STRATEGIES FOR LANDSLIDE DISASTER MITIGATION IN BAKTIRAJA'STOURISM ZONES, HUMBANG HASUNDUTAN REGENCY, INDONESIA

ABSTRACT

Mitigation disaster is very important to develop region in many areas. This study addresses landslide mitigation for tourism development in the Baktiraja District, HumbangHasundutan Regency. Four parameters, including slope inclination, rainfall, soil type, and land use, reveal four levels of landslide vulnerability: low, moderate, high, and very high. The method in this study used spatial analysis using ArcGIS (Geographic Information Systems) 10.8 identifies Tipang Village, Simangulampe Village, and Marbun Tonga MarbunDolok Village as areas with the highest vulnerability, covering 77.60% of the Baktiraja District. MSP+DM analysis categorizes the tourism potential in these villages as "Embryonic." To elevate this status to "Growing" and "Self-sustaining," emphasis on improving marketability indicators through enhanced packaging, diverse promotional models, and an extensive marketing network is needed. Sustainable development efforts by the local government and active community participation in preserving local wisdom, natural attractions, and cultural heritage are crucial. Recommendations include regular updates on disaster vulnerability data, establishment of evacuation routes and shelters, early warning systems, and community training. Regulations on open land use for physical development need attention, and the government should allocate budget for tourism infrastructure. Ensuring synergy among the government, local community, and tourism stakeholders is key to sustainable tourism development in this area

Keywords: Landslide mitigation, Tourism development, spatial analysis, MSP+DM, HumbangHasundutan

I. INTRODUCTION

Tourism, as a promising economic sector, is often haunted by natural disaster risks, especially landslides, which can jeopardize the sustainability and development of tourism (Bayuaji et al., 2016). Many factors influence slope stability, leading to landslides. Natural causes of landslides include surface morphology, land use, lithology, geological structure, rainfall, and seismic activity. Additionally, human activities such as agriculture, slope loading, slope cutting, and mining can contribute to landslides (Mubekti and Alhasanah, 2008).

Areas prone to landslides can be categorized into three levels of vulnerability (Ministerial Regulation PU, 2007) based on the above characteristics:

1. Areas with high vulnerability
2. Areas with moderate vulnerability

3. Areas with low vulnerability

Factors causing landslides involve various elements, including:

1. **Soil Type (Wati, 2010):**
   - Clayey or loamy soil with loose texture tends to cause landslides.
   - Clay soil has small pores, is prone to saturation, and is easily movable.
   - Certain soil types, such as Oxisol, Ultisol, and Alfisol, have a high score in terms of landslide potential.
2. **Rainfall (Arsyad.S, 2010):**
   - Sudden increases in rainfall intensity, especially at the beginning of the rainy season, can trigger landslides.
   - Extended dry seasons can cause cracks in the soil, allowing water to enter and accumulate on slopes, initiating lateral movement.
3. **Slope Gradient (Wati, 2010; Arsyad.S, 2010):**
   - Steep slope gradients increase the risk of landslides by magnifying the driving force.
   - Steep slopes can be formed due to water erosion, and their gradient affects shear stress and soil strength.
4. **Land Use (Sheila, 1995):**
   - Human activities, such as wet farming on slopes, can affect soil stability.
   - Plants can have stabilizing effects or widen cracks, depending on the vegetation type.

Disaster mitigation involves efforts to reduce disaster risks, including physical development, awareness, and enhancing the ability to face disaster threats. According to Law No. 24 of 2007, disaster mitigation involves physical development and increased awareness. The Ministry of Home Affairs of the Republic of Indonesia identifies two groups of disaster hazards: main hazards and collateral hazards, with landslides being classified as a main hazard.

Disaster mitigation comprises two approaches:

1. **Structural Mitigation:**
   - Involves the construction of physical infrastructure and technology, such as wire gabions and specialized evacuation routes for landslide prevention.
2. **Non-Structural Mitigation:**
   - Involves policies, regulations, urban spatial planning, disaster-prone area maps, and other activities that strengthen community capacity.

Mapping disaster-prone areas is crucial in disaster mitigation, aiding in anticipatory decision-making. Geographic Information Systems (GIS) provide an effective technological solution. Computer-based GIS with spatial data provides information close to real-world conditions. ArcGIS Desktop, including ArcView, ArcCatalog, ArcToolbox, ArcGlobe, and ArcReader, is a framework used for mapping landslide-prone areas.

Overlay analysis, one of the spatial analysis methods in GIS, involves stacking or layering information from two or more maps to generate new information. This method is commonly used in thematic map overlay processes, focusing on thematic geospatial information. In the context of tourism development, the Overlay Method involves at least two different types of maps.

Land suitability class determination is done by analyzing variables such as slope gradient, soil type, rainfall, topography, land use, and landslide potential. Scoring is used to determine land suitability values, where scores from various variables are summed (Arifin et al., 2006).

In tourism development, tourism activities involve multidimensional and multidisciplinary interactions between tourists, local communities, government, and entrepreneurs. Tourism area development not only transforms existing conditions but also improves and packages them to attract tourists.

HumbangHasundutan Regency, particularly Baktiraja District, is the focus of this research due to recurring landslide incidents, posing a serious threat to public facilities, transportation infrastructure, and tourism facilities (Regional Disaster Management Agency of HumbangHasundutan Regency, 2019-2022). Disaster data from the Regional Disaster Management Agency of HumbangHasundutan Regency from 2019 to 2022, as presented below, indicate frequent landslide occurrences in Baktiraja District, HumbangHasundutan Regency.

Table 1 Landslide Disaster Data in Baktiraja District HumbangHasundutan Regency for The Years 2019-2022

No	Year	Number of incidents
1	2019	5 incidents
2	2020	5 incidents
3	2021	7 incidents
4	2022	6 incidents

Source: BPBD HumbangHasundutan (data processed) in year 2019, 2020,2021,2022

Geographic Information Systems (GIS) provide an effective technological solution. Computer-based GIS with spatial data provides information close to real-world conditions. ArcGIS Desktop, including ArcView, ArcCatalog, ArcToolbox, ArcGlobe, and ArcReader, is the framework used for mapping landslide-prone areas.

