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Analysis of Land Movement Zone Based on Classification of PVMBG Area Using GIS in Ciater Sub-District, Subang Regency, West Java

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Abstract— *The research took place in the Ciater District, Subang Regency, West Jawa, at coordinate 107□39’30”-107□43’30” BT dan 6□42’0”-6□45’30” LS. The purpose of this research is to determine the class and type of soil movement, materials in the research area, and to identify villages where the soil movement occur frequently. The method used in this research is scoring and weighting the soil movement’s parameters, classified the soil movement, and by overlying two or more maps to determine the lanslide vulnerability map with the land cover map and urban planning map. The type of data used are primary data and secondary data. The primary data source are geological conditions, geotechnical aspects, rainfall data, DEM, and satellite image data. Secondary data obtained from Geospatial Informastion data (RBI) and urban planning map (RTRW) data. Based on the research findings, there are four classes of landslide vulnerability: moderate, low, very low, and high. In the research area, there are also 12 landslide points characterized by rotational movement and soil material. Cibitung Village is the most affected by landslides. As for the overlay results, there are 20 zoning areas when overlaying landslide vulnerability modification with urban planning area map (RTRW), and 15 zoning areas when overlaying landslide vulnerability with land cover area.*

Keywords— *Ciater, GIS, Soil movement*

I. Introduction

Soil movement, commonly known as landslides, is the displacement of slope-forming materials such as rocks, fill materials, soil, or mixed materials, moving downhill and outward from the slope [1]. According to Karnawati (2005), soil movement is caused by two factors, identified as controlling factors and triggering factors. The controlling factors are components that can make slopes vulnerable to a movement, including morphological conditions, lithological types, relationships between lithology, geological structures, geohydrology, and land use. While the triggering factors are processes that change the slope from vulnerable to critical, which may caused the landslides. which are rain infiltration, vibration that can be caused by the earthquakes or human activities, and the utilization of land in the slope area [2].

According to SNI 13-6982, 2004 [1], Landslides hazard are soil movement phenomena caused by geological processes, human activities, or both o fit, resulting in human casualties and suffering, property loss, environmental damage, infrastructure damage, and disruption of community life and livelihoods. The National Disaster Management Authority (BNBP) defines that landslide hazard is controlled by several parameters which include morphology, geology, soil, and hydrology.

Landslides are one of the frequent disasters in Indonesia. According to the National Disater Management Authority (BNPB) in the Indonesian Disaster Risk Indeks (IRBI) in 2020, the Subang Regency has a high disaster risk score, especially in the Ciater District. The Ciater district is a new district in Subang known for its tourist areas, so the study for landslides in this area is quite important, duet o security reasons. Therefore, researcher conducted a study in this area to determine the class and type of soil movement, materials in the research area, and to identify villages where the soil movement occur frequently.

II. Methodology

The data analysis was conducted using three methods: scoring and weighting, classification, and overlay. Scoring and weighting were carried out to determine the soil vulnerability value. The map generated from the scoring and weighting processes has its own set of values that will be placed into a certain class. The overlay step is then carried out to determine land cover and which areas are affected by the soil movement zone along with the soil movement class.

The scoring and weighting method is carried out by giving scores and weights to each parameter that affects soil movement. This process then produces a map combined using ArcGIS 10.5 software with the union feature, resulting in a soil movement vulnerability map. The score and weighting are based on the PVMBG classification from 2015[3], modified to adapt to the field conditions, shown by Table 1.

To conduct the research mentioned above, the author used two kinds of data: primary data and secondary data. The data used by the author are as follows:

1. Digital Elevation Model (DEM) from DEMNAS to identified slope. The DEM data was processed with ArcGIS software to create slope gradient and slope aspect maps [4].

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2. Geological conditions are determined from field data obtained through geological mapping. From the field results, data on rock types and their characteristics are gathered to be included in the zoning of rock distribution in that location. Additionally, fault data is collected to observe the structural conditions of the area.
3. Geotechnical aspects are determined from field data, where soil samples are collected and then taken to a geotechnical laboratory to determine the soil texture type based on the USDA 1975 and PVMBG 2015 classifications. Soil depth is also obtained to create zoning according to its class.
4. Daily rainfall data, obtained from Indonesian Agency for Meteorological, Climatological and Geophysics (BMKG) for the years 2012-2021[5]

TABLE 1. The score and weight of parameter that affect soil movement (modified from PVMBG, 2015)

