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Mapping the land movement level of Langsa Baro district using the Geographic Information System (GIS)

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Abstract

Langsa Baro District is an area that often experiences floods and a lot of uneven elevation in the area so that land movement can be possible. This study aims to analyze the parameters that affect soil movement and make a zoning map of the level of vulnerability of land movement using spatial data in Langsa Baro District. Data processing with GIS (Geographic Information System) is intended to obtain soil movement mapping. To help determine the weight score on each parameter, this study used the AHP (Analytic Hierarchy Process) method. Factors that greatly influence the occurrence of soil movement that occurs in Langsa Baro District are soil type and rainfall. The Langsa Baro District area has five levels of vulnerability, namely the level of vulnerability of very low soil movement with a percentage of 0.26% and area of 17.02 Ha, the level of vulnerability of low soil movement with a percentage of 3.58% and an area of 234.02 Ha, the level of vulnerability of medium soil movement with a percentage of 18.42% and an area of 1204.22 Ha, the level of vulnerability of high soil movement with a percentage of 73.74% and an area of 4819.54, the level of vulnerability of soil movement is very high with a percentage of 4.00% and an area of 261.26 Ha.

Introduction

Landslides or geological phenomena commonly called soil movements occur due to the unstable movement of various types of rocks and landscapes, including the fall of rocks or large chunks of soil due to the influence of gravity. Landslides cause direct damage such as damage to public facilities and agricultural land, as well as disruption of community activities (Firmansyah M S Nursuwars et al., 2019).

Soil movement is a process in which a layer of soil or rock undergoes mass movement by moving vertically, horizontally or obliquely relative to its original position under the influence of gravity, load, and water flow (Departemen Pekerjaan Umum Direktorat Jenderal Penataan Ruang, 2007)

Landslides, natural disasters that cause soil shifts from year to year, are increasingly common in Indonesia, especially in the rainy season. These tectonic conditions cause very fragile layers, faults, and volcanic rocks, supported by a humid tropical climate in Indonesia that increases the risk of landslides. This is supported by the intensification of land use change and the increasing occurrence of landslides. Landslides are often caused by a combination of human and natural factors, resulting in damage to people and property. Remediation measures are needed to minimize the impact of landslides (Heru Sri Naryanto et al., 2019)

Events that occur can have a big impact on humans, that's what natural disasters mean. Human impacts can be mental, physical and socioeconomic suffering for individuals, families or groups. There are several factors that contribute to the occurrence of natural disasters, namely internal (natural) factors and external factors (Wihartati, 2014). Therefore, the vulnerability of soil movement can be understood as a trend of soil movement. The movement of the whole soil can cause damage and loss of soil so it is necessary to monitor and identify places that may cause damage (Erik Febriarta & Yunus Aris Wibowo, 2021).

Langsa Baro District is an area that produces groundwater as a source of clean water, most of the people of Langsa City consume this water. Langsa Baro District is an area where floods often occur and there are many uneven elevations in the area so that soil movement can occur. According to Lentera 24, The rampant exploitation of clean water that is excessive and already very unnatural in Gampong Lengkong is suspected to have caused dozens of residents' houses to be damaged to the point of almost collapse. In fact, there are no special regulations for Langsa City regarding the exploitation of clean water, so the community does not have restrictions on the exploitation of clean water(Redaksi, 2018).

Based on the Aceh Disaster Management Agency, it was noted that on October 20, 2022, floods that occurred after heavy rain accompanied by lightning at 18.30 WIB caused several villages in the Langsa City area to be flooded. The flood that inundated 3 sub-districts of Langsa City with water levels ranging from ±80 cm to 1.2 meters. The floods that hit Langsa Baro District were Paya Bujok Seulemak Village, Karang Anyer, Lengkong (Haslinda Juwita, 2022).

Based on this study, by using the Quantum Geographic Information System (Qgis) Software, it is possible to identify soil movement areas with data obtained such as slope data, soil type, land use, and rainfall.

Geographic Information System (GIS) is a software-based system for managing, analyzing, and storing spatial data or geographic coordinates. The Geographic Information System (GIS) application uses Arcview software, one of ESRI's trusted Geographic Information System (GIS) software systems (Wikipedia bahasa Indonesia, n.d.).