The MSP+DM (Marketability, Sustainability, Participatory, Disaster Mitigation) analysis model is an alternative to SWOT analysis in the context of tourism development. This model is more objective, consistent, and easily understood by various stakeholders. MSP+DM analysis involves Marketing, Sustainability, Community Participation, and Disaster Mitigation aspects in measuring the feasibility and potential of tourism area development (Priatmoko, 2019).

In the context of disaster mitigation, the application of Weighted Overlay in mapping the probability levels of landslide-prone zones in Sumedang Regency, West Java, by Muhammad Farhan Yassar et al. (2020) shows that Sumedang Regency has a moderate to high possibility of landslide disasters. The importance of mapping landslide disaster risks and tourism development in vulnerable areas becomes a central point in this study.

Several factors influence slope stability leading to landslides. Natural causes of landslides include surface morphology, land use, lithology, geological structure, rainfall, and seismic activity. Human activities affecting natural landscapes, such as farming, slope loading, slope cutting, and mining, also contribute to landslides (Mubekti and Alhasanah, 2008). An area prone to landslides can be categorized into three vulnerability levels (Minister of Public Works Regulation, 2007) based on the above characteristics:

Priatmoko et al. (2019) in his paperapply MSP+DM analysis in tourist areas showed that Disaster Mitigation assessment in the form of quantitative assessment helps in evaluating and determining improvement targets in specific tourist areas.Muhammad FarrelSyuhada et al. (2022) apply Geographic Information Systems (GIS) to analyze disaster-prone zones around Mount Semeru. This research can serve as a reference for disaster preparedness mitigation in settlements around Mount Semeru.

This paper emerges in response to the need for a deeper understanding of the distribution and vulnerability levels to landslides. In this context, the findings of Bayuaji et al. (2016) are relevant, describing that approximately 73.244% of the Banjarnegara Regency area has a high threat level to landslides. In another study, Hamidah and Widyasamrati (2019) emphasize the need for detailed disaster risk identification, especially in the context of tourist areas, using Geographic Information Systems (GIS).

In the conceptual framework of this paper, the researcher based the determination of landslide vulnerability levels in Baktiraja District, HumbangHasundutan Regency, on physical condition parameters such as soil type, rainfall, slope inclination, and land use. The methodology comprised risk mapping through overlay methods, scoring, and weighting, ultimately leading to the delineation of landslide-prone zones. Simultaneously, an analysis of tourism development in Baktiraja District incorporated variables such as marketing, sustainability, participation, and disaster mitigation. This holistic approach aimed to integrate geological factors with considerations essential for sustainable tourism planning in landslide-prone areas.

II. METHOD

This study was conducted in the Baktiraja District, HumbangHasundutan Regency, North Sumatra, Indonesia, spanning from May to October 2023. The regency is situated in North Sumatra Province, bordered by Tapanuli Utara Regency to the East, Tapanuli Tengah Regency to the South, Pakpak Bharat Regency to the West, and Samosir Regency to the North.

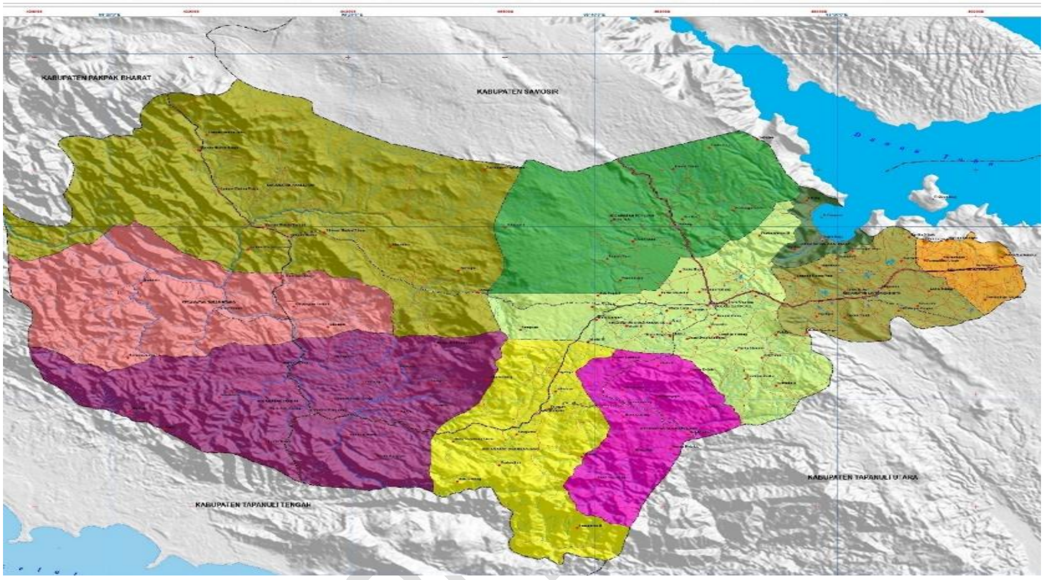


Figure 1 Research Location

The research utilized a variety of spatial and non-spatial data, including maps of land cover, slope, soil type, average rainfall, village administration, and the distribution of tourist locations. Various tools and materials were employed, including these maps, along with Global Positioning System (GPS) devices, compasses, cameras, voice recorders, tally sheets, and writing instruments. Data analysis involved the use of software such as Excel and ArcGIS.

To assess landslide vulnerability in the Baktiraja District, a spatial method based on Geographic Information System (GIS) was implemented. Critical variables considered in this analysis included rainfall, slope inclination, land cover, and soil type. These parameters were sourced from reputable institutions such as the Regional Forest Area Consolidation Office I Medan, the Soil and Agroclimate Research Center, and the Meteorology, Climatology, and Geophysics Agency.

