in North Sumatra tends to increase each year [6]. This phenomenon is linked to unpredictable global weather pattern changes, where extreme weather events have become more frequent and severe. This situation is exacerbated by the lack of flood management infrastructure, such as adequate drainage systems and flood control dams, as well as the low public awareness and knowledge regarding disaster mitigation.

One concrete example of the impact of flooding in the Mandailing Natal mountains is the flash flood that occurred in 2018, which caused damage to infrastructure, agricultural land, and residential areas (National Disaster Management Agency [7]. The flood also resulted in loss of life and forced many residents to evacuate. This event highlights the region's vulnerability to flood disasters and the urgent need for strategic measures to reduce disaster risk. The economic losses included damage to homes, roads, bridges, and other public facilities, as well as the loss of livelihoods for many affected farmers and livestock breeders.

Weaknesses in disaster risk management, including the lack of coordination between local governments and communities, as well as the absence of an effective early warning system, have exacerbated the impact of floods. For instance, during the 2018 flash flood, many residents did not receive early warnings and were forced to evacuate suddenly, leaving them no time to save their belongings. Previous research by Herlina, R., Santoso, B., & Pratama, A. [1] indicated that around 70% of the Mandailing Natal mountain region is categorized as high-risk for flooding. This underscores the need to enhance the region's capacity for disaster response and mitigation.

This research aims to identify and analyze the factors influencing flood disasters in the Mandailing Natal mountains using the SWOT (Strengths, Weaknesses, Opportunities, Threats) method. Through this analysis, it is hoped that strategic recommendations can be generated for implementation by local governments and other stakeholders to reduce the risks and impacts of floods in the future.

Literature Review

Disaster Theory

A disaster is an event or series of events that causes significant disruption and loss to human life, the environment, and infrastructure. Disasters can be natural, such as earthquakes, floods, and volcanic eruptions, or anthropogenic, such as wildfires caused by human activities. According to Wisner et al. [7], a disaster is the interaction between hazard, vulnerability, and capacity. Hazard refers to a natural phenomenon or human activity that can trigger a disaster, while vulnerability is the condition that makes a community or system more susceptible to the

impacts of that hazard. Capacity refers to the ability of a community to cope with and recover from disasters.

Disasters can be classified into several categories, including hydrometeorological disasters (floods, storms, droughts), geological disasters (earthquakes, volcanic eruptions), and biological disasters (epidemics). Each type of disaster has distinct characteristics, causes, and impacts, which require specific management approaches.

The impacts of disasters can include material losses, loss of life, social and economic disruptions, and environmental damage. Floods, for example, can cause damage to infrastructure, loss of agricultural produce, and result in the displacement of populations.

1. Mitigation: Actions taken to reduce or eliminate disaster risks, such as constructing disaster-resistant infrastructure and managing natural resources sustainably.
2. Preparedness: Preparations made before a disaster occurs, including developing emergency plans, training, and conducting disaster simulations.
3. Response: Actions taken during a disaster, including evacuation, rescue operations, and providing emergency assistance.
4. Recovery: Efforts to restore the community and environment after a disaster, including infrastructure reconstruction and economic rehabilitation.

The participatory approach emphasizes the importance of community involvement in all stages of disaster risk management. According to Wisner et al. [7], this approach can enhance the effectiveness and sustainability of disaster risk reduction programs, as local communities possess specific knowledge and skills related to their environment.

Research Methodology

This research employs a combination of descriptive qualitative models, which allows for comprehensive insights into the context of the problems and the objects of study, specifically in formulating flood mitigation strategies in Mandailing Natal Regency. Additionally, the SWOT model—Strengths, Weaknesses, Opportunities, and Threats [8]—is utilized. SWOT analysis is an effective tool for formulating strategies in disaster risk management by identifying existing strengths, weaknesses, opportunities, and threats.

