Jurnal Geografi, Edukasi dan Lingkungan (JGEL) Vol. 7, No. 2, Juli 2023:118-138
P-ISSN: 2579–8499; E-ISSN: 2579–8510
Doi: https://doi.org/10.22236/ jgel.v7i2.10817
Website: http://journal.uhamka.ac.id/index.php/jgel

Identification Of Landslide-Prone Areas In Citeureup Sub-District, Bogor Regency, West Java, Indonesia

Hizkia Tuejeh[1*], Muzani[1], Ilham Badaruddin Mataburu[1], Dan Lyzia Nabilla[1]
[1]Geography Education, Faculty of Social Science, Universitas Negeri Jakarta, Indonesia

***E-mail:** hizkiatuejeh@gmail.com
Received: 12 01 2023 / *Accepted:* 14 07 2023/ *Published online:* 26 07 2023

ABSTRAK

Kejadian bencana longsor di Kecamatan Citeureup pada tahun 2017 – 2021 tercatat sebanyak 21 kejadian yang menyebabkan puluhan rumah rusak ringan hingga berat, serta infrastruktur jalan dan jembatan terputus. Penelitian ini bertujuan untuk mengidentifikasi wilayah rawan longsor di Kecamatan Citeureup. Metode yang digunakan yaitu metode deksriptif dengan pendekatan spasial. Pengolahan data menggunakan software ArcGIS 10.8 dengan teknik analisis yang digunakan adalah analisis spasial dengan melakukan tumpang susun antar lima parameter kerawanan longsor. Setelah itu, dilakukan validasi lapangan. Subjek dalam penelitian ini yaitu 12 unit lahan terpilih. Hasil penelitian menunjukan bahwa wilayah yang masuk pada kategori rawan longsor rendah yaitu Desa Citeureup, Leuwinutug, Puspanegara, Puspasari, Sanja, serta Kelurahan Karangasem Barat dan Karangasem Timur. Sebaran wilayah pada kategori rawan longsor sedang berada di sebagian kecil Desa Hambalang, Sanja, Kelurahan Karangasem Timur, dan Desa Leuwinutug. Sebaran wilayah pada kategori rawan longsor tinggi berada di sebagian besar Desa Hambalang, Tajur, dan Tangkil. Sebaran wilayah pada kategori rawan longsor sangat tinggi berada di sebagian besar Desa Hambalang, Tangkil, Sukahati, dan sebagian kecil di Kelurahan Karangasem Timur. Persebaran daerah rawan longsor didominasi oleh wilayah pada kategori rawan longsor tinggi. Sedangkan persebaran daerah rawan longsor paling sedikit terdapat pada wilayah kategori rawan longsor sedang.

Kata Kunci: Bencana Longsor, Wilayah Rawan Longsor, Unit Lahan.

ABSTRACT

There were 21 landslides in Citeureup Subdistrict in 2017-2021 which caused several houses to be slightly damaged to severely damaged, and road and bridge infrastructure was cut off. This study aims to identify landslide-prone areas in Citeureup Sub-District. The method used was descriptive method with a spatial approach. Data was processed using GIS 10.8 software with the analytical technique used was a spatial analysis by overlaying five parameters of landslide susceptibility. After that, field validation was carried out. The subjects in this study were 12 selected land units. The results showed that areas that are included in the category of low landslide prone are Citeureup, Leuwinutug, Puspanegara, Puspasari, Sanja, and West Karangasem and East Karangasem Villages. The distribution of areas in the landslide-prone category is in a small part of Hambalang Village, Sanja, East Karangasem Village, and Leuwinutug Village. The distribution of areas in the high landslide-prone category is in most of Hambalang, Tajur, and Tangkil Villages. The distribution of areas in the landslide-prone category is very high in most of Hambalang, Tangkil, Sukahati, and a small part of it in East Karangasem Village. The distribution of landslide-prone areas is dominated by areas in the high landslide-prone category. Meanwhile, the distribution of landslide-prone areas is at least found in the medium landslide-prone category area.

Keywords: *Landslide Disaster, Landslide-Prone Areas, Land Unit.*

INTRODUCTION

Geographically, the country of Indonesia is located at the confluence of 3 large tectonic plates of the world, namely the Continental Eurasian plate, the Oceanic Indo-Australian Plate, and the Oceanic Pacific Plate. Because of this geographical location, is also what causes Indonesia to be in the Ring of Fire area of the world which of course has the potential to often experience disaster events (Nirwansyah and Nugroho, 2015). Indonesia is the largest archipelagic country in the world in which of course many complex elements occur, both physical (natural) and social elements of its people. Indonesia is prone to disasters, be it natural or non-natural disasters. The total number of natural disasters in 2020 in Indonesia was recorded as many as 4,650 times which claimed the lives of 376 people died, 42 people were missing, 6.7 million more residents were displaced, and 619 people were injured. 65,743 houses were damaged, and 1,683 facilities were damaged. In 2020, the number of landslide disasters was recorded as many as 1,054 times (BNPB, 2020).

