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Identification of Landslide Susceptibility Level in Buffer Village Lore Lindu National Park Using Scoring Method

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Abstract

A landslide is a form of natural phenomenon that often occurs in mountainous and hilly regions with steep up to very steep slopes. Landslides are one of the most dangerous natural hazards and occur frequently in many hilly or mountainous areas, often occurring without warning and causing loss of life and property, marked with movement material of slope-forming materials in the form of rocks, soil, or materials down the slope. This study aimed to identify the distribution of landslide-prone areas in 86 buffer villages in Lore Lindu National Park, Central Sulawesi Province using geographic information system (GIS) based spatial analysis with scoring and overlay. The research parameters consisted of land cover/use, rainfall, elevation, slope, soil type, lithology, and distance from the fault. Identification of vulnerability factors for susceptibility level was determined according to 7 parameters used in the analysis. The results showed that the level of landslide susceptibility in the study area was divided into 3 classes, namely low (85.679,74 ha), moderate (363.184,89 ha), and high (26.888,46 ha). Villages that have a high level of vulnerability are Lempelero, Runde, Sedoa, Tuare, and Tongoa.

Keywords: landslide susceptibility, vulnerability, scoring, overlay, lore lindu

Introduction

Lore Lindu National Park has an important role as a conservation area with important values such as protection of endemic animals, water regulation, cultural and historical values, representatives of the Sulawesi mountain rain forest ecosystem, local community wisdom values, and the cohesiveness of the landscape. Until now, the area of the Lore Lindu National Plant continues to change. Based on SK.Minister of Forestry No. 869/Menhut-II/2014 concerning Forest Areas and Waters Conservation in Central Sulawesi Province, it is recorded that the area is 215.733,70 ha.

Indonesia is a country prone to natural disasters because it is located in an area that is tectonic and volcanic active as a result of the confluence of three tectonic plates, namely the Indian-Australian, Pacific and Eurasian Plates. One of the natural disasters that often occurs in Indonesia is flood disaster (Sigit, et al., 2011).

Landslides are one of the most dangerous natural hazards and occur frequently in many hilly or mountainous areas, often occurring without warning and causing loss of life and property. The occurrence of landslides mainly depends on local terrain conditions and is controlled by geological and geomorphological processes. However, landslides can be triggered on unstable slopes by external factors such as heavy rainfall, earthquakes, floods, snowmelt, river erosion, changes in groundwater levels, volcanic eruptions, or a combination of these natural factors. (Fadil, et al., 2023).

Therefore, the frequency, magnitude, and volume of landslides are expected to increase both by internal and external factors. In addition, the frequency and magnitude of landslides are increasing due to the extreme climate in fragile hilly or mountainous areas. Despite this fact, many countries around the world face large-scale human tragedies, material damage, and economic losses due to landslides (Promper, et al., 2014).

Some of the symptoms that can be observed visually include the appearance of cracks on the slopes parallel to the direction of the cliff, buildings that are starting to look cracked, trees or electricity poles tilting, and new springs appearing (Kinanti, Awaluddin, & Yusuf, 2023)

Geographic Information System (GIS) is a tool/instrument that can be used to process, analyze and make decisions in determining vulnerable zoning in an area using a parameter approach. Determination of zoning of vulnerable areas can be done by integrating disaster phenomena and satellite data capabilities. Image can provide physical information about an area, so that it can be analyzed and identify natural phenomena that occur. (Suni, et al., 2023).

Landslides can occur due to natural faults and weather factors in soil and rocks, especially in areas with humid and hot climates (Kurniawan, 2019). Another cause of landslides is human activity, such as illegal logging, logging which causes slope instability, changes in steepness slopes, excessive loading of buildings in hilly areas and so on. Based on the trigger factors for landslides, the area around Lore Lindu National Park is an area with the potential for landslides to occur. One of the methods used to predict landslide hazard is a remote sensing method that is integrated with a Geographic Information System (GIS).

This study aims to examine the geophysical factors of the land, determine the level of vulnerability of areas to landslides and identify the level of vulnerability to landslides in 86 buffer villages of Lore Lindu National Park.

Literature Review

Landslide is an event of shifting of rock, soil or other mixed materials caused by geological, morphological, physical and human activities factors resulting in slope movement/collapse. Mountainous areas, hills, riverbanks, or piles are places where landslides often occur (Muntohar, 2010).

Information related to the prevention of landslides is important to do so that the surrounding community minimizes material losses that occur as a result of landslides and the community is able to implement disaster mitigation (Sari et al., 2020).

Landslide hazard mapping using a geographic information system (GIS) is very important because it helps reduce disaster risks and protects communities from their impacts. In landslide hazard mapping, scoring and weighting methods and overlay analysis help determine the level of landslide vulnerability. (Erfani, et al., 2023).