No	Data	Parameters	Classification	Score	Weight
1	DEM	Slope (%)	<15	0	0.3
			15 – 30	1	
			30 – 50	2	
			50 – 70	3	
			>70	4	
		Slope Direction	Flat	0	0.1
			North	1	
			North west	2	
			West	3	
			North east	4	
			South west	5	
			East	6	
			South east	7	
			South	8	
2	Geology	Lithology	Alluvium	1	0.2
			Volcanic rocks 1	2	
			Sedimantary rocks 1	3	
			Sedimentary and volcanic rocks 2	4	
		Distances from structures	>400	1	0.05
			300 – 400	2	
			200 – 300	3	
			100 – 200	4	
			0 – 100	5	
3	Soil	Soil type	Sandy	1	0.1
			Loamy sand	2	
			Loam	9	
		Soil depth (Solum depth)	<30	1	0.05
			30 – 60	2	
			60 – 90	3	
			>90	4	
4	Hydrology	Annual rainfall	<2000	1	0.2
			2000 – 3000	2	
			>3000	3	

III. RESULT AND DISCUSSION

Slope

The slope gradient parameter has a weight of 0.3. This research data was obtained from processed DEM data, resulting in a slope gradient map (Fig. 1). Based on the processed data, three classes are identified in the research area: very low, low, and moderate classes. The detailed clasiification and weight of the slope shown in table 2.

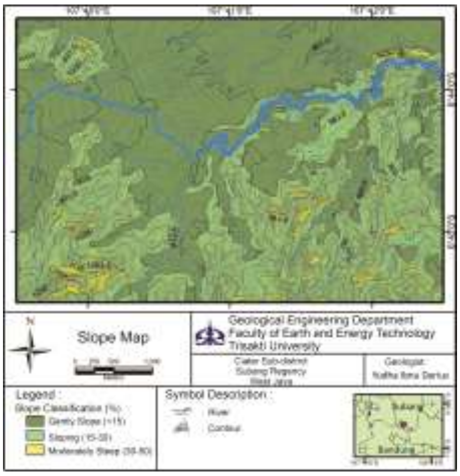

Fig. 1. The slope map in the research area

TABLE 2. Classification and weight of slope parameter

No	Classi-fication	Slope (%)	Score	Weight	Total	Area (km^2)	Area (%)
1	Gently slope	<15	0	0.3	0	10.43	51.11
2	Sloping	15 – 30	1		0.3	9.37	45.92
3	Moderately steep	30 – 50	2		0.6	0.61	2.98
4	Steep	50 – 70	3		0.9	-	-
5	Very steep	>70	4		1.2	-	-
					Total	20.40	100

Slope Direction

The slope direction parameter has a weight of 0.1. This research data was obtained from processed DEM data, resulting in a slope direction map (Fig. 2). Based on the processed data, there are 10 slope aspects identified in the research area: flat, north, northeast, east-northeast, east, southeast, south, southwest, west-southwest, and northwest. The detailed classification and weight of the slope direction shown in table 3.

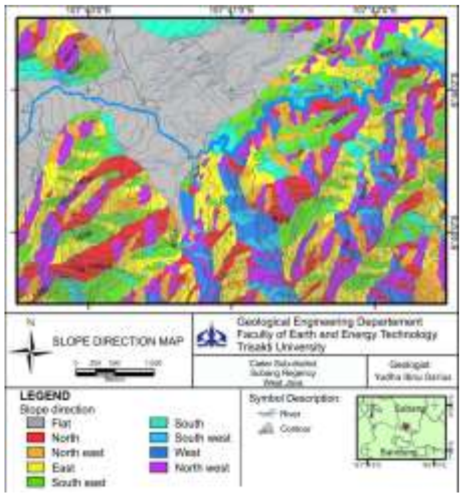

Fig. 2. Slope direction map in the research area

Lithology

The modified lithology parameter has a weight of 0.2. The data obtained comes from geological mapping results depicting rock distributions grouped according to the parameters used, resulting in several classes within the research location: good class, moderate class, and very poor class (Fig. 3). The detailed classification and weight of the lithology shown in table 4.