The first stage involves collecting primary and secondary data to understand the context of flood disasters in the Mandailing Natal mountainous area. Primary data includes field surveys, interviews with stakeholders, and direct observations of conditions in the field, while secondary data encompasses previous disaster risk reports, meteorological data, and topographic maps. Following this, the identification of strengths, weaknesses, opportunities, and threats in flood disaster risk management is conducted.

Internal strengths, such as adequate emergency response infrastructure, effective early warning systems, and the active involvement of local communities in disaster mitigation, are identified as supporting factors [9]. On the other hand, weaknesses such as insufficient budget for mitigation and recovery, a lack of understanding of disaster risks among the community, and limitations in access to technology and information become obstacles in disaster risk management efforts.

Results

Descriptive analysis using empirical data on flood intensity from 2020 to 2024 aims to objectively illustrate the flooding disasters in the Mandailing Natal Mountains. This data provides a deep understanding of the patterns and trends of flooding in the region, as well as helps identify periods or seasons that are vulnerable to flood occurrences. The data was obtained from BPS Sumut, 2024, and is outlined as follows:

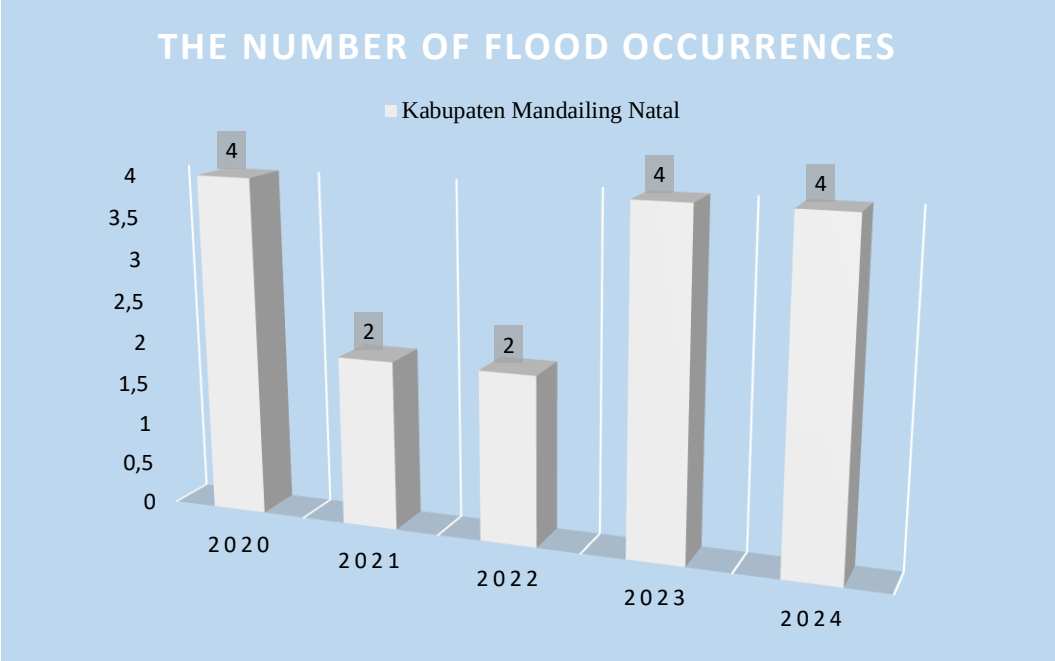

Figure 1. Number of Flood Occurrences in Mandailing Natal Regency 2020-2024
Source: Indonesia Disaster Information Data (DIBI), 2024 (https://dibi.bnpb.go.id/xdibi2)

The data on the number of flood occurrences from 2020 to 2024 shows the frequency of flood events in Mandailing Natal Regency over these years. From this data, it can be observed that there were 4 flood occurrences in 2020. In 2021, the number of flood events drastically decreased to 2. This downward trend continued in 2022, with the number of flood occurrences remaining at 2, showing no change from the previous year. However, in 2023, the number of flood events increased again to 4, the same as in 2020. This trend continued in 2024, with the number of flood occurrences still at 4. This data indicates that after two years of decline, the number of flood events has risen again and stabilized at 4 occurrences per year over the last two years. This shows a significant fluctuation in the frequency of floods in the region.