The Analytical Hierarchy Process (AHP) is a method that can create the priority of several options based on multiple criteria (multi-standard). In addition to several criteria, AHP also relies on an orderly and logical process. Choosing or setting priorities follows a logical process and structure. This activity is carried out by experts who represent priority choices (Retna E. Wulandari & Semlinda Juszandri Bulan, 2019)

Based on this, the research was carried out with scoring and *overlay* maps, so that with this method it was obtained to find areas of vulnerability to soil movement. The compilation of GIS-based data using this technology will facilitate the implementation of this research using QGIS software and only includes mapping soil movements in Langsa Baro District.

This study aims to analyze the parameters that affect soil movement in Langsa Baro District and make a zoning map of the level of soil movement vulnerability using spatial data in Langsa Baro District

Research Methods

This study utilizes the application of QGIS and Analytical Hierarchy Process (AHP) to determine the score and weight of the overlay on each criterion parameter.

The parameter data used in this study:

1. RBI Map of Langsa Baro District
1. Administrative map or village boundaries of Langsa Baro District
2. DEMNAS map
3. Map of land types of Langsa Baro District
4. Land use map of Langsa Baro District in 2019
5. Rainfall data from 2010 to 2019

Research Location

This research will take place in Langsa Baro District consisting of 12 gampongs, namely: Alue Dua Bakaran Batee, Alue Dua, Gedubang Aceh, Birem Puntong, Geudubang Jawa, Lengkong, Karang Anyar, Paya Bujuk Tunong, Paya Bujuk Seuleumak, Pondok Kelapa, Sukajadi Makmur, and Timbang Langsa (Figure 1).

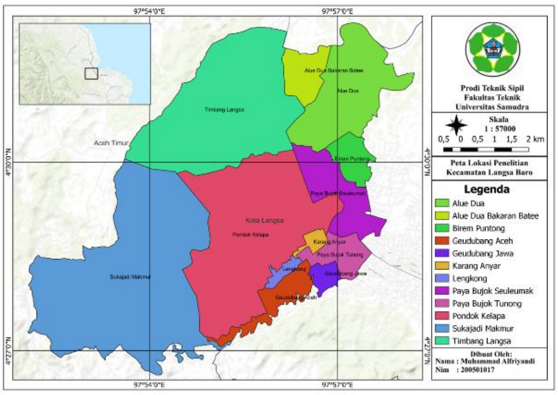

Figure 1. Map of the research location

Research Stages

The research was carried out in stages, including problem identification, data collection, and data analysis. In the initial stage, problems will be identified to find the desired solution to the soil movement in the Langsa Baro area. The second stage is data collection, this stage consists of primary and secondary data. Primary data consists of questionnaire data and secondary data such as demnas, rainfall data, land use maps, and soil type maps. The third stage is the analysis of the collected data that will produce a score of weights and processing of the map. These maps are parameters in the analysis of the Analytical Hierarchy Process (AHP) method for zoning soil movement vulnerability in Langsa Baro District. If one parameter is as important as the other, each parameter is worth 1 (Table 1). Once the weighting process is complete, the next step is to create a paired comparison matrix that normalizes the weighting of the importance level of each criterion parameter. After the paired comparison matrix is designed, the Consistency Index (CI) test uses Equation 1 and to calculate the CR value using a comparison of the Random Consistency Index (RI) with the Consistency Ratio (CR) using Equation 2. The RI value is shown in table 2.

Table 1. Paired Comparison Scale (BNPB, 2012).

Scala	Elements being compared
1	Equally important
3	Moderately more important
5	Strongly more important
7	Very strongly more important
9	Extremely more important
2, 4, 6, 8	Intermediate values

$$CI = \frac{\lambda maks - n}{n - 1} \quad (1)$$

$$CR = \frac{CI}{RI} \quad (2)$$

Table 2. Random Consistency Indeks (RI)(Saaty, 1987)

n	1	2	3	4	5	6	7
RI	0	0	0,58	0,90	1,12	1,24	1,32

Results and Discussion

Analysis of soil movement parameters based on criteria

These parameters have an influence on the occurrence of soil movement. The soil movement parameters based on criteria can be seen in table 3.

Table 3. Soil Movement Parameters

Criteria	Abbreviation
Slope	SL
Soil Type	ST
Land Use	LU
Rainfall	RF

Calculation of the answer alignment or geometric mean of the questionnaire results from the respondents based on the criteria of soil movement parameters.