TABLE 3. Classification and weight of slope directions parameter

No	Classi-fication	Azimuth (°)	Score	Weight	Total	Area (km^2)	Area (%)
1	Flat	-	0		0	4.56	22.35
2	North	337.5–22.5	1		0.1	1.99	9.75
3	North west	22.5–67.5	2		0.2	2.98	14.63
4	West	67.5–112.5	3		0.3	1.15	5.66
5	North east	112.5-157.5	4	0.1	0.4	1.81	8.88
6	South west	157.5–202.5	5		0.5	0.43	2.08
7	East	202.5-247.5	6		0.6	3.31	16.23
8	South east	247.5–292.5	7		0.7	2.84	13.94
9	South	292.5–337.5	8		0.8	1.32	6.47
					Total	20.40	100

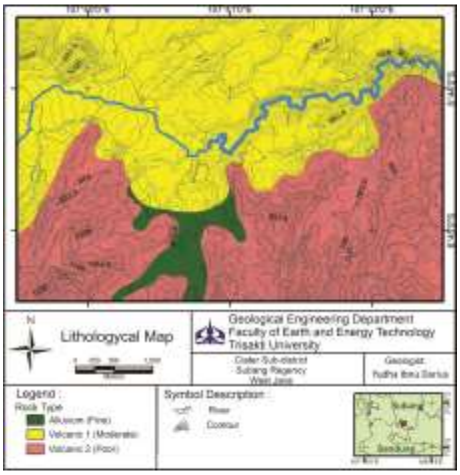

Fig. 3. Lithology map in the research area

TABLE 4. Classification and weight of lithology parameter

No	Lithology	Score	Weight	Total	Area (km^2)	Area (%)
1	Alluvium	1		0.2	0.85	4.15
2	Volcanic rocks 1	2		0.4	10.50	51.48
3	Sedimantary rocks 1	3	0.2	0.6	-	0
4	Sedimentary and volcanic rocks 2	4		0.8	9.05	44.37
				Total	20.40	100

Distances from structures(faults/fractures)

The parameter of distance from faults or fractures has a weight of 0.05. This research data was obtained from processed geological mapping data, resulting in a map of distances from faults or fractures (Fig. 4). Based on the processed data, there are five classes of distance from faults or fractures in the research area: very close, close, moderate, far, and very far. The detailed classification and weight of the distance from structure parameter shown in table 5.

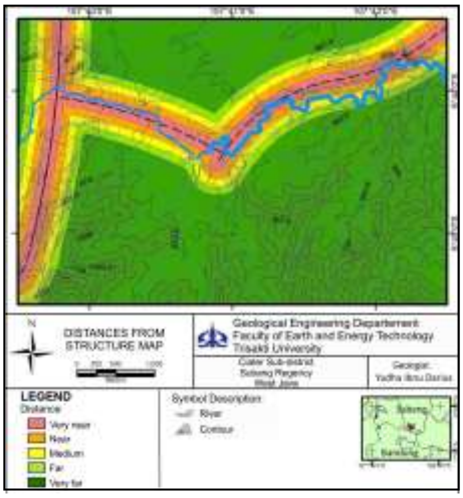

Fig. 4 Distances from structures (faults/fractures) map in the research area

TABLE 5. Classification and weight of distances from structures(faults/fractures) parameter

No	Distances from structures (m)	Score	Weight	Total	Area (km^2)	Area (%)
1	>400	5		0.25	13.64	66.86
2	300 – 400	4		0.2	1.54	7.54
3	200 – 300	3	0.05	0.15	1.65	8.09
4	100 – 200	2		0.1	1.75	8.56
5	0 – 100	1		0.05	1.83	8.94
				Total	20.40	100

Soil type

The soil texture parameter has a weight of 0.05. This research data was obtained from field observations with a total of 30 samples, which will later be processed in the laboratory to determine the soil texture of each sample. Based on the processed data, there are two soil texture classes identified in the research area: moderate class and poor class (Fig. 5). The detailed classification and weight of the soil type parameter shown in table 6.

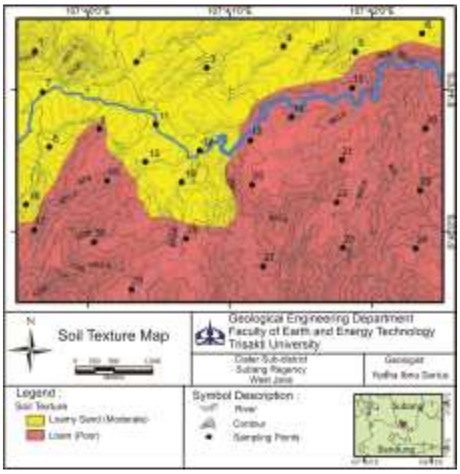

Fig. 5. Soil type map in the research area

TABLE 6. Classification and weight of soil type parameter

No	Classi-fication	Soil type	Score	Weight	Total	Area (km²)	Area (%)
1	Fine	Sandy	1		0.1	-	-
2	Moderate	Loamy sand	2	0.1	0.2	8.24	40.37
3	Poor	Loam	3		0.3	12.17	59.63
					Total	20.40	100