Mitigation and early warning systems are very important in reducing the impact of disasters caused by landslides. Mapping landslide-prone areas using a Geographic Information System (GIS) can also be an effective solution in identifying areas prone to landslides. By using GIS, spatial information such as soil type, topography, rainfall, and vegetation can be collected, analyzed and presented in the form of a map, in order to provide a clear picture of the characteristics and factors that can cause disasters caused by landslides. This information can be used as a basis for planning and taking appropriate mitigation actions to reduce the risk of landslides. (Hamida & Widyasamratri, 2019).

Making a landslide disaster risk map can be done in several steps, namely vulnerability modeling, hazard maps, capacity modeling, and risk modeling. Threat modeling can be done using overlays (Faizana, Nugraha, & Yuwono, 2015). Geographic Information Systems can be used to map landslide areas (Rahmad, Suib, & Nurman, 2018), several methods can be used in a Geographic Information System (GIS), one of which is the weighting method. This method is a spatial analysis that includes several maps related to factors that influence vulnerability (Akbar et al., 2020).

slope shape, land cover/land use, excessive rainfall, earthquakes, and human activities as the main factors causing landslides in an area. (Asmare, 2022). Natural factors of landslides can also be caused by human activities that affect the landscape, such as agricultural activities, slope loading and mining (Rakuasa et al., 2022).

To find out the distribution of landslide-prone areas as a mitigation and preparedness effort for landslides, modeling of the potential for landslide-prone areas is carried out using spatial analysis of Geographic Information Systems (GIS) on landslide trigger factors which have been weighted with the Analytical Hierarchy Process (AHP). (Aditama, & Fatimah, 2020).

Research Method

The research locations are in the Lore Lindu National Park Area and 86 Buffer Villages as presented in Figure 1.

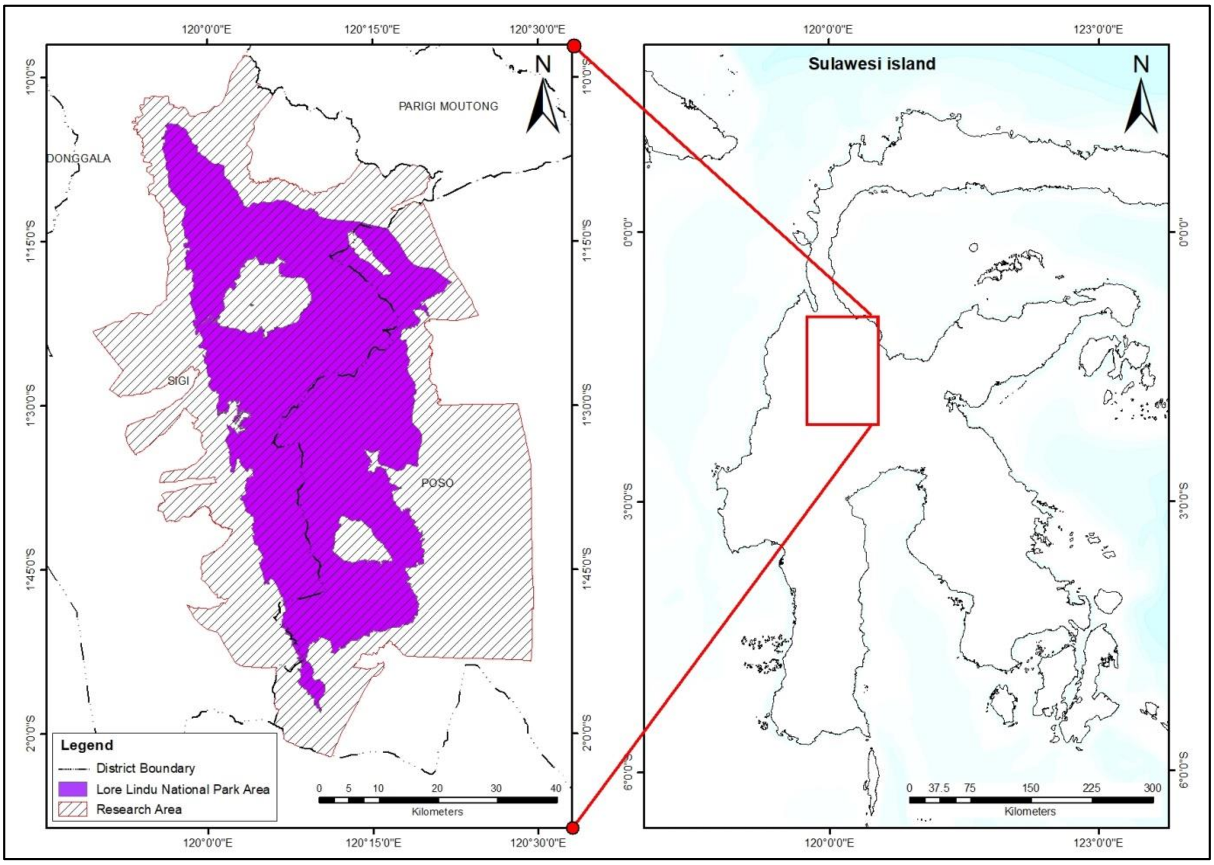


Figure 1. Location Map of Buffer Village Lore Lindu National Park

The method used in processing this research data is overlay by giving scoring and weighting on landslide-prone parameters. Assessment and determination of scoring and weight with the method of expertise judgment, namely the opinion of experts. Parameters used include slope, rainfall, land use, elevation, soil type, lithology, and fault (Table 1).