Table 3. Results of Equalization of Respondents' Answers Based on Criteria

	Results of Equalization Answers Based on Criteria			
Criteria	SL	ST	LU	RF
SL	1,00	0,59	0,79	0,44
ST	1,68	1,00	2,00	0,96
LU	1,27	0,50	1,00	1,47
RF	2,28	1,04	0,68	1,00

Sum	6,23	3,14	4,47	3,87

A calculation that divides the value in each cell by the number in that column and calculates the average value for each row. The example of calculating the slope criteria to the number of results of the slope criteria column is as follows :

Table 4. Vector Eigenvalues Based on Criteria

Vector Eigenvalues Based on Criteria					
Criteria	SL	ST	LU	RF	Average
SL	0, 16	0, 19	0, 18	0, 11	0, 16
ST	0, 27	0, 32	0, 45	0, 25	0, 32
LU	0, 20	0, 16	0, 22	0, 38	0, 24
RF	0, 37	0, 33	0, 15	0, 26	0, 28
				Eigen	1, 00

The matrix calculation is obtained from the value of the respondent's answer alignment (table 4) multiplied by the average eigenvalue per criterion (table 5) and then the results of the multiplication are summed. Determine the average result of parameter consistency with each number of matrices divided by the average eigenvalue per criterion (table 5). Average results of parameter consistency (table 6)

Table 5. Average Results of Parameter Consistency

Criteria	Rasio Consistency	Result
SL	0,66 : 0,16	4,14
ST	1,34 : 0,32	4,17
LU	1,01 : 0,24	4,19
RF	1,14 : 0,28	4,12
Sum		16,62
Average Consistency		4,16

Calculate the Consistency Index (CI) value of how consistent the value is. The consistency index of each randomly paired comparison matrix. Using equation 1 with the details of the calculation as follows.

$$CI = \frac{\lambda\text{maks} - \text{n}}{n - 1}$$

$$CI = \frac{4{,}16 - 4}{4 - 1} = 0{,}05$$

The calculation of the Consistency Ratio (CR) value using the Random Consistency Index (RI) value can be seen in table 2 in this study which is used are 4 parameters and can be determined RI of 0.90 with equation 2 of the calculation details as follows:

$$CR = \frac{CI}{RI}$$

$$CR = \frac{0{,}05}{0{,}90}$$

$CR = 0{,}058 < 0{,}1$ (Konsisten)

The CR ratio value is designed following the following characteristics:
1. If the CR< 0.10 means that it has shown a fairly rational level of consistency.
2. If the CR> 0.10, it means that it has shown an inconsistent level of consistency.

The calculation of the concentration ratio in this study shows that the comparison process of pairs is quite rational/consistent using the concentration ratio (CR) value with a number of 0.058 smaller than the standard of 0.10. Therefore, the weight values for the four parameters were used to determine the level of vulnerability of soil movement in Langsa Baro District.

The comparison of the parameter scale was given to several experts in their fields totaling 13 people (such as academics, geotechnical expert practitioners, geotechnical laboratory experts) in Langsa City and will be filled in based on the Pairwise Comparison Assessment Scale to become a reference value for determining the zoning of areas with potential for land movement.

The results obtained were then analyzed in determining the value of the level of vulnerability of soil movement in Langsa Baro District which will be explained in the analysis such as overlay, scoring, vulnerability level, weighting and validation. The analysis will produce a map of the level of soil movement vulnerability in Langsa Baro District. The results of the criteria weights show the criteria that have a great influence on soil movement in Langsa Baro District in table 7.

Table 7. Criterion weight results

Criteria	Weight
Slope	0,16
Soil Type	0,32
Land Use	0,24
Rainfall	0,28

Slope

The slope is the difference between the percentage of vertical distance (land height) and the comparison of horizontal distance (length of flat plane).

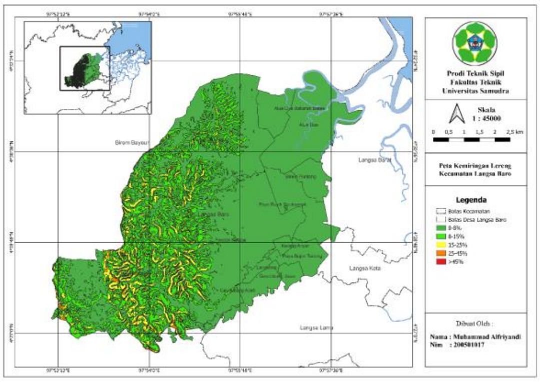

Figure 2. Slope Map

From the slope map in Langsa Baro District, the area is obtained (table 8).