The Storie Index method was employed to determine landslide potential and vulnerability. Parameters were evaluated based on specified criteria, as outlined in Table 2.

Table 2: Characteristic Parameters for Landslide Vulnerability

No	Variable	Criteria	Value
1	Rainfall	- Rainfall> 33700 mm year	8
		- Rainfall3400 - 3700 mm year	7
		- Rainfall3100 – 3400 mm year	6
		- Rainfall2800 – 3100 mm year	5
		- Rainfall2500 – 2800 mm year	4
		- Rainfall2200 – 2500 mm year	3
		- Rainfall1900 – 2200 mm year	2
		- Rainfall< 1900 mm tahun	1
2	Slope inclination	- steep to very steep, inclination > 75%	6
		- Very steep to steep, inclination 46 - 75%	5
		- Sloping to very steep, inclination 31 – 45%	4
		- Moderately steep, hilly, inclination 16 – 30%	3 2
		- Gentle, undulating, wavy, inclination 4 – 15%	1
		- Flat, inclination 0 – 3%	
3	Land Cover	- Without vegetation	5
		- Grass, shrubs, agricultural vegetation (rice, corn)	4
		- Mixed gardens, yard plants	3
		- Plantation (trees)	2
		- Dense Forest	1
4	Soil Type	- Oxisol	7
		- Ultisol	6
		- Alfisol	5
		- Mollisol	4
		- Enseptisol	3
		- Entisol	2
		- Histosol	1

Source: Arifin et al (2006)

The Storie Index analysis was computed using the formula

$$L = A \times \frac{B}{10} \times \frac{C}{10} \times \frac{D}{10}$$

Where:

L represents landslide potential, and A, B, C, and D represent rainfall, slope inclination, land cover, and soil type, respectively.

To determine landslide vulnerability levels, GIS applications were utilized with the Storie Index method, resulting in scores that were converted into five categories: Very High, High, Moderate, Low, and Very Low. Subsequently, the analysis of tourism development and disaster mitigation was conducted using the MSP+DM method, encompassing Marketing, Sustainability, Participatory approaches, and Disaster Mitigation.

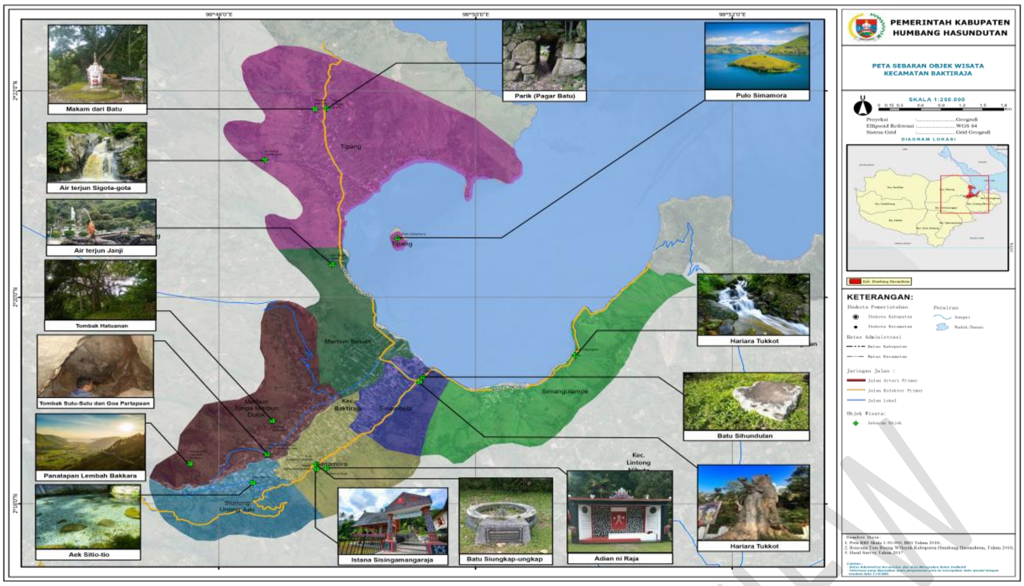


Figure 2: Distribution Map of Tourism Potential in the Baktiraja District

Tourism potential data in the Baktiraja District were acquired from the Department of Tourism, Youth, and Sports of HumbangHasundutan Regency. Data collection involved structured interviews with various stakeholders, including relevant agencies, local communities, business entities, and tourists. All these steps aimed to provide a comprehensive understanding of landslide vulnerability and tourism development in the research area.

III. RESULT AND DISCUSSION

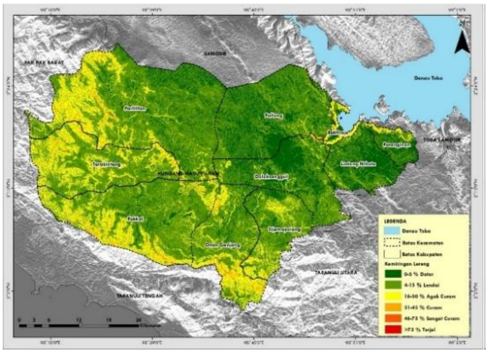
3.1 Overview of HumbangHasundutan Regency

HumbangHasundutan Regency consists of 10 districts, including Baktiraja District. The regency covers an area of 2,337.695 km² or 233,769.46 ha, situated between 2°1'-2°28' North Latitude and 98°10'-98°58' East Longitude, centrally positioned in North Sumatra Province. The administrative boundaries of HumbangHasundutan Regency are as follows:

1. East: Tapanuli Utara Regency
2. South: Tapanuli Tengah Regency
3. West: Pakpak Bharat Regency
4. North: Samosir Regency

3.1.1 Slope Inclination Levels in HumbangHasundutan Regency

The elevation of HumbangHasundutan Regency ranges from 330 m to 2,075 m above sea level, with varying slope inclinations from flat to very steep.