Soil depth (Solum depth)

In the parameter of soil depth (solum), it holds a weight of 0.1. This research data was obtained from field measurements and observations, then processed to yield soil depth. Based on the acquired data, there are four classes of soil depth identified in the research area: shallow, moderate, deep, and very deep (Fig. 6). The detailed classification and weight of soil depth shown in table 7.

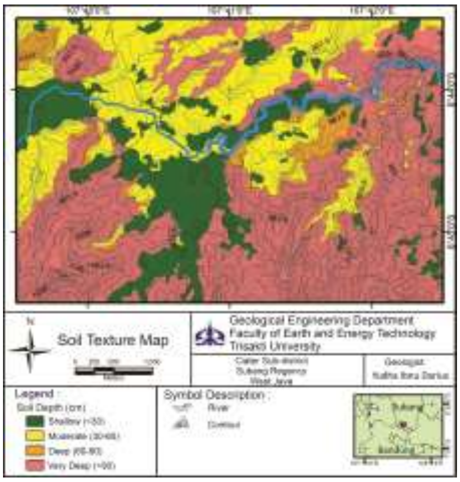

Fig. 6. Soil depth map in the research area

TABLE 7. Classification and weight of soil depth parameter

No	Classi-fication	Solum depth	Score	Weight	Total	Area (km²)	Area (%)
1	Shallow	<30	1		0.05	3.80	18.61
2	Moderate	30 – 60	2	0.05	0.1	5.31	4.32
3	Deep	60 – 90	3		0.15	0.88	26.01
4	Very deep	>90	4		0.2	10.42	51.05
					Total	20.40	100

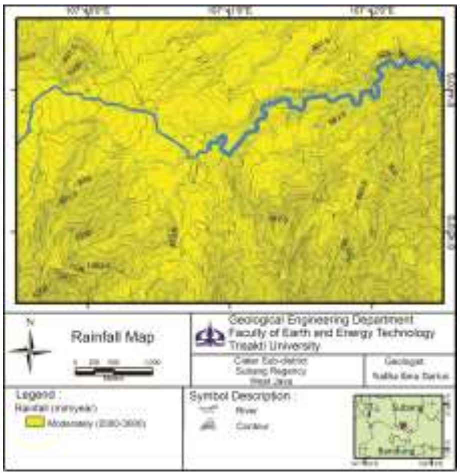

Fig. 7. Annual rainfall map in the research area

Annual rainfall

The rainfall parameter has a weight of 0.2. This research data was obtained from the BMKG data center and then processed to calculate the average rainfall over ten years. Based on the acquired data, the research area falls into the moderate class (Fig. 7). The detailed classification and weight of the annual rainfall shown in table 8.

TABLE 8. Classification and weight of annual rainfall parameter

No	Classi-fication	Annual rainfall (mm)	Score	Weight	Total	Area (km²)	Area (%)
1	Dry	<2000	1		0.2	-	0
2	Moderate	2000 – 3000	2	0.2	0.4	20.40	100
3	Wet	>3000	3		0.6	-	0
					Total	20.40	100

Land Cover Area

Land cover is grouped based on the DVMBG classification (2004) [6]. Considering the dominant conditions in the field, the research area is divided into three classes: forest or dense vegetation and water bodies, plantations and irrigated rice fields, and industrial and residential areas (Fig. 8). The detailed land cover area shown in table 9.

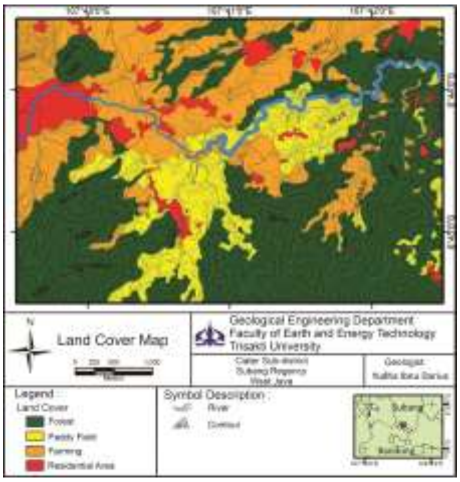

Fig. 8. Land cover area map in the research area

TABLE 9. Land cover area

No	Classi-fication	Land Cover	Area (km²)	Area (%)
1	1	Forests or dense vegetation and water bodies	10.40	50.96
2	2	Garden and shrub mix	-	0
3	3	Plantations and irrigated paddy fields	8.61	42.20
4	4	Industrial and residential areas	1.40	6.84
5	5	Empty land	-	0-
		Total	20.40	100