Table 8. Slope of Langsa Baro District

Class	Information	Slope	Area (Ha)	Percentage (%)
1	Flat	< 8	4620,63	70,69
2	Sloping	8-15	1485,33	22,73
3	A Rather Steep	15-25	418,64	6,40
4	Steep	25-45	11,46	0,18
5	Very Steep	> 45	-	-
	Sum		6536,06	100

The area of flat land (0-8%) dominates Langsa Baro District with an area of 4620.63 Ha and has a percentage of 70.69% for the slope slope (8-15%) has an area of 1485.33 Ha with a percentage of 22.73%, for the slope with a rather steep slope (15-25%) has an area of 418.64 Ha and a percentage of 6.40%, while for the area of the very slope for the steep category (25-45%) is 11.46 Ha with a percentage of 0.18%. From the results obtained, it is explained that most of the areas in Langsa Baro District are flat so that the vulnerability of soil movement is very few gampongs which affects the slope of the slope that occurs in Langsa Baro District.

Soil Type

Soil types have a condition of sensitivity to soil so that it causes differences in erosion sensitivity to soil. The soil type in Langsa Baro District consists of two types of soil, namely alluvial and podsolic. From the soil type map, it can be seen that the most dominant area is found in podsolic soil types. The part where there is alluvial soil has a level of sensitivity to erosion that is not sensitive, while the part where there is a type of podsolic soil has a level of sensitivity to erosion.

The classification of soil types is based on the main characteristics of the horizontal composition, the formation process (genesis), and other characteristics. At the level of soil type there are soil properties or other characteristic formations. The nomenclature at the soil type level basically uses the old land type names with some new additions. In contrast, at the soil type level all names/terms derived from the FAO/UNESCO soil type and or the USDA soil classification system are used. Soil classification is based on the key to determining soil types and species (Djadja Subardja S. et al., 2014).

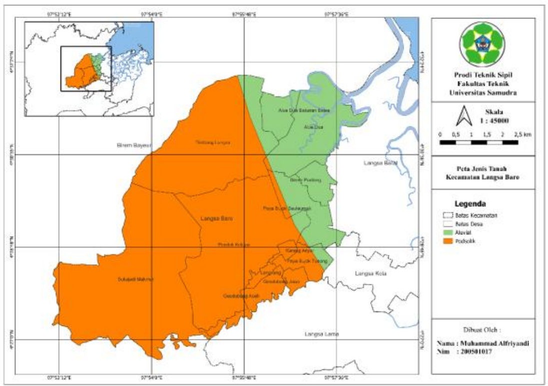

Figure 3. Soil Type Map

Based on the Regulation of the Minister of Public Works No.41/PRT/M/2007, the classification of soil types has an erosion level called sensitivity to erosion, which means whether the soil is easily eroded or not (Ditjen Penataan Ruang, 2007).

From the soil type map in Langsa Baro District, the area for each soil movement vulnerability value in the form of alluvial and podsolic soil type categories can be seen in table 9.

Table 9. Land Type Langsa Baro District

Class	Information	Sensitive to Erosion	Area (Ha)	Percentage (%)
1	Aluvial, Soil, Glei, Planossol, Grey Hydromorph, Groundwater Literite	Insensitive	1455,26	22,27
2	Latosol	A Little Sensitive	-	-
3	Brown Forest Soil, Non Calcic	Somewhat Sensitive	-	-
4	Andosol, Laterictic Gromusol	Sensitive	5080,80	77,73
5	Podsolik	Highly Sensitive	-	-
	Sum		6536,06	100

The types of soil in Langsa Baro District are alluvial and podsolic soil types, having their respective areas. The alluvial soil type has an area of 1455.26 Ha with a percentage of 22.27% and the podsolic soil type has an area of 5080.80 Ha with a percentage of 77.73%. In podsolic soil types, there is a level of sensitivity that is sensitive to the vulnerability of soil movement in Langsa Baro District.

Land Use

Land Use in Langsa Baro District has five classifications, in addition to that there are land covers in the form of ponds, agriculture/plantations, bushes, settlements, open land, and mangrove forests.