According to Nugroho (2015), disaster events that occur in Indonesia every year are dominated by hydrometeorological disasters. Hydrometeorological disasters in Indonesia have occurred more than 1900 times with an average per year of 1124 times from 2010-2014. One of the disasters that often occurs is the landslide disaster with a total of 3032 events that claimed 2326 lives. According to the National Disaster Management Agency 2016, landslides in 2011 – 2015 in Indonesia recorded 2,425 incidents. Meanwhile, according to Indonesian Disaster Information Data, from 2016-2020 there were 4,659 landslides spread to various regions in Indonesia. Landslide events are usually caused by various factors, such as hydrology (rain), geology, distance from faults, land cover, and altitude of the place (Wang, et al., 2017). Landslide is a mass movement of material from the breakdown of soil or rock that moves down a slope due to the force of gravity (Noor, 2010). As some areas in Indonesia are located in hilly or mountainous regions, coupled with Indonesia being situated in a tropical climate with high rainfall, several areas often experience landslides (Ramadhan, et al., 2017). Before the occurrence of a landslide event, some symptoms can be observed, including usually occurring after rain, house buildings in the slope area experiencing cracks, there are soil sticks on the slopes, inclined electricity poles, and the emergence of new springs from soil cracks (Pusat Vulkanologi dan Mitigasi Bencana, 2015).

Landslides usually occur during the rainy season in high areas with steep slopes and result in various losses. The high impact of disaster losses that occur can be caused because people do not understand the geographical conditions of the region so that understanding of local disasters is still very lacking. After knowing the symptoms before the landslide, people who live not far from the slope area must go far from the place as soon as possible to avoid unwanted events (Yuniarta, et al., 2015).

Bogor Regency is one of the regencies in West Java Province that is included in the landslide-prone area. In 2020, the number of landslide disasters in Bogor Regency was 928 with a total death toll of 118 people, 13 people missing, and the number of injured as many as 135 people (DIBI, 2020). Judging from data from Indonesia's disaster-prone index in 2020, Bogor Regency is an area with a high level of landslide disaster risk with 18 districts prone to landslides or have been hit by landslides. One of the districts that are prone to landslides is in Citeureup Sub-District. Recorded from 2017 to

2021, 21 landslides in the Citeureup Sub-District caused dozens of houses to be damaged, which was estimated to have suffered losses of tens to hundreds of millions. In addition, infrastructure such as roads and bridges are cut off which results in disrupted community activities (BPBD of Bogor Regency, 2020). Based on this background, it is necessary to identify areas with the potential for landslides. Therefore, *this study aims to identify landslide-prone areas in Citeureup Sub-District.*

RESEARCH METHODS

This research was conducted in Citeureup Sub-District, Bogor Regency. This research method uses a descriptive method with a spatial approach. The determination of the research area uses the purposive method, which is the selection of research areas based on the consideration that the area is considered by the research objectives. The subjects in this study were 12 selected land units from a total of 120 homogeneous land units resulting from the overlay of three map parameters, including slope maps, soil types, and land use (Setiawan, 2005). The taking of research subjects on 12 units of land was carried out based on the presence or absence of landslides in a land unit.

Rainfall data was obtained from the Meteorology, Climatology, and Geophysics Agency (BMKG) of Bogor Regency, soil type data was obtained from the Center for Research and Development of Agricultural Land Resources, slope inclination, rock type, and land use data were obtained from the Regional Development Planning Agency and Research and Development Agency (BAPPEDALITBANG) of Bogor Regency and the United States Geological Survey (USGS).

The data analysis technique used in this study uses spatial analysis by filling in Scores and Weights on each map parameter for analysis and classification. The classification and Weighting of each map parameter refer to the model issued by Puslittanak (2004) (Table 1-5), including rainfall classification, rock types, slope slopes, land use, and soil types. The five parameters of the landslide-prone map were then overlaid using ArcGIS 10.8 Software. After that, field validation is carried out. This model by Puslittanak (2004) used because of the clear and simple and accurate, also released by the experised and credible instance that focused on land and agroclimate.