Based on information from BNPB (National Disaster Management Agency) and BPBD (Regional Disaster Management Agency), the primary cause of flooding in Mandailing Natal Regency is extremely high rainfall intensity. Extreme weather conditions, such as those triggered by Typhoon RAI, have led to a significant increase in rainfall in the area. This situation is exacerbated by the geographical conditions that are prone to flooding, particularly in areas near riverbanks that easily overflow during heavy rains [10][11]. The impact of flooding on the environment is highly destructive [12]. Thousands of houses have been inundated, several bridges and access roads have been cut off, and some electric poles have fallen [13]. The damaged infrastructure disrupts the socioeconomic life of the community, hinders mobility, and causes power outages. Additionally, the floods have also damaged

buildings around the river, including pesantren (Islamic boarding schools) and places of worship [11][13]. Recovery requires time and good coordination between local governments and various stakeholders to ensure that logistical assistance and reconstruction can proceed smoothly.

Meanwhile, the results of the qualitative analysis focus on a deep understanding of the factors influencing flood disasters in the Mandailing Natal Mountains. This approach involves case studies and interviews with local communities. Thus, it enables an understanding of the social, economic, and cultural contexts that influence perceptions and responses to floods, as well as non-technical factors affecting the effectiveness of mitigation and disaster response efforts in the area [10]. Based on the results of the questionnaire distribution and interviews with local residents, the main factors contributing to flooding include:

A. High Rainfall: The Mandailing Natal Mountains frequently experience heavy rain, leading to significant and rapid water flow toward valleys and settlements.
B. Deforestation: Deforestation in the upstream areas reduces the soil's capacity to absorb water, causing rainwater to flow quickly downstream and result in flooding.
C. Poor River Management: There is a lack of efforts to maintain and restore river flow and to construct adequate flood control infrastructure.

The analysis based on the SWOT model (Strengths, Weaknesses, Opportunities, Threats) will further clarify the situation in flood disaster risk management in the Mandailing Natal Mountains. Using this model, the SWOT Matrix is as follows:

Tabel 1. SWOT Matrix

	Strenght (S)	**Weakness (W)**
Internal Factors	a. Traditional knowledge of the community regarding signs of flooding. b. Early coordination between the National Disaster Mitigation Agency (BNPB) and the Regional Disaster Mitigation Agency (BPBD). c. Rapid response capability of the disaster response team. d. Government support in providing resources for emergency response.	a. Inadequate flood control infrastructure. b. Insufficient community participation in mitigation programs. c. Poor drainage systems and suboptimal river management. d. Lack of education and training on disaster preparedness among the local community.
External Factors		

Opportunities (O)	**S-O Strategy/ Analysis**	**W-O Strategy/ Analysis**
a. Development of greening and reforestation programs in upstream river areas. b. Collaboration with the private sector for the procurement of flood control infrastructure. c. Increased education and awareness among the community regarding disaster mitigation. d. Development of technology and information systems for early flood detection.	a. Utilizing traditional knowledge from the community and government support to develop greening and reforestation programs in upstream river areas, thereby reducing the risk of flooding. b. Leveraging the coordination between BNPB and BPBD, as well as the rapid response capability of disaster response teams, to implement educational programs and raise community awareness about disaster mitigation.	a. Addressing the inadequate flood control infrastructure through collaboration with the private sector for the procurement and development of better infrastructure. b. Enhancing community participation in mitigation programs by improving education and disaster preparedness training.
Threats (T)	**S-T Strategy/ Analysis**	**W-T Strategy/ Analysis**
a. Increasing rainfall intensity due to climate change. b. Ongoing deforestation exacerbates flood risks. c. Damage to ecosystems and the environment resulting from recurrent flooding. d. Limited funding for post-disaster rehabilitation and reconstruction.	a. Utilizing rapid response capabilities and traditional knowledge to mitigate the impacts of climate change by establishing a technology-based flood early warning system. b. Leveraging government support in resource provision to enhance post-disaster rehabilitation and reconstruction efforts, thereby reducing damage to ecosystems and the environment.	a. Improving drainage systems and river management by addressing ongoing deforestation and developing reforestation programs. b. Enhancing disaster preparedness education and training to address funding limitations and strengthen community awareness in facing flood risks.