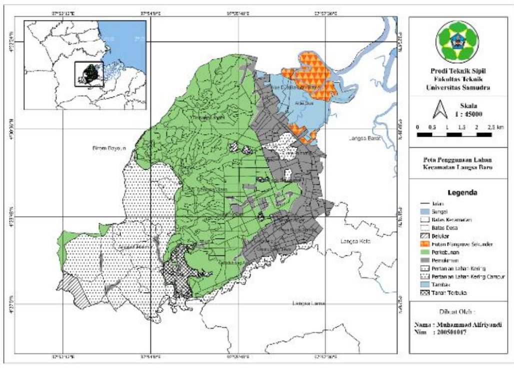

Figure 4. Land Use Map

Based on the Regulation of the Minister of Public Works No.41/PRT/M/2007, the classification of land use has an erosion level called sensitivity to erosion, which means whether or not the soil is eroded easily or not (Ditjen Penataan Ruang, 2007).

From the land use map in Langsa Baro District, the area for each value of soil movement vulnerability was obtained (table 10).

Table 10. Land Use of Langsa Baro District

Class	Land Use	Erosion Rate	Area (Ha)	Percentage(%)
1	Forests are not the same	Insensitive	-	-
2	Similar forests	A Little Sensitive	234,02	3,59
3	Plantations, Agriculture	Somewhat Sensitive	4903,82	75,22
4	Settlements, rice fields	Sensitive	1121,87	17,21
5	Moor, Open Ground	Highly Sensitive	259,32	3,98
	Sum		6519,03	100

Land use in Langsa Baro District in the form of similar forests in the form of mangrove forests with an area of 234.02 Ha with a percentage of 3.59%, then land use in the form of agriculture and plantations has an area of 4903.82 Ha with a percentage of

75.22%, while land use in the form of settlements has an area of 1121.87 Ha with a percentage of 17.21%, land use in the form of open land has a very sensitive erosion rate with an area of 259.32 Ha and a percentage of 3.98%. The area of land use in Langsa Baro includes rivers and others whose total area is not the same as others with an area of 17.03 Ha. Land use can affect the vulnerability of land movement in Langsa Baro District.

Rainfall

Rainfall is the amount of rainwater that falls on an area at a certain time. In Langsa Baro District, the level of rainfall that occurred in the last 10 years from 2010 - 2019 uses rainfall data from Langsa City which is still classified as rainfall with medium intensity of 139.21 mm/month.

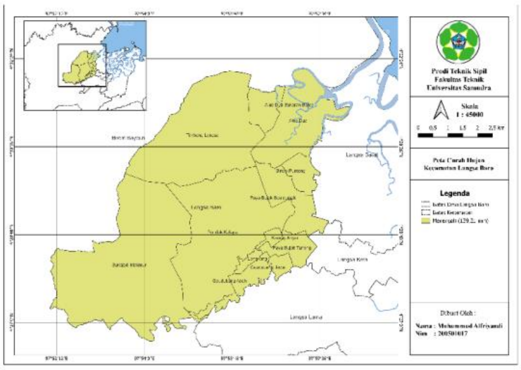

Figure 5. Rainfall Map

From the rainfall map in Langsa Baro District, the area for each soil movement vulnerability value with the rainfall category (table 11) was obtained.

Table 11. Rainfall in Langsa Baro District

Class Rain fall Inten sity	Rainfall Range (mm/rai ny month)	Informati on	Area (Ha)	Percen tage (%)
1	0 - 100	Low	-	
2	100 – 300	Intermedi ate	6536,0 6	100
3	300 – 500	Tall	-	
4	>500	Very High	-	
	Sum		6536,0 6	100

The condition of rainfall in the Langsa Baro District area shows that rainfall within 10 years has rainfall of 100 – 300 mm, which is 139.21 mm/month which occurs in the entire Langsa City area, including Langsa Baro District with an area of 6536.06 Ha with a percentage of 100%. With the results obtained, it can be said that for Langsa Baro District, it is classified as medium and the determination of the weight value on the vulnerability of soil movement.

Scoring and Vulnerability Values of Land Movement

The preparation of the level of soil movement vulnerability in Langsa Baro District resulted in five levels of areas, namely very low, low, medium, high, and very high areas with soil movement vulnerability. The classification of soil movement vulnerability classes from the calculation of scoring values on each parameter and variable is used to determine the soil movement vulnerability class.