Table 1. Rainfall Classification (mm/year)

Parameters (mm/year)	Weight	Score
Very Wet (>3000)		5
Wet (2501-3000)		4
Intermediate (2001-2500)	30%	3
Dry (1501-2000)		2
Very Dry (<1500)		1

Source: Puslittanak, 2004

Table 2. Slope Classification

Parameter	S (°) Weight	Score
>45		5
30 – 45		4
15 – 30	20%	3
8 – 15		2
<8		1

Source: Puslittanak, 2004

Table 3. Land Use Classification

Parameters (Land Use)	Weight	Score
Moor, Rice Field		5
Shrubs		4
Forest and Garden	20%	3
Urban/Settlements		2
Fishpond, Reservoir, Inland Water		1

Source: Puslittanak, 2004

Table 4. Soil Type Classification

Parameters	Weight	Score
Regosol		5
Andosol, Podcolic		4
Brown Latosol	10%	3
Yellowish brown latosol association		2
Alluvial		1

Source: Puslittanak, 2004

Table 5. Rock Type Classification

Parameters	Weight	Score
Volcanic Rocks		3
Sedimentary Rocks	20%	2
Alluvial Rocks		1

Source: Puslittanak, 2004

Based on these parameters to produce a total indeks of landslide susceptibility using the **Formula 1**.

Score Total = 0,3 RF + 0,2 RTF + 0,2 SAF + 0,2 LUF + 0,1 STF…………...(1)

Information:

RF = Rainfall Factors

RTF = Rock Type Factors

SAF = Slope Angle Factors

LUF = Land Use Factors

STF = Soil Type Factors

0,3; 0,2; 0,1 = Weight Value

To find the interval in creating a landslide susceptibility map as follows the **Formula 2**.

$$Interval = \frac{Max\ Score - Minimum\ Score}{Number\ of\ Classes} \quad ..(2)$$

RESULTS AND DISCUSSION

Research Area

Bogor Regency is one of the regencies in West Java Province with an area of 299,378.8 ha. The district is located at 6º18'0" – 6º47'10" South Latitude and 106º23'45" – 107º13'30" East Longitude and has as many as 40 sub-districts with the district capital located in Cibinong District. Geographically, Citeureup Subdistrict is located between 6° 29' 8" South Latitude and 106° 52' 55" East Longitude (**Figure** 1), with a distance of about 10.5 km from the center of the government of Bogor Regency. Based on data from the Central Statistics Agency, the area of the Citeureup Sub-District is 68.81 km^2 which consists of 12 villages and 2 sub-district.

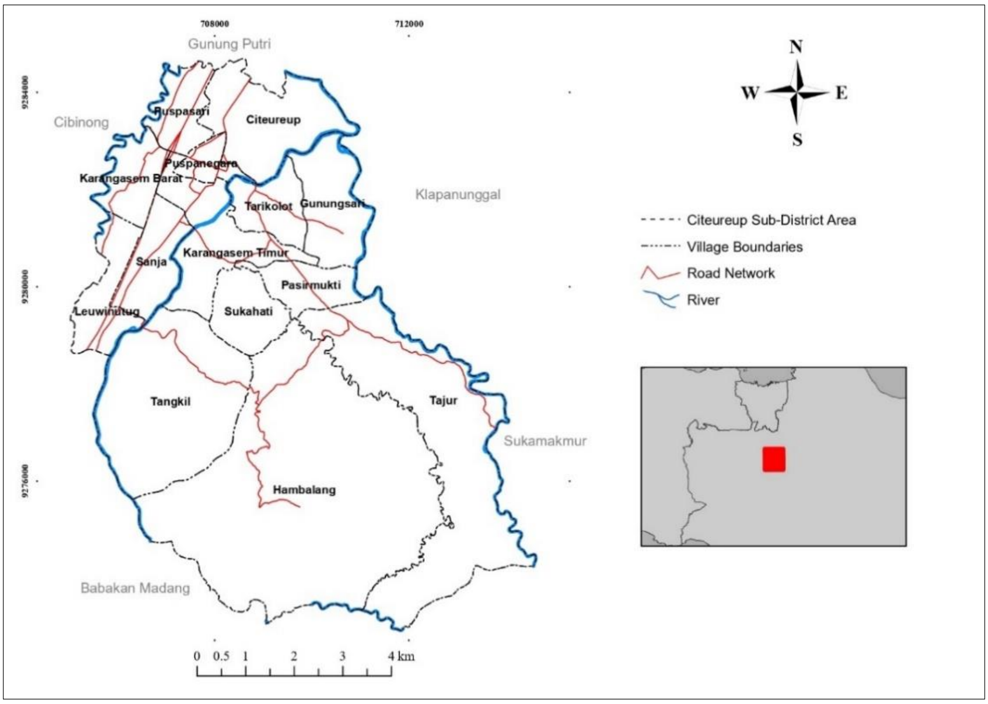

Figure 1. Research Location Map of Citeureup Sub-District

Slope Angle

Slope conditions in the field vary greatly, some are flat (<8%) to steep (45%). This is because in the research area the topographical shape is very complex, ranging from lowlands to hills. The following are processed data in the form of tables related to slopes in Citeureup Sub-District, Bogor Regency (**Table 2**).