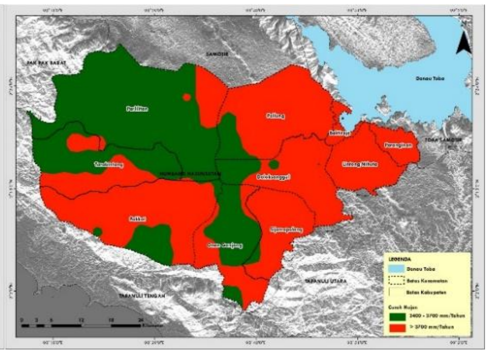


Figure 3. Slope Inclination Levels in HumbangHasundutan Regency

Figure 4 Soil Types in HumbangHasundutan Regency

3.1.2 Rainfall in HumbangHasundutan Regency

Rainfall exceeding 3700 mm/year is considered very high. The data indicates that rainfall >3700 mm/year in HumbangHasundutan Regency covers 59.43% of the total area.

3.1.3 Soil Types in HumbangHasundutan Regency

There are three soil types in HumbangHasundutan Regency: Entisol, Inseptisol, and Ultisol. Inseptisol dominates the regency, constituting 99.22% or 231,941.04 ha of the total area.

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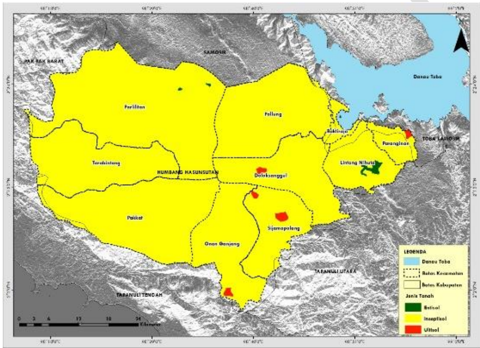


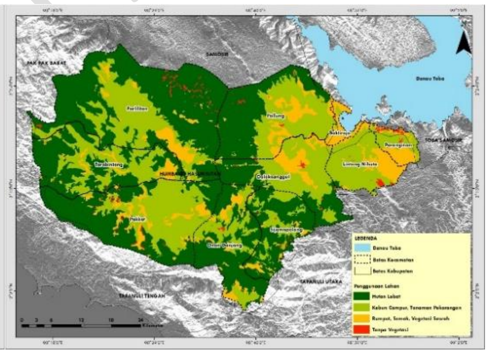


Figure 5. Soil Types in HumbangHasundutan Regency

Figure 6. Land Cover in HumbangHasundutan Regency

3.1.4 Land Cover in HumbangHasundutan Regency

The largest land use in HumbangHasundutan Regency is dense forest, covering 116,632.03 ha or 49.89%. Other extensive land uses include mixed gardens and home garden plants (36.98%) and grass, shrubs, and rice field vegetation (12.23%).

Table 3. Land Cover Percentage in HumbangHasundutan Regency

No	Land Use	Area (ha)	Percentage (%)
1	Dense Forest	116,632.03	49.89

2	Mixed Gardens, Home Garden Plants	86,453.55	36.98
3	Grass, Shrubs, Rice Field Vegetation	28,593.19	12.23
4	Without Vegetation	2,090.69	0.89
Total Area		**233,769.46**	**100**

In addition, the land is extensively used for mixed gardens and home garden plants, accounting for 36.98%, and for grass, shrubs, and rice field vegetation at 12.23%. The development of this region, especially in the context of land clearing for plantations and paddy fields, may increase the demand for land without corresponding availability. Land exploitation activities without considering its carrying capacity escalate the risk of disasters, particularly landslides. Changes in land use, especially in hilly areas for cultivation or settlement, become a crucial factor accelerating soil erosion and slope instability, significantly contributing to the risk of landslides.

3.1.5. Landslide Vulnerability Levels in HumbangHasundutan Regency

Based on the results of the four aforementioned maps, employing overlay methods in GIS software using ArcGIS 10.8 produced a new map. The classification of landslide vulnerability levels in HumbangHasundutan Regency is categorized as very low, low, moderate, high, and very high.

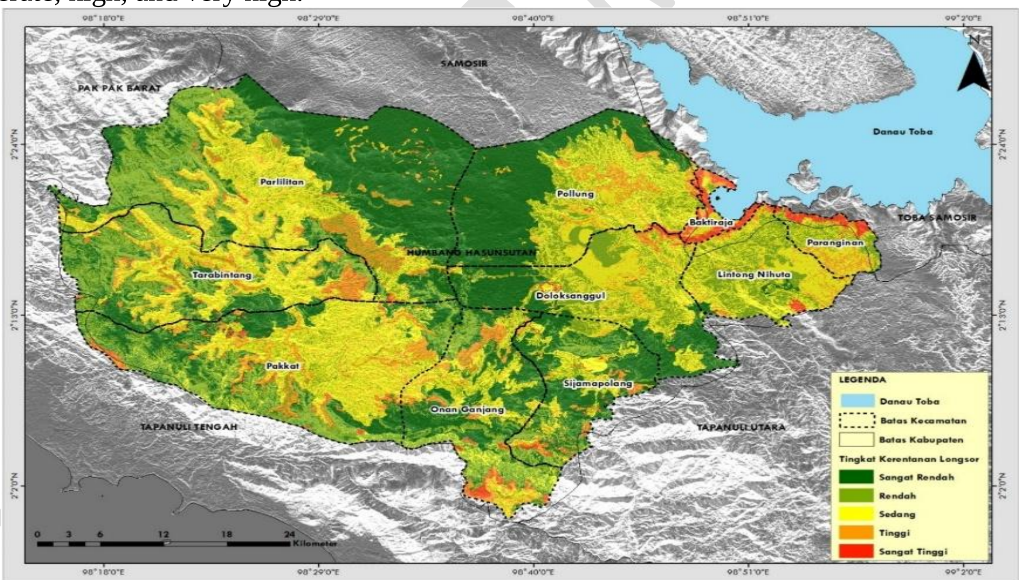


Figure 7. Map of Landslide Vulnerability Levels in HumbangHasundutan Regency

Table 4. Landslide Vulnerability Levels in HumbangHasundutan Regency

No	Vulnerability Level	District	Area (ha)	Percentage (%)
1	High - Very High	Baktiraja	1,861.60	6.66
2	High - Very High	Doloksanggul	1,657.86	5.93
3	High - Very High	LintongNihuta	1,318.32	4.72
4	High - Very High	OnanGanjang	3,220.70	11.52