The results of the analysis were carried out using the AHP method, weighting was carried out by determining the scale of importance. Calculate the paired comparison matrix and determine the value of the paired comparison matrix weights.

The value produced from the calculation with the AHP method is then used in calculating the level of soil movement vulnerability. The result of the multiplication of each variable by the weight of the parameter that determines the probability of soil movement (Muzani, 2021).

As for the zoning from the results of the overlay analysis, the classification of the level of soil movement vulnerability is obtained by summing the scores of each and dividing by four parameters so that five levels of soil movement vulnerability are obtained and the level of soil movement vulnerability can be classified, namely:

Table 12. Weight of Soil Movement Vulnerability

Sangat Rendah	Rendah	Sedang	Tinggi	Sangat Tinggi
<0, 20	0, 20 - 0, 40	0, 40 - 0, 60	0, 60 - 0, 80	>0, 80

Weighted overlay analysis is a spatial analysis that overlays several maps related to causes that affect risk assessment. Some of the functions of this weighted overlay are to solve multi-criteria problems such as determining the optimal location and modeling accordingly (Feryanika Ukhti et al., 2021). Weighted overlay analysis can combine different types of inputs as grid maps with weights from the Analytical Hierarchy Process (AHP) method (Awalin Khusnawati & Kusuma, 2020).

Map of the Vulnerability of Land Movement

The scoring analysis and determination of the soil movement vulnerability value are divided into five classes of soil movement vulnerability (Figure 5).

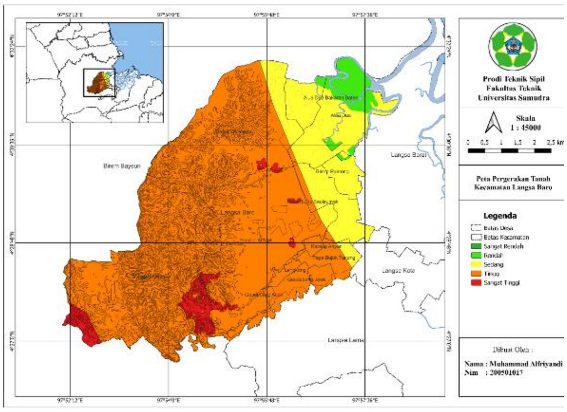

Figure 5. Map of the Vulnerability of Land Movement

From the map of the level of soil movement vulnerability of Langsa Baro District, the area for each value of soil movement vulnerability is obtained, on the map there is no very low value of the level of soil movement in Langsa Baro District because when overlaying using intersection on the land use map there is a void in the river section so that it does not have a value in that part can be assumed to be low level of soil movement. Area of soil movement level (table 13).

Table 13. Vulnerability Level of Land Movement in Langsa Baro District

Vulnerability Level	Area (Ha)	Percentage (%)
Very Low Ground Movement	17,02	0,26
Low Ground Movement	234,02	3,58
Medium Ground Movement	1204,22	18,42
High Ground Movement	4819,54	73,74
Very High Ground Movement	261,26	4,00
Sum	6536,06	100

Conclusion

This research will draw conclusions, this conclusion is based on the results and discussions given:

1. The factors that greatly affect the occurrence of soil movement that occurs in Langsa Baro District are the type of soil that has a weight of 0.32 and rainfall has a weight of 0.28.
2. The Langsa Baro District has five levels of vulnerability, namely a very low level of soil movement vulnerability with a percentage of 0.26% and an area of 17.02 Ha, a low level of soil movement vulnerability with a percentage of 3.58% and an area of 234.02 Ha, a medium level of soil movement vulnerability with a percentage of 18.42% and an area of 1204.22 Ha, a high level of soil movement vulnerability with a percentage of 73.74% and an area of 4819.54, The level of soil movement vulnerability is very high with a percentage of 4.00% and an area of 261.26 Ha.

References

Awalin Khusnawati, N., & Kusuma, A. P. (2020). Sistem Informasi Geografis Pemetaan Potensi Wilayah Peternakan Menggunakan Weighted Overlay. *Jurnal Mnemonic*, *3*(2), 21–29. https://doi.org/10.36040/mnemonic.v3 i2.2788

BNPB. (2012). Perka BNPB No.2 Tahun 2012 Tentang Pedoman Umum Pengkajian Risiko Bencana. In *Badan Nasional Penanggulangan Bencana* (p. 20).