Urban Planning

The urban planning (RTRW) map of Subang Regency for the period 2011-2031 indicates that there are several areas within the research area, namely protected forests, limited production forests, permanent production forests, dryland agriculture, wetland agriculture, and tourist areas (Fig. 9). The detailed area of urban planning shown in table 10.

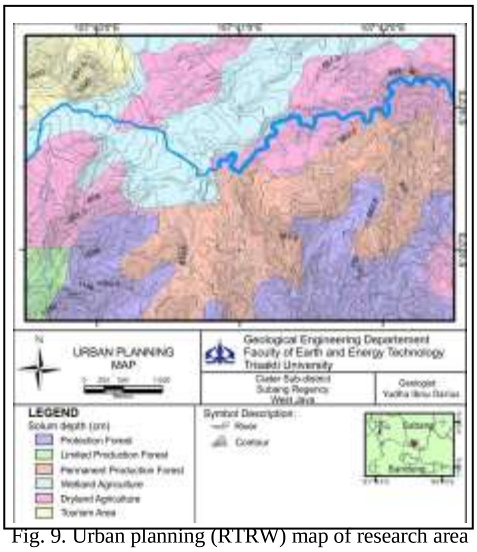

Fig. 9. Urban planning (RTRW) map of research area

TABLE 10. Urban planning for 2011-2031 in research area

No	Urban Planning	Area (km^2)	Area (%)
1	Protection forest	4.19	20.53
2	Wetland agriculture	4.05	19.87
3	Dryland agriculture	5.27	25.82
4	Tourism area	1.15	5.61
5	Permanent production forest	5.32	26.06
6	Limited production forest	0.43	2.11
	Total	20.40	100

A. *Land Movement Vulnerability*

The vulnerability of modified land movement is divided into five classes. The class interval is obtained by subtracting the highest value from the lowest value of the parameter, divided by the number of classes.

$$Class\ interval = \frac{4.15 - 0.6}{5} = 0.71$$

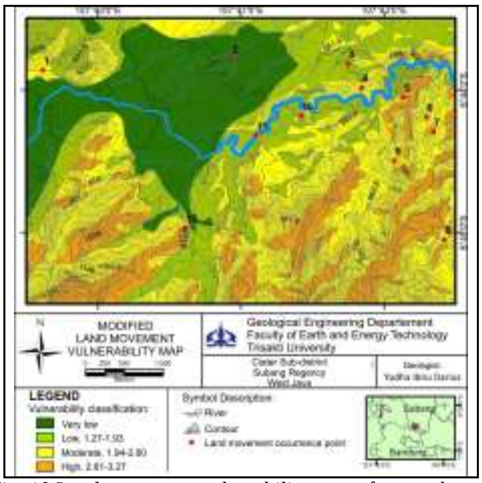

Fig. 10 Land movement vulnerability map of research area

The lowest value of the modified PVMBG (2015) weighting parameter is 0.6, while the highest value is 4.15, with an interval value between classes is 0.71. Based on the class division, there are four classes in the research area: very low, low, medium, and high classes (Fig. 9). The detailed of land movement vulnerability is shown by table 11.

TABLE 11. Classification of land movement vulnerability by modification

No	Classification (modified)	Class Interval (modified)	Area (km^2)	Area (%)
1	Very low	0.6-1.30	4.30	21.07
2	Low	1.31-2,01	4.68	22.93%
3	Moderate	2.02-2.72	8.06	39.51%
4	High	2.73 – 3.43	3.36	16.48
5	Very high	3.44-4.15	-	0-
		Total	20.40	100

B. *Land Movement Type*

There are 12 points of landslides hazard in the research area, predominantly located in the high and medium vulnerability classes of landslide movement. Based on observations, soil material is found at the locations of landslide hazard. According to the classification by Varnes (1978) [7], the type of landslide movement in the research area belongs to rotational landslides.