5	High - Very High	Pakkat	5,085.75	18.19
6	High - Very High	Paranginan	1,664.66	5.95
7	High - Very High	Parlilitan	5,110.95	18.28
8	High - Very High	Pollung	2,617.40	9.36
9	High - Very High	Sijamapolang	1,362.24	4.87
10	High - Very High	Tarabintang	4,059.18	14.52
Total Area			**27,958.65**	**100**

From Table 4, it can be observed that for the landslide vulnerability level classified as high-very high, BaktirajaDistrict accounts for 6.66% of the total area of this classification in HumbangHasundutan Regency. Out of the total area of 2,398.928 ha in BaktirajaDistrict, 1,861.60 ha or 77.60% is classified as having a high-very high landslide vulnerability.

3.2. Landslide Vulnerability Level in BaktirajaDistrict

BaktirajaDistrict is located approximately 15 km from Doloksanggul, the capital of HumbangHasundutan Regency. BaktirajaDistrict has a total area of 2,398.928 hectares, consisting of seven villages.

Table 5. Area of BaktirajaDistrict

No	Village	Area (Ha)
1	Marbun Tonga MarbunDolok	385,661
2	MarbunToruan	225,814
3	Simamora	226,869
4	Simangulampe	401,033
5	Sinambela	157,380
6	Siunong-unongJulu	223,089
7	Tipang	779,083
T o t a l		**2398,928**

Source: BPS (2023)

3.2.1 Slope Inclination in BaktirajaDistrict

The slope inclination in BaktirajaDistrict can be classified as follows:

Table 6. Slope Inclination in BaktirajaDistrict

No	Slope Inclination	Description	Area (ha)	Percentage (%)
1	0-3 %	Flat	400.036	16.68
2	4-15 %	Gentle	1,170.258	48.78
3	16-30 %	Moderately	154.534	6.44

		Steep		
4	31-45 %	Steep	665.633	27.75
5	46-75 %	Very Steep	8.467	0.35
Total			**2,398.928**	**100**

From the table, it can be seen that gentle slope inclination dominates BaktirajaDistrict, covering an area of 1,170.258 ha or 48.78% of the total area.

It can be observed that the dominant slope inclination in BaktirajaDistrict is gentle, covering an area of 1,170.258 ha or 48.78% of the total area.

3.2.2 Climate and Rainfall Conditions in BaktirajaDistrict

Based on rainfall data from satellite sources, obtained from the chrs.web.uci.edu website throughout the year, BaktirajaDistrict experiences very high rainfall, exceeding 3700 mm/year.

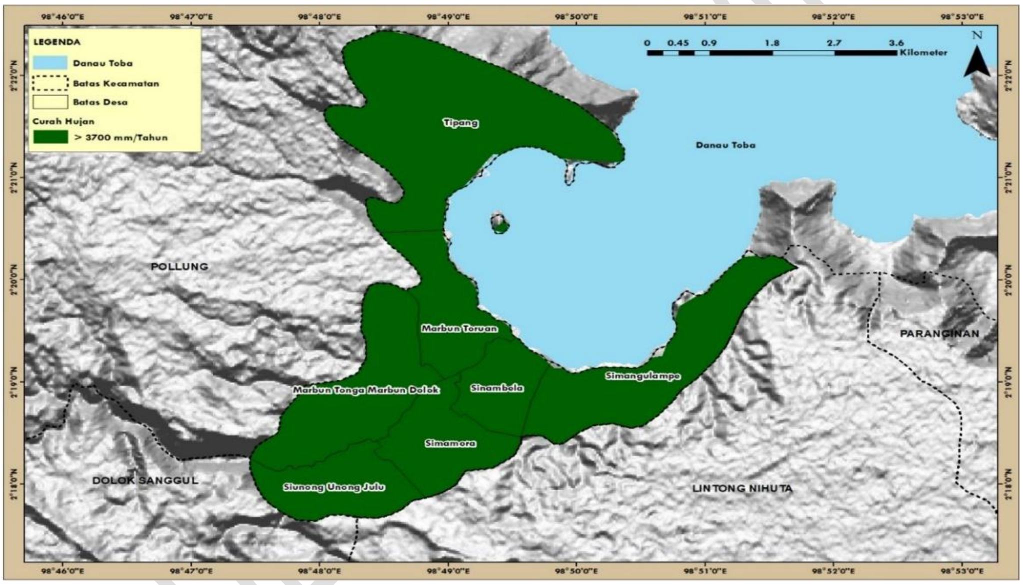


Figure 8. Rainfall Map of BaktirajaDistrict

From the rainfall map, it can be seen that high rainfall with a volume of more than 3700 mm/year is evenly distributed across all villages in BaktirajaDistrict.

3.2.3 Soil Types in BaktirajaDistrict

Based on soil type maps obtained from the Soil and Agroclimate Research Center (Puslittanak), the soil type in BaktirajaDistrict is Inceptisol. Inceptisol is fertile for agricultural land but is highly susceptible to landslides when situated on steep slopes.