Departemen Pekerjaan Umum Direktorat Jenderal Penataan Ruang. (2007). *Pedoman Penataan Ruang Kawasan Rawan Bencana Longsor (PERMEN PU NO.22/PRT/M/2007)* (Vol. 53, Issue 9, pp. 1689–1699).

Ditjen Penataan Ruang. (2007). *Pedoman Kriteria Teknis Kawasan Budi Daya: Peraturan Menteri Pekerjaan Umum No. 41/PRT/M/2007* (Issue 41, pp. 1–60).

Djadja Subardja S., S. R., Markus Anda, Sukarman, Erna Suryani, & Rudi E. Sabandiono. (2014). *Petunjuk Teknis Klasifikasi Tanah Nasional* (K. N. Hikmatullah, Suparto, Chendy Tafakresnanto, Suratman (ed.); Edisi Pert, Issue 28). Balai Besar Litbang Sumberdaya Lahan Pertanian Badan Penelitian dan Pengembangan Pertanian.

Erik Febriarta, & Yunus Aris Wibowo. (2021). Kerentanan Gerakan Tanah Menggunakan Teknik Geospasial Statistik Di Macang Pacar, Nusa Tenggara Timur. *Jurnal Geografi : Media Informasi Pengembangan Dan Profesi Kegeografian*, *18*(1), 9–20. https://doi.org/10.15294/jg.v18i1.26234

Feryanika Ukhti, Zelica Krismalia Manurung, & M. Dhery Mahendra. (2021). Perbandingan Teknik Boolean Dengan Weighted Overlay Dalam Analisis Potensi Longsor di Banjarmasin. *Jurnal Geosains Dan Remote Sensing*, *2*(1), 25–32. https://doi.org/10.23960/jgrs.2021.v2i1.53

Firmansyah M S Nursuwars, Neng Ika Kurniati, & Muhamad Taufik Hidayat. (2019). Accelerometer sebagai Pendeteksi Dini Pergerakan Tanah. *Jurnal Ilmiah Setrum*, *8*(1), 9–17. https://doi.org/10.36055/setrum.v8i1.4110

Haslinda Juwita. (2022). *Tiga Kecamatan di Kota Langsa Terendam Banjir Seorang Lansia Dievakuasi*. Badan Penanggulangan Bencana Aceh. https://bpba.acehprov.go.id/berita/kategori/bencana/tiga-kecamatan-di-kota-langsa-terendam-banjir-lagi-seorang-lansia-dievakuasi-kerumah-anaknya

Heru Sri Naryanto, Hasmana Soewandita, Deliyanti Ganesha, Firman Prawiradisastra, & Agus Kristijono. (2019). Analisis Penyebab Kejadian dan Evaluasi Bencana Tanah Longsor di Desa Banaran, Kecamatan Pulung, Kabupaten Ponorogo, Provinsi Jawa Timur Tanggal 1 April 2017. *Jurnal Ilmu Lingkungan*, *17*(2), 272. https://doi.org/10.14710/jil.17.2.272-282

Muzani. (2021). Bencana Tanah Longsor Penyebab dan Potensi Longsor. In *CV BUDI UTAMA*.

Redaksi. (2018). *Puluhan Rumah Warga Lengkong Rusak Akibat Eksploitasi Air Bersih*. Lentera24.

Retna E. Wulandari, & Semlinda Juszandri Bulan. (2019). Penerapan Analytical Hierarchy Process (Ahp) Dalam Perangkingan Bengkel Mobil Terbaik Di Kota Kupang. *Jurnal Teknologi Terpadu*, *5*(1), 13–17. https://doi.org/10.54914/jtt.v5i1.189

Saaty. (1987). *The Analytic Hierarchy Process-What It Is and How It Is Used*. *9*(3–5), 161–176.

Wihartati, W. (2014). Dakwah Pada Korban Bencana Alam Dan Bencana Sosial. *Jurnal Ilmu Dakwah*, *34*(1), 277–294.

Wikipedia bahasa Indonesia. (n.d.). *Sistem Informasi Geografis*. Wikipedia Ensiklopedia Bebas. https://qgis.org/id/site/about/index.html