Determination of scoring qualitatively is guided by several research results on landslide susceptibility through the classification of the parameters that cause landslides. The landslide susceptibility value was obtained from the total score and weight of the 7 (seven) parameters used in this study, namely slope, rainfall, land use, elevation, soil type, lithology, and fault. Determination of the level of landslide vulnerability is carried out using the multiplication of the arithmetic parameter model (Rahayu et al., 2019) with the formula:

Score = (15% x R) + (20% x S) + (10% x E) + (10% x St) + (20% x Lu) + (10 x L) + (15 x F)

Information:

R = Rainfall

S = Slope

E = Elevation

St = Soil type

Lu = Land use

L = Lithology

F = Fault

Calculation of accuracy is done by comparing the data from the analysis results with the results of field checks. The accuracy test aims to see analysis errors so that the percentage of accuracy (accuracy) can be determined. Commission error is a misclassification in the form of an excess number of pixels in one class due to the inclusion of pixels from another class. The level of mapping accuracy is determined by using a classification accuracy test referring to Hanifa & Suwardi (2023) with the formula:

MA = (Xcr pixel)/(Xcr pixel + Xo pixel + Xco pixel)*100%

Information:
MA = mapping accuracy
Xcr = corrected number of class X
Xo = number of class X who entered another class
Xco = number of additional X classes from other classes

Abellera explained that an accuracy result of 85% was considered very satisfactory. While Susanto explained the criteria for accuracy in ranking as follows 80% (very good) and 60-70% (good) (Akhbar, et al. 2013).

Table 1. Scoring and quality of parameter level of Landslide Susceptibility

Parameter	***Class***	***Score***	***Quality***
Land Use	Mining	9	20
	Rice fields	9	
	Open land	9	
	Shrubs	7	
	Savannah/grassland	7	
	Dryland farming	7	
	Mixed dryland agriculture	7	
	Swamp bush	7	
	Swamp	5	
	Settlement	5	
	Plantation	5	
	Secondary swamp forest	5	
	Secondary dryland forest	3	
	Primary dryland forest	3	
	Water Body	1	
Slope	> 40%	9	20
	25 - 40%	7	
	15 – 25%	5	
	8 - 15%	3	
	0 - 8%	1	
Soil Type	Vertisol, oxisol	9	10
	Alfisol, Ultisol, Molisol	7	
	Inceptisol	5	
	Entisol, Histosol	3	
	Spodosol, Andisol	1	
Elevation	>2000 masl	9	10
	1500 – 2000 masl	7	
	1000 – 1500 masl	5	

Parameter	***Class***	***Score***	***Quality***
	500 – 1000 masl	3	
	0 – 500 masl	1	
Rainfall	>3000 mm/year	9	15
	2500 – 3000 mm/year	7	
	2000 – 2500 mm/year	5	
	1500 – 2000 mm/year	3	
	<1500 mm/year	1	
Lithology	Metamorph	9	10
	Frozen/igneous	7	
	Volcanic	5	
	Sediment	3	
	Alluvial	1	
Distance from Fault	0 – 1 km	9	15
	1 – 2 km	7	
	2 – 3 km	5	
	3 – 4 km	3	
	>5 km	1	

Source: Hanifa & Suwardi (2023); Suni, et al., (2023); Sholikhan, (2019); Nugroho, et al., (2010); Eraku et al., (2019); Krisnandi, et al., (2021) and modification.

Result and Discussion

a. Landslide susceptibility parameters

Mapping the vulnerability and risk of landslide in the TNLL buffer villages is obtained through the scoring and weighting results of 7 (seven) landslide parameters. Scoring is based on the class's influence on events. The greater the influence on the event, the higher the value. Scoring is intended as giving a value to each class in each parameter (Nurlina, et al., 2014).

1) Land Use Parameters

The Land Use Map was obtained from the analysis of Sentinel-2A Imagery for 2022. Based on the classification results, 15 land use classes were obtained, namely, primary dryland forest, secondary dryland forest, secondary swamp forest, dryland agriculture, mixed dryland agriculture, plantations, paddy fields , shrubs, swamp scrub, swamps, Settlement, open land, mining, savannah/grassland and water body (Figure 2).

Land use will have a major effect on the height of ground motion. Heterogeneus forest that insensitive to errotion, homogeneus forest that less sensitive to errotion, farm that rather sensitive to errotion, occupation and rice fields that sensitive to errotion, then moor and open land that very sensitive to errotion. Change in land use can be destroy the precipitation of ground water that can cause the land movement is more sensitive to happen (Eraku et al., 2019).