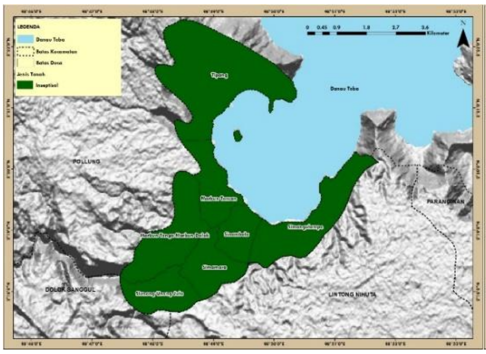


Figure 9.Soil Types in BaktirajaDistrict

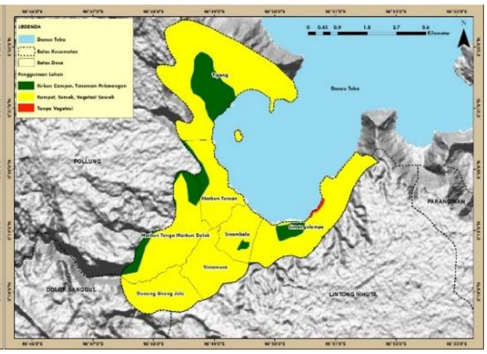


Figure 10.Land Cover in BaktirajaDistrict

3.2Land Cover in BaktirajaDistrict

Based on data obtained from the Forest Area Stabilization Center (BPKH) Region I North Sumatra in 2023, land use in BaktirajaDistrict can be classified as follows:

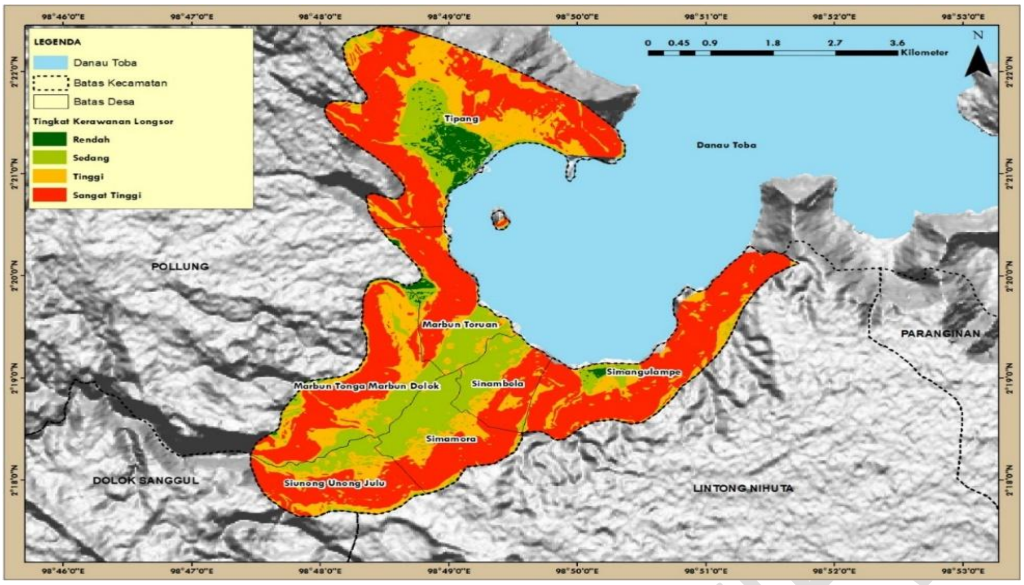
Table 7. Land Cover in Bakitraja District

No	Land Use	Area(ha)	Percentage(%)
1	Mixed Gardens, Home Garden Plants	290,14	12,09
2	Grass, Shrubs, Rice Field Vegetation	2104,39	87,72
3	Without Vegetation	4,40	0,18
	Total	2398,93	100,00

The land cover conditions with less or no vegetation, such as grasslands, shrubs, and agricultural land, might be due to extensive land conversion for plantations and agricultural areas. A significant portion of the converted areas has become abandoned land. Opening up forests for agriculture with reduced vegetation cover can increase the vulnerability to landslides in BaktirajaDistrict.

3.3. Landslide Vulnerability Analysis in BaktirajaDistrict:

The landslide vulnerability analysis in BaktirajaDistrict was conducted using overlay analysis (tumpengsusun) in ArcGIS 10.8. The results indicate four levels of landslide vulnerability: low, moderate, high, and very high. The landslide vulnerability map can be seen in Figure 11.



Source: Data Analysis

Figure 11 Landslide Vulnerability Analysis in BaktirajaDistrict

Table 8. Area of Landslide Vulnerability Levels in BaktirajaDistrict (ha)

Village	Low	Moderate	High	Very High	Total
Marbun Tonga MarbunDolok	2,689	79,312	127,032	176,628	385,661
MarbunToruan	6,681	65,010	34,566	119,556	225,814
Simamora		91,189	43,755	91,924	226,869
Simangulampe	3,592	22,610	73,807	301,025	401,033
Sinambela		63,339	30,616	63,425	157,380
SiunongUnongJulu		39,784	65,677	117,628	223,089
Tipang	56,322	106,804	216,458	399,499	779,083
Total Area	**69,284**	**468,048**	**591,912**	**1269,684**	**2398,928**

Based on the overlay, seven villages in BaktirajaDistrict have high and very high levels of landslide vulnerability. The overall area of BaktirajaDistrict with high vulnerability is 24.67%, while the very high vulnerability is 52.93%. The focus of landslide disaster mitigation analysis in tourism development will be directed towards areas with high and very high vulnerability, which have the largest areas, as shown in Table 9.