C. *Overlay*

The modified landslide vulnerability map will be overlaid with the urban planning (RTRW) map and the land cover map to determine the extent and classification of the landslides. Overlaying the modified landslide vulnerability map with the RTRW map results in 20 zones (Fig. 10) and overlaying the landslide vulnerability map with the land cover map results in 15 zones (Fig. 11).

Based on the overlay results of the modified landslide vulnerability map with the land cover map, it can be observed that forest land cover with medium to high vulnerability classes is prone to landslides, supported by the high incidence of landslides in those locations. Land cover with very low to low landslide vulnerability classes is relatively safer because landslides occur less frequently, supported by field data on landslide occurrences.

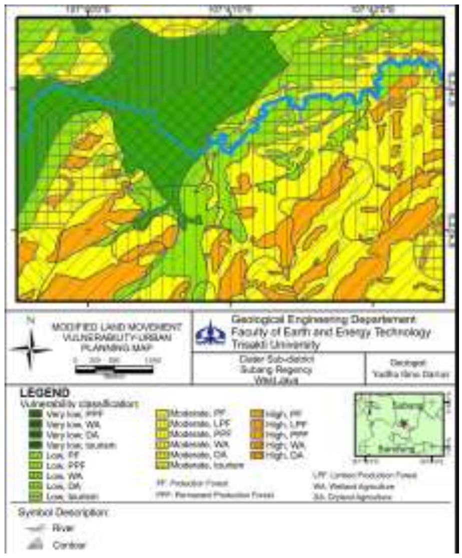

Fig. 11. Overlay map of landslide vulnerability-RTRW

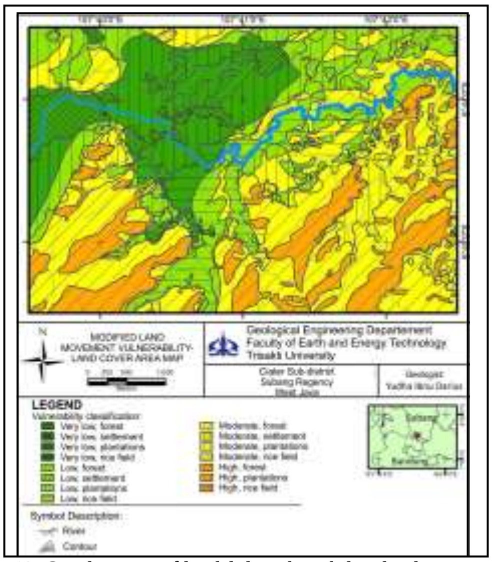

Fig. 12. Overlay map of landslide vulnerability-land cover area

IV. CONCLUSION

Based on the research results, there are four classes of landslide vulnerability: moderate, low, very low, and high. In the research area, there are 12 landslide points with rotational movement and a soil material. Cibitung Village experiences the most landslides. Overlaying landslide vulnerability with urban planning map results in 20 zoning areas, where very low class covers wetland agricultural areas, low class covers dryland agricultural areas, moderate class covers permanent production forest areas, and high class covers protected forest areas, which are the widest zones in the research area. Overlaying landslide vulnerability with land cover results in 15 zoning areas, where very low class and low class covers plantations, also moderate and high class covers forests, which are the widest zones in each landslide vulnerability class.

REFERENCES

[1] SNI 13-6982.2-2004, Pemeriksa Lokasi Bencana Gerakan Tanah Bagian 2: Tata Cara Pelaporan Hasil Pemeriksaan, BSN, Jakarta, 2004.

[2] Karnawati, D., "Bencana Alam Gerakan Massa Tanah di Indonesia dan Upaya Penanggulangannya", Jurusan Teknik Geologi Universitas Gajah Mada, Yogyakarta, 2005.

[3] PVMBG (Pusat Vulkanologi Mitigasi Bencana Geologi Indonesia).

[4] Badan Informasi Geospasial., Data DEM serial no 1209-31 dan 1209-33, 2022. Available: https://tanahair.indonesia.go.id

[5] Badan Meterologi, Klimatologi dan Geofisika., 2012-2021 Data Curah Hujan Stasiun Meterologi Bandung, 2021. Available: https://dataonline.bmkg.go.id/

[6] Direktorat Vulkanologi dan Mitigasi Bencana Geologi, Model Pendugaan Kawasan rawan tanah longsor, Bandung: DVMBG, 2004.

[7] Varnes, D.J., "Slope Movement and Type and Processes Landslide Analysis and Control", special Report 176. Washington D.C: Special report National Research Council, Transportation Research Board, 1978.