2) Slope Parameters

Slope Map obtained from DEMNAS data processing. From the results of the analysis obtained 5 classes of slope. Its classified using the percentage of slope. 0-8 % is categorized as flat class, 9-15 % is categorized as Sloping class, 16-25 % is categorized as rather steep, 26-45 % is categorized as steep, and >45 % is categorized as very steep. (Figure 2).

The slope parameter also plays a role in the high potential for ground movement, the steeper the slope, the higher the potential for landslides to occur. Meanwhile, the lower (sloping) the slope, the lower the probability of landslides occurring. Areas with a large slope will cause the downward force acting on the slope to increase, so that the slope has a major role in the occurrence of landslides, as in the study area with a slope of > 45% which is included in the very steep category (Krisnandi, et al., 2021).

3) Rainfall Parameters

The rainfall map is obtained from the processing of rainfall data for the last five years using the IDW interpolation method. According to Erfani, et al., (2023) Absorbed rainwater saturates the soil and can weaken slope-forming materials and trigger landslides. Heavy rainfall and its intensity increase the risk of landslides.

From the analysis of rainfall data, it is divided into 5 classes, <1500 mm/year, 1500-2000 mm/year, 2000-2500 mm/year, 2500-3000 mm/year and > 3000 mm/year (Figure 2). Rainfall is one of the determining factors for the potential level of landslide hazard in the study area. The higher the rainfall value, the possibility that the area is an area that has the highest potential for landslides (Krisnandi, et al., 2021).

4) Soil Type Parameters

Knowledge of this type of soil is very important in determining the possibility of landslides caused by different soil types. This is because they have different physical and chemical properties, such as water absorption, slope stability, and mineral content. Soil Texture Maps are obtained by processing soil type data which is then classified based on the National Soil Classification with the 2014 Soil Taxonomy (Subardja et al., 2014). From the results of the classification, there are 3 types of soil namely, ultisols, entisols, and inceptisols (Figure 2).

5) Elevation Parameters

The land elevation/height map is obtained from DEMNAS data processing. From the results of the analysis obtained 5 altitude classes in in meters above sea level, <500 masl, 1000-1500 masl, 1500-2000 masl, 2000-2500 masl, 2500-3000 masl, and > 3000 masl (Figure 2). The elevation parameter results in a greater gravitational force affecting the material on the slope. Elevation also plays a role in the high potential for landslides, the higher an area, the greater the chance of landslides.