Table 9. High-Very High Landslide Vulnerability in BaktirajaDistrict

Village	High	Very High	Total	Percentage
Tipang	216,46	399,50	615,96	33,09
Simangulampe	73,81	301,02	374,83	20,13
Marbun Tonga MarbunDolok	127,03	176,63	303,66	16,31
SiunongUnongJulu	65,68	117,63	183,31	9,85
MarbunToruan	34,57	119,56	154,12	8,28
Simamora	43,76	91,92	135,68	7,29
Sinambela	30,62	63,42	94,04	5,05
Luas Total	**591,91**	**1269,68**	**1861,60**	**100,00**

From the table, it is evident that Tipang Village has the highest landslide vulnerability with a total area of 615.96 ha or 33.09%, followed by Simangulampe Village with an area of 374.83 ha or 20.13%, and Marbun Tonga MarbunDolok Village with an area of 303.66 ha or 16.31%. Disaster data from the Regional Disaster Management Agency (BPBD) of HumbangHasundutan Regency for the years 2018, 2019, 2020, 2021, and 2022 show that these three villages have experienced landslide disasters (attached data).

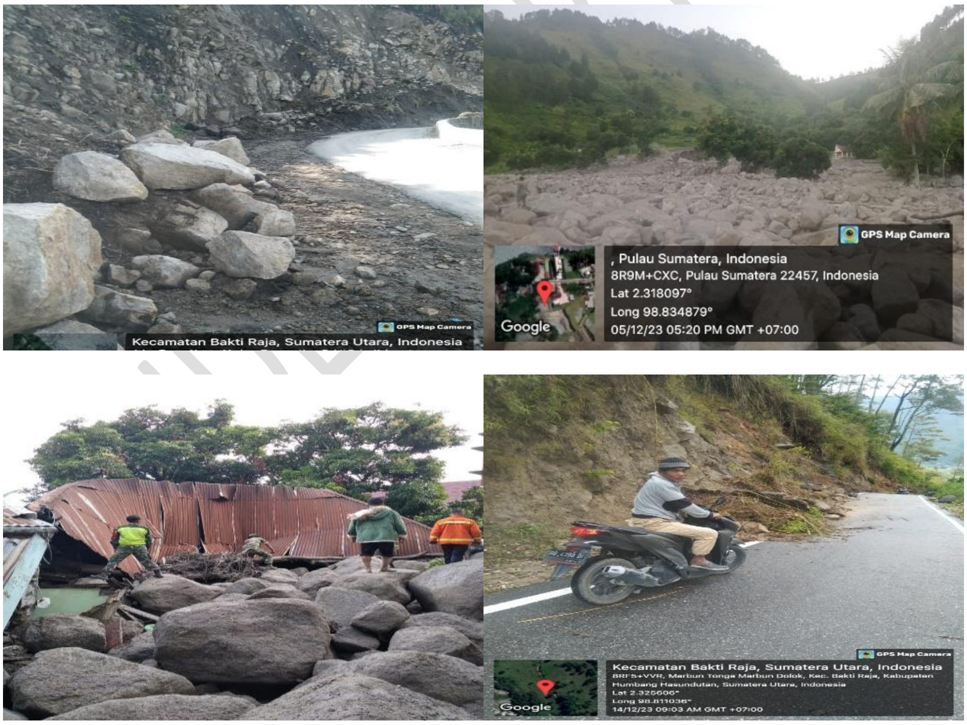


Figure12.Results of Field Research Validation in BaktirajaDistrict

Based on the validation results from field research (groundcheck), it is revealed that in Tipang Village, Simangulampe Village, and Marbun Tonga MarbunDolok Village, there is vulnerability to landslide disasters. It is known that these three villages experienced heavy rainfall from August to December 2023, leading to landslides at several points.

3.4 Analysis of Tourism Area Development in Tipang Village, Simangulampe Village, and Marbun Tonga MarbunDolok Village:

Using the MSP+DM method (Priatmoko, 2019), the tourism potential in Tipang Village, Simangulampe Village, and Marbun Tonga MarbunDolok Village was analyzed with a high to very high landslide vulnerability. The tourism potential is analyzed based on four main variables: Marketability, Sustainability, Participatory, and Disaster Mitigation.

3.4.1. Results of Tourism Area Development Analysis in Tipang Village

Based on the MSP+DM analysis for Tipang Village, the results are presented in Table 10

Table 10. MSP+DM Analysis Results in Tipang Village, BaktirajaDistrict

No	Tourist Attraction	Village	1. Markebility					2. Sustainability							3.Participatory					Disaster Mitigation	
			A	B	C	D	Sub total	A	B	C	D	E	F	Sub total	A	B	C	D	Sub total	A	Sub total
1.	Air TerjunSigo ta-gota	Tipang	1	3	3	2	2,25	1	3	1	4	3	1	2,17	4	3	2	1	2,5	2	2
2.	Air terjunSipul tak Huda	Tipang	1	3	3	2	2,25	1	3	1	4	3	1	2,17	4	2	2	1	2,25	2	2
3.	PuloSima mora	Tipang	1	3	3	2	2,25	1	3	1	4	3	2	2,17	4	3	2	1	2,5	2	2
4.	Makamdar iBatu	Tipang	1	3	2	2	2	1	3	1	4	3	2	2,17	1	2	2	1	1,5	2	2
Average Value							2							2,17					2		2

On average, the value for tourism potential in Tipang Village is 2.04, and the potential category is "Embryo." To improve the potential category, development programs are needed to enhance indicators from the "Embryo" category to "Growth" or "Independent."

3.4.2. Results of Tourism Area Development Analysis in Simangulampe Village

For Simangulampe Village, the results of the MSP+DM analysis are presented inTable 11

Table 11. MSP+DM Analysis Results in Simangulampe Village, BaktirajaDistrict

No	Tourist Attraction	Village	1. Marketability	2. Sustainability	3. Participatory	4. Disaster Mitigati

																				on	
			A	B	C	D	Sub total	A	B	C	D	E	F	Sub total	A	B	C	D	Sub total	A	Sub total
1.	AekSipan golu	Simangu-lampe	1	3	4	4	3	1	4	1	3	5	2	2,67	4	4	3	2	3,25	3	3
							3							2,67					3,25		3

The average value for tourism potential in Simangulampe Village is 2.89, and the potential category is "Embryo.