Based on the SWOT analysis results regarding flood disasters in the Mandailing Natal Mountains region, we can understand how strengths, weaknesses, opportunities, and threats influence disaster risk management in this area. This analysis refers to previous research and various relevant sources.

Strengths: The traditional knowledge of local communities about natural signs before flooding is very useful in early detection of potential floods and taking preventive measures [14]. Early coordination between BNPB (National Disaster Management Agency) and BPBD (Regional Disaster Management Agency) indicates the existence of an effective disaster response system [15]. The rapid response capability of disaster management teams is a key strength in minimizing disaster impacts [16]. Government support in providing necessary resources for emergency response is also an important factor in the sustainability of mitigation and disaster response efforts.

Weaknesses: A lack of flood control infrastructure, such as dams and drainage systems, makes this area vulnerable to flooding [17]. The lack of community participation in mitigation programs reduces the effectiveness of mitigation efforts [18].

Poor drainage management increases the risk of flooding [19]. A lack of education and training on disaster preparedness reduces the community's ability to respond when disasters occur.

Opportunities: The development of greening and reforestation programs in upstream areas can reduce the risk of flooding [20]. Collaboration with the private sector in building flood control infrastructure can accelerate project realization and improve its quality [21]. Increasing public awareness and knowledge about disaster mitigation can reduce risks and impacts of disasters. The development of flood early detection technology can provide communities with enough time to evacuate and take preventive actions [22].

Threats: Climate change causes more extreme and unpredictable rainfall, increasing the risk of flooding [23]. Ongoing deforestation in upstream areas increases the risk of flash floods by reducing the land's capacity to absorb rainwater [24]. Repeated flooding causes damage to local ecosystems, reducing the area's natural ability to absorb water and prevent flooding [25]. Limited funding for post-disaster rehabilitation and reconstruction hampers effective recovery efforts [26].

Conclusion

A descriptive analysis of flood data from 2020 to 2024 shows that the Mandailing Natal region experiences significant fluctuations in the frequency of flood events. At the beginning of the period, the frequency of flooding decreased from 4 incidents in 2020 to 2 incidents in 2021 and 2022. However, this trend changed in 2023 and 2024, when the number of flood events increased again to 4 per year. The primary cause of flooding is high rainfall, influenced by extreme weather conditions such as Typhoon RAI, and the region's geographical vulnerability to flooding. The impact of flooding on the environment is highly damaging, leading to infrastructure destruction and disrupting the socio-economic lives of the community. Based on the SWOT analysis of flood disasters in Mandailing Natal, it can be concluded that this area has strengths in the traditional knowledge of the local community and an effective coordination system between BNPB and BPBD, which supports a rapid response to disaster management.

However, weaknesses are evident in the inadequate flood control infrastructure, low community participation in mitigation efforts, and poor drainage management. Opportunities include the development of greening programs, collaboration with the private sector, increased public awareness, and the development of early detection technology. Meanwhile, threats arise from climate change, deforestation in upstream areas, and ecosystem damage due to recurrent flooding, which necessitates holistic and sustainable mitigation strategies to enhance resilience to flood disasters in the region. Recommendations for improving flood resilience include: building better flood control infrastructure, developing early warning systems, increasing community participation in mitigation efforts, implementing greening programs, integrating climate change considerations into mitigation planning, and continuous monitoring of infrastructure conditions for more effective response and mitigation.

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