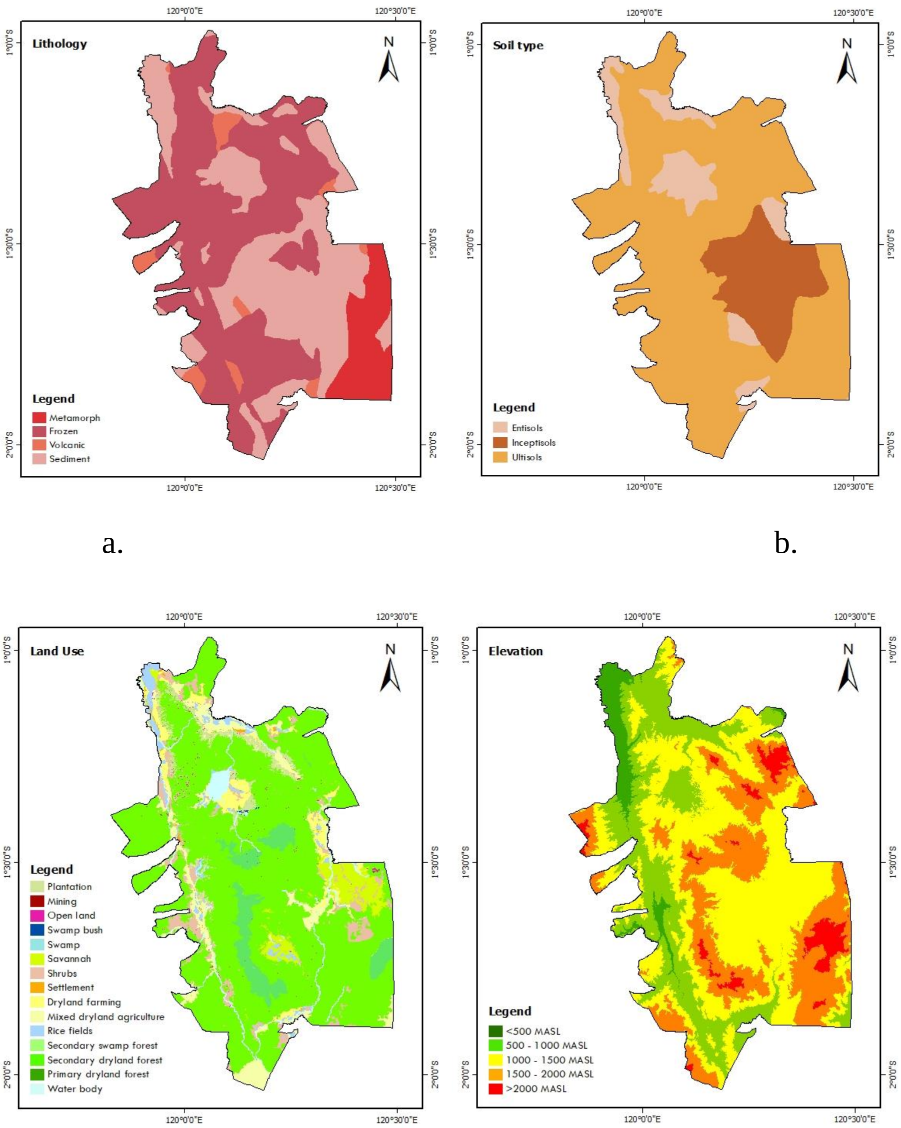
6) Lithology Parameters

Knowledge of these rock types is very important in determining the likelihood of landslides caused by rock types with different physical and chemical properties. In terms of lithology, the study site is divided into 4 main rock classes, metamorphic, igneous, volcanic, and sedimentary. Most of its area consists of igneous and sedimentary rocks. Complete rock types can be seen in (Figure 2).

7) Fault Parameters

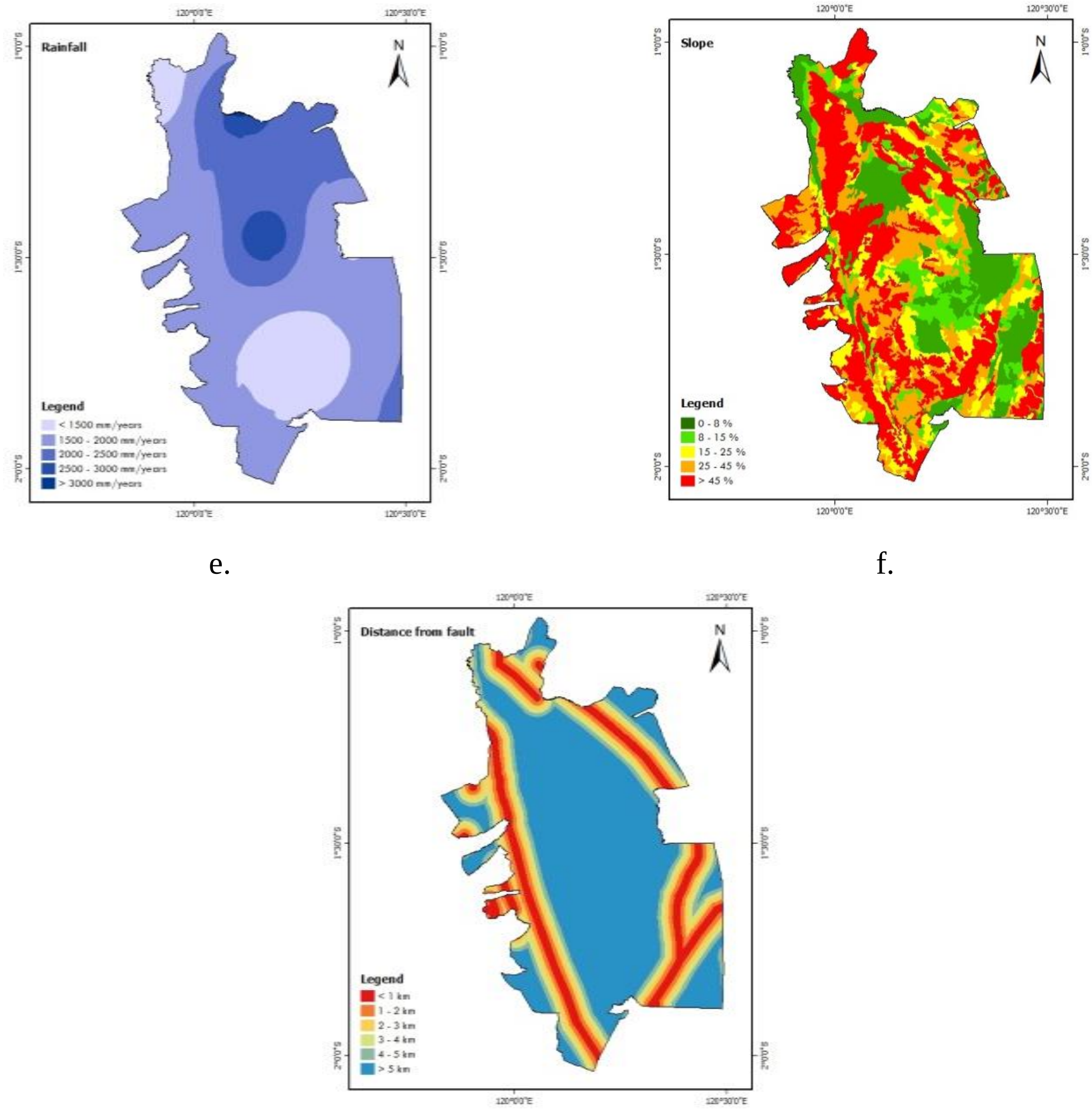
A fault is a field of fracture that has undergone a shift that can be observed with the naked eye. Areas close to the existence of structures are areas that are prone to landslides. From the results of data analysis at the study site, there are several active faults including the Palu-Koro fault, Palolo fault, Napu fault, and Maleei fault (Figure 2).