3.4.3. Results of Tourism Area Development Analysis in Marbun Tonga MarbunDolok Village

The MSP+DM analysis results for Marbun Tonga MarbunDolok Village are presented in Table 12

Table12 MSP+DM Analysis Results in Marbun Tonga MarbunDolok Village, BaktirajaDistrict

No	Tourist Attraction	Village	1. Marketability					2. Sustainability							3. Participatory					4. Disaster Mitigation	
			A	B	C	D	Sub total	A	B	C	D	E	F	Sub total	A	B	C	D	Sub total	A	Sub total
1.	Tombak Sulu-sulu	Marbun Tonga Marbun Dolok	1	3	4	4	3	1	4	1	3	5	2	2,67	4	4	3	2	3,25	3	3
2.	Tombak Hatuanan	Marbun Tonga Marbun Dolok	1	3	4	4	3	1	4	1	3	5	2	2,67	4	4	3	2	3,25	3	3
Average Value							3							2,67					3,25		3

The average value for tourism potential in Marbun Tonga MarbunDolok Village is 2.89, and the potential category is "Embryo.

3.5. Tourism Potential Categories for Tipang Village, Simangulampe Village, and Marbun Tonga MarbunDolok Village

After data processing and MSP+DM analysis, the potential tourism categories for these three villages are summarized in Table 13

Table13 Categories for Tourism Potential

No	Tourist Attraction	Village	Sub Total M	Sub Total P	Sub Total S	Sub Total DM	Area Value	Category
1	Air terjunsigota-gota	Tipang	2,25	2,17	2,5	2	2,23	Rintisan

2	Air terjunsipultakhoda	Tipang	1,5	2,17	1,5	2	2,16	Rintisan
3	PuloSimamora	Tipang	2,25	2,17	2,5	2	2,23	Rintisan
4	Makamdaribatu	Tipang	2	2,17	1,5	2	1,92	Embrio
5	AekSipangolu	Simangulampe	3	2,67	3,25	3	2,98	Rintisan
6	Tombak Sulu-sulu	Marbun Tonga MarbunDolok	3	2,67	3,25	3	2,98	Rintisan
7	TombakHatuanan	Marbun Tonga MarbunDolok	3	2,67	3,25	3	2,98	Rintisan

From these results, it can be concluded that Tipang Village has the "Rintisan" category, and the same applies to Simangulampe Village and Marbun Tonga MarbunDolok Village. Based on the analysis, there are recommendations to improve the tourism potential category from "Embryo" to "Growth" or "Independent." Development programs are required to enhance the indicators for each village, including marketing, sustainability, community participation, and disaster mitigation, to achieve sustainable and high-quality tourism potential.

3.6 Results of Data Processing and Recommendations:

1. **Enhancing Markebility (Marketing):**
    - Development of packaging for tourism goods and services by tourism businesses in all three villages.
    - Implementation of tourism promotion through various models and media to increase national visibility.
2. **Sustainability Development:**
    - Government efforts in developing sustainable tourism potential.
    - Construction of infrastructure and supporting facilities to maintain the sustainability of tourism potential.
3. **Participatory Empowerment:**
    - Involvement of the community as tourism entrepreneurs by providing participation in preserving the uniqueness of nature, cultural history, and traditions in these villages.
4. **Disaster Mitigation:**
    - Anticipation of disaster risks through policies and recovery planning in Tipang Village, Simangulampe Village, and Marbun Tonga MarbunDolok Village.
    - Training and education for the community on disaster mitigation and appropriate actions in emergency situations.

The villages of Tipang, Simangulampe, and Marbun Tonga MarbunDolok hold promising tourism potential, falling into the "Initiation" category. Developing tourism in this region with a focus on disaster mitigation requires collaborative efforts from the government, businesses, and the local community. Implementing educational programs is crucial to enhance the knowledge and skills of businesses and the local community in disaster mitigation. This involves conducting socialization sessions and providing training on emergency response during disasters.

A significant step is the establishment of a Tourism Rescue Agency through collaboration between the Tourism Office and BPBD of HumbangHasundutan Regency. This initiative aims to boost the capacity of security volunteers, ultimately reducing disaster-related casualties and ensuring a secure environment for tourists. To address potential landslides, dedicated evacuation routes need to be developed, and shelters strategically constructed. These measures are essential for ensuring the safety of both tourists and the local community during emergencies.

Installing disaster management facilities at tourist sites is crucial. This includes placing warning signs in landslide-prone areas, distributing informative brochures, and implementing an effective early warning system. These initiatives not only promote tourism but also prioritize the safety and well-being of tourists and the local community. By fostering collaboration among government agencies, businesses, and the community, a comprehensive approach to disaster mitigation in tourism development can be achieved in these villages.

IV. CONCLUSION AND RECOMMENDATIONS

The assessment of landslide vulnerability in Tipang, Simangulampe, and Marbun Tonga MarbunDolok Villages reveals high-risk areas. Meanwhile, the MSP+DM analysis categorizes the tourism potential in these villages as embryonic. To elevate this potential to a growing and independent status, a concerted effort is needed. This involves enhancing marketing strategies, ensuring sustainable development, fostering community participation, and implementing disaster mitigation measures.

The HumbangHasundutan Regency government is advised to prioritize several key recommendations for sustainable tourism development. Periodic updates of landslide vulnerability data through relevant agencies are crucial for adaptive planning. Evaluation of spatial planning and the implementation of regulations for open land use can enhance planning effectiveness and prevent inappropriate construction. Addressing the low awareness and commitment of both the local community and tourists in preserving natural environments requires concerted efforts to raise awareness and engage them in conservation. Lastly, improving the effectiveness of disaster mitigation-based tourism development programs is essential to enhance the contributions of tourism activities to the well-being of the local community, promoting overall prosperity. These recommendations underscore the importance of proactive measures in data management, spatial planning, regulations, community engagement, and program effectiveness for sustainable tourism development in the region.

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