This vulnerability to landslides is caused by the presence of joints or cracks caused by forces that trigger fractures. The existence of weak areas in these rocks will reduce the strength of the rock mass which can act as a channel for water entry which results in tensile cracks in the rock so that the safety factor of the slope decreases. The farther from the structure has more resistance to the possibility of landslides. (Sustriani, 2012)



a. b.

c. d.



e. f.

g.

Figure 2. Landslide Susceptibility Parameter (a. lithology, b. soil type, c. land use, d. elevation, e. rainfall, f. slope, g. distance from fault

b. Landslide susceptibility level

The landslide susceptibility value was obtained from the total score of the seven parameters used in this study, namely rainfall, slope, elevation, soil type, land use, lithology, and distance from the fault. Classification for classifying landslide hazard classes or class intervals for landslide susceptibility levels is calculated using interval classes obtained based on calculations using the following formula (Reppi, et al., 2021):

$I = R/K$

Information:

I = class intervals
R = range / range of highest values and lowest values
K = number of class intervals

Based on the results of the calculation of the vulnerability value, it can be determined the class of landslide hazard in the study area by dividing the landslide vulnerability into four classes, namely not prone, moderately vulnerable, vulnerable, and very vulnerable. The classification of landslide hazard classes is presented in (Table 2).

Tabel 2. The results of digitizing landslide susceptibility

The Level of Landslide Susceptibility	value	Area (Ha)	Percent
Low	180 – 366	85.679,74	18,01
Moderate	367 – 553	363.184,89	76,34
High	554 – 740	26.888,46	5,65
Total		**475.753,08**	**100**

The results of the analysis carried out show that areas that are prone to landslides are areas that have a value of 554 – 740, the medium class has a value of 367 – 553 and the low class has a value of 180 – 366 from the sum of the parameter scores. Based on the results of tracing the points of landslides occurring in several buffer villages, landslides were caused by land use conditions which were dominated by shrubs and open land besides that, there were active faults. Topographically, the landslide points are areas with steep to very steep slopes and with high rainfall. Aditama, T., & Fatimah, F. (2020) stated that the high vulnerability to landslides is caused by moderate to very steep slopes (25-49%) which results in greater gravitational forces acting on the material on the slopes. The landslide vulnerability map can be seen in Figure 3.

c. Accuracy test and validation

Based on Table 3, it is known that the largest commission error is found in digitized areas with a high level of vulnerability, 17%, and the smallest commission error is found in digitized areas with a moderate level of vulnerability, 12%. Meanwhile, the largest commission error is at a moderate vulnerability level of 16,19% and the smallest commission error is at a low vulnerability level of 11,46%. The highest mapping accuracy was found in digitizing areas with a moderate level of vulnerability, 88%, while the lowest mapping accuracy was found in digitizing areas with a high level of vulnerability, 83%. Overall the accuracy of landslide hazard mapping is 85,33%.

Tabel 3. The results of the Accuracy Test of landslide susceptibility maps

Classification Results	Field Data			Columns Total	Commission Error (%)		Map Accuracy	Overall Accuracy
	A	B	C		Field Data	Classification		
A	85	8	7	100	15	11,46	85	
B	3	88	9	100	12	16,19	88	85,33
C	8	9	83	100	17	16,16	83	
Rows Total	96	105	99	300				

Information:
A = low, B = moderate, C = high

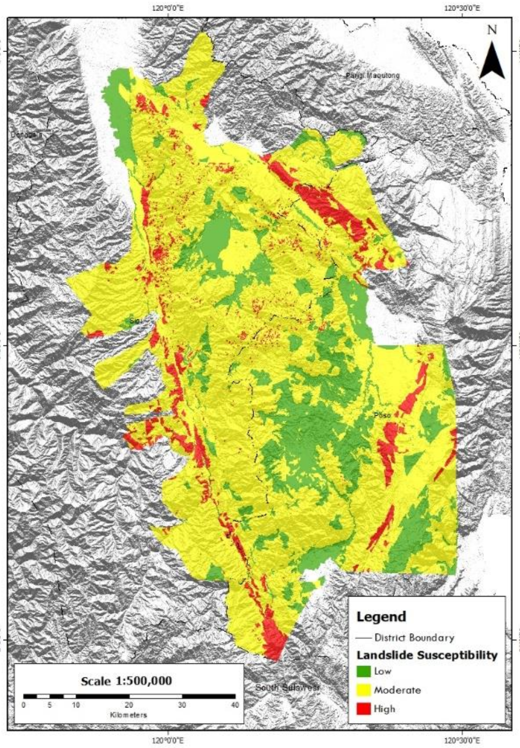


Figure 3. Landslide susceptibility level map

d. Landslide susceptibility area

Low vulnerability class

Areas included in this class have a low level of vulnerability to landslides and are quite safe against the potential or possibility of landslides. In general, failures occur in this zone infrequently if the slope is not disturbed and, if there is a long failure, the slope has stabilized. Minor landslides may occur, especially on river valley banks (grooves). This zone is an area dominated by slopes with a slope of 0% (sloping) to 15% (flat). In this low-class zone, areas on flat to rather steep slopes are formed by metamorphic rocks, with latosol soil types, are more than 5 km from faults or segments, and are mostly vegetated with secondary dryland forest. The areas included in this class are the villages of Baliura, Torire, Wanga, Watutau, and Talabosa

Moderate susceptibility class

Areas included in this class are areas that have a moderate level of landslide vulnerability. In this zone, small and large dimensions of landslides can occur, especially in areas bordering river valleys, hydrological transition areas, or road cliffs. Old landslides may be reactivated mainly due to prolonged high rainfall intensity. In general, it is a rather steep zone with a slope of 15-25% to a steep slope of 15-40%, podzolic soil type, within 3 to 5 km of faults or segments and mostly vegetated with shrubs and savannah. The areas included in this class are parts of the villages of Banasu, Bomba, Langko, Moa, Sedoa, Salua, Tomado, and Watutau.

High susceptibility class

Areas that have a high level of landslide vulnerability are included in this class. In this zone small and large-scale landslides often occur, mainly caused by high rainfall intensity and fault activity. It is a steep zone with a steep slope of 25-40% to very steep or more than 40%, depending on the condition of the physical properties of the soil and rock forming the slope. Vegetation conditions are generally lacking or in the form of open land, shrubs, and dry land agriculture mixed with shrubs and within 0 to 2 km from faults and segments. The areas included in this class are the villages of Lempelero, Runde, Sedoa, Tuare, and Tongoa.

This is in line with research results According to Triwahyuni, et al., (2017), slope is one of the factors that influence the occurrence of landslides in an area. The high vulnerability of landslides in this area is caused by the moderate to very steep slope (25-49%) which results in a greater gravitational force acting on the material on the slope. In general, this area is in the form of shrubs and dry fields Aditama, T., & Fatimah, F. (2020).

Hanifa & Suwardi (2023) in their research stated that the high level of landslide vulnerability is influenced by high rainfall intensity in the long term and strong lateral erosion and very steep slopes.

Conclusion

The results showed that the level of vulnerability to landslides was divided into 3 classes, namely a low area of 85.679,74 ha (18,01%), a medium area of 363.184,89 ha (6,34%), and a high area of 26.888,46 ha (5,65%). Villages that do not have a high level of vulnerability to landslides are the villages of Wuasa, Siliwanga, Sidondo IV, Rahmat, Olu, Maranata, Lengkeka, Kamarora B, Kageroa, and Hanggira. Meanwhile, villages that have a high level of vulnerability are Lempelero, Runde, Sedoa, Tuare, and Tongoa. Based on the factors that cause landslides, the high level of vulnerability is influenced by relatively high rainfall intensity, land class (dry land agriculture mixed with shrubs, shrubs, open land), distance from the fault (< 2km), slope (steep to very steep) and soil types (ultisols).

The research results are expected to assist the government in future landslide disaster mitigation efforts and disaster mitigation-based spatial planning efforts. For the manager as a reference in making policies for the development of regional spatial arrangements and patterns. Other erosion susceptibility analysis methods should be compared with this research for further improvement.

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Declaration of conflicting interest

The authors declare that there is no conflict of interest in this work.

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Appendix

Table Comparison of landslide susceptibility classes and village area

No	Village	landslide susceptibility class (Ha)			Total Area (Ha)
		Low	Moderate	High	
1	Anca	1.908,94	6.763,82	9,73	8.682,49
2	Baku-Bakulu	121,16	2.786,76	261,75	3.169,67
3	Baliura	3.677,78	2.574,10	2,16	6.254,05
4	Banasu	722,08	10.362,04	54,96	11.139,09
5	Bariri	4.667,71	11.361,75	778,47	16.807,93
6	Betue	1.918,97	4.241,29	667,99	6.828,25
7	Bobo	124,05	2.231,77	37,04	2.392,86
8	Bolapapu	1,33	2.003,87	116,55	2.121,74
9	Bomba	7.509,97	20.245,08	1.041,91	28.796,96
10	Bora	652,07	1.225,23	81,63	1.958,94
11	Bulili	214,47	2.988,93	136,34	3.339,74
12	Bunga	113,97	2.250,24	43,91	2.408,12
13	Doda	1.218,95	3.284,19	0,71	4.503,85
14	Dodolo	1.400,92	3.433,74	15,41	4.850,07
15	Gimpu	56,45	3.247,58	46,55	3.350,58
16	Hanggira	2.773,81	3.102,12	-	5.875,93
17	Kadidia	13,44	505,65	0,33	519,42
18	Kaduwaa	919,52	2.315,03	3,88	3.238,43
19	Kageroa	660,38	3.003,32	-	3.663,70
20	Kalawara	464,76	1.536,88	2,11	2.003,74
21	Kamarora A	1,62	982,23	0,72	984,57
22	Kamarora B	21,31	1.097,59	-	1.118,90
23	Kapiroe	22,96	1.894,08	51,63	1.968,67
24	Karunia	32,75	936,58	8,67	978,01
25	Katu	2.793,80	3.869,94	0,01	6.663,75
26	Kolori	1.152,45	5.880,65	0,20	7.033,30
27	Lambara	748,27	481,65	0,48	1.230,40
28	Langko	2.722,12	11.741,12	48,32	14.511,56
29	Lawua	12,43	2.536,58	96,81	2.645,82
30	Lelio	1.309,15	4.044,72	0,53	5.354,40
31	Lemban Tongoa	1.620,52	9.933,94	282,85	11.837,31
32	Lempe	748,13	834,69	0,41	1.583,24
33	Lempelero	13,27	2.971,40	1.517,20	4.501,87
34	Lengkeka	1.926,63	5.683,14	-	7.609,77
35	Lonca	67,28	5.239,75	515,53	5.822,57
36	Makmur	3,02	695,13	8,65	706,80
37	Mapahi	20,09	6.468,19	103,76	6.592,04
38	Maranata	545,34	61,95	-	607,29
39	Marena	183,10	1.223,66	337,39	1.744,15
40	Mataue	0,68	1.651,38	21,45	1.673,51
41	Moa	731,23	10.109,86	401,72	11.242,82
42	Namo	13,04	3.027,64	194,15	3.234,82
43	Olu	100,69	1.722,32	-	1.823,01

44	Omu	48,91	4.110,73	280,39	4.440,03
45	O'O	325	3.160,72	352,41	3.838,13
46	Pakuli	2,42	176,99	53,34	232,75
47	North Pakuli	12,66	2.934,64	191,80	3.139,10
48	Pandere	146,68	3.045,03	21,69	3.213,40
49	Petimbe	0,85	1.370,34	291,98	1.663,18
50	Pili Makujawa	500,47	7.809,67	1.050,05	9.360,18
51	Puro'O	723,91	3.108,20	1,48	3.833,59
52	Rahmat	30,54	533,46	-	564,01
53	Rompo	1.267,03	4.928,40	837,73	7.033,15
54	Runde	1.280,43	6.990,09	2.598,05	10.868,57
55	Salua	22,39	13.140,53	557,40	13.720,32
56	Sedoa	775,57	19.567,23	5.737,80	26.080,60
57	South Sibalaya	309,56	960,52	0,77	1.270,86
58	North Sibalaya	359,73	417,24	0,68	777,65
59	Sibowi	998,68	1.064	36,32	2.099
60	Sidondo I	1.177,24	951,55	119,29	2.248,08
61	Sidondo III	437,15	44,19	0,46	481,80
62	Sidondo IV	607,24	195,45	-	802,70
63	Sigimpu	257,46	4.321,77	88,20	4.667,43
64	Siliwanga	232,29	1.405,15	-	1.637,45
65	Simoro	36,50	2.194,93	200,61	2.432,04
66	Sintuwu	41,97	4.457,12	61,35	4.560,44
67	Sopu	131,51	1.463,02	0,85	1.595,39
68	Sungku	28,14	3.779,14	140,80	3.948,08
69	Talabosa	2.012,57	4.574,62	592,63	7.179,82
70	Tangkulowi	479,51	4.704,74	264	5.448,24
71	Tomado	4.651,46	20.933,99	69,45	25.654,90
72	Tomehipi	96,47	895,30	3,35	995,11
73	Tompi Bugis	3,63	3.067,46	387,48	3.458,57
74	Tomua	0,66	863,69	363,12	1.227,47
75	Tongoa	0,98	4.386,29	1.256,08	5.643,34
76	Torire	8.138,07	6.470,98	1.068,82	15.677,86
77	Toro	1.196,12	7.978,69	496,73	9.671,54
78	Tuare	208,13	8.696,96	1.361,66	10.266,76
79	Tuwa	29,95	3.199,12	104,64	3.333,71
80	Wanga	3.795,71	6.623,35	20,01	10.439,07
81	Wangka	-	1.876	267,86	2.143,86
82	Watukilo	24,24	1.414,97	1,43	1.440,64
83	Watumaeta	956,45	1.411,59	94,26	2.462,30
84	Watutau	4.994,72	19.372,82	788,56	25.156,10
85	Winatu	7,12	629,85	233	869,98
86	Wuasa	2.085,98	1.402,64	-	3.488,62
87	Lindu Lake	3.313,00	0,11	-	3.313,11
Total		**85.679,74**	**363.184,89**	**26.888,46**	**475.753,08**