Table 6. Slope Angle in Citeureup Sub-District

No.	Slope	Area (ha)	Percentage (%)
1.	0 - 8%	2890.9	42.0
2.	8 - 15%	2776.8	40.4
3.	15 - 30%	1063.9	15.5
4.	30 - 45%	149.5	2.2
	Total	6881.1	100.0

The greater the angle of inclination of the slope, the more prone it is to landslides. The steeper a slope is, the more it will affect the stability of the slope, which in turn leads to a high flow of water on the surface, resulting in intense erosion compared to flat or gentle areas. The intense erosion process leads to the exposure of many rock outcrops, accelerating weathering compared to normal conditions, thus reducing slope stability (Sitorus, et al., 2021). Angle of slope is rather steep to steep and can be found in hilly areas, in this case namely in Hambalang, Tajur, and Tangkil Villages. While the rest is dominated by villages and sub-districts located in low-topographic areas (**Figure 2**).

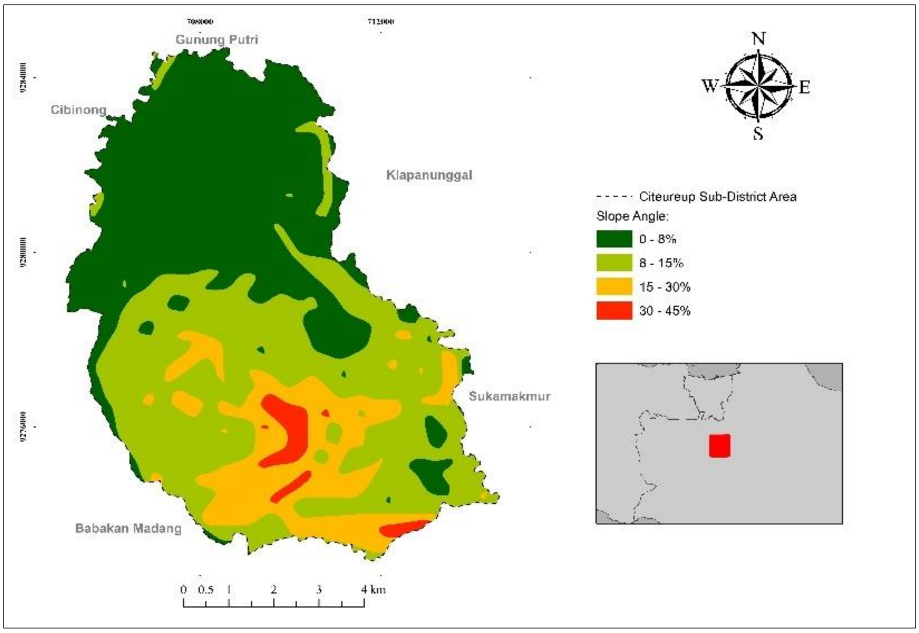

Figure 2. Slope Angle Map of Citeureup Sub-District
Source: Data Processing Results, 2022

Land Use

Every community certainly uses and maximizes the existing land for their living needs. The use of existing land also varies depending on the characteristics of each region. If the existing land is used properly and is environmentally oriented, then the community can benefit a lot from it. On the other hand, if the land is only exploited and is not oriented towards the environment to maintain it, it can trigger disasters, one of which is a landslide disaster. This is in line with what Khafid (2019) stated, that the impacts resulting from land use can be divided into two categories: positive and negative, depending on the aspects of utilization and management. Land use in Citeureup Sub-District is very diverse, there are 10 categories of land use that can be seen in the **Table 7**.

Based on the data presented in the table above, it can be seen that land use in Citeureup Sub-District is dominated by mixed gardens with an area of 1890.5 ha and the least land use, namely shrubs and shrubs with an area of 30.6 ha of the total area as a whole. For residential areas, it is still quite minimal, especially in high-top areas. This is because the area is dominated by slopes ranging from 8% to >45% resulting in quite difficult to build settlements (**Figure 3**).

Table 7. Land Use of Citeureup Sub-District

No.	Land Use	Area (ha)	Percentage (%)
1.	Industrial Building	691.4	10.0
2.	Mix Garden	1890.5	27.5
3.	Open-Space Area	124.7	1.8
4.	Inland Water	129.6	1.9
5.	Settlements	1700.5	24.7
6.	Rice Field	267.5	3.9
7.	Shrubs	30.6	0.4
8.	Moor	1880.1	27.3
9.	Open Pit Mining	103.6	1.5
10.	Garden	62.8	0.9
	Total	**6881.1**	**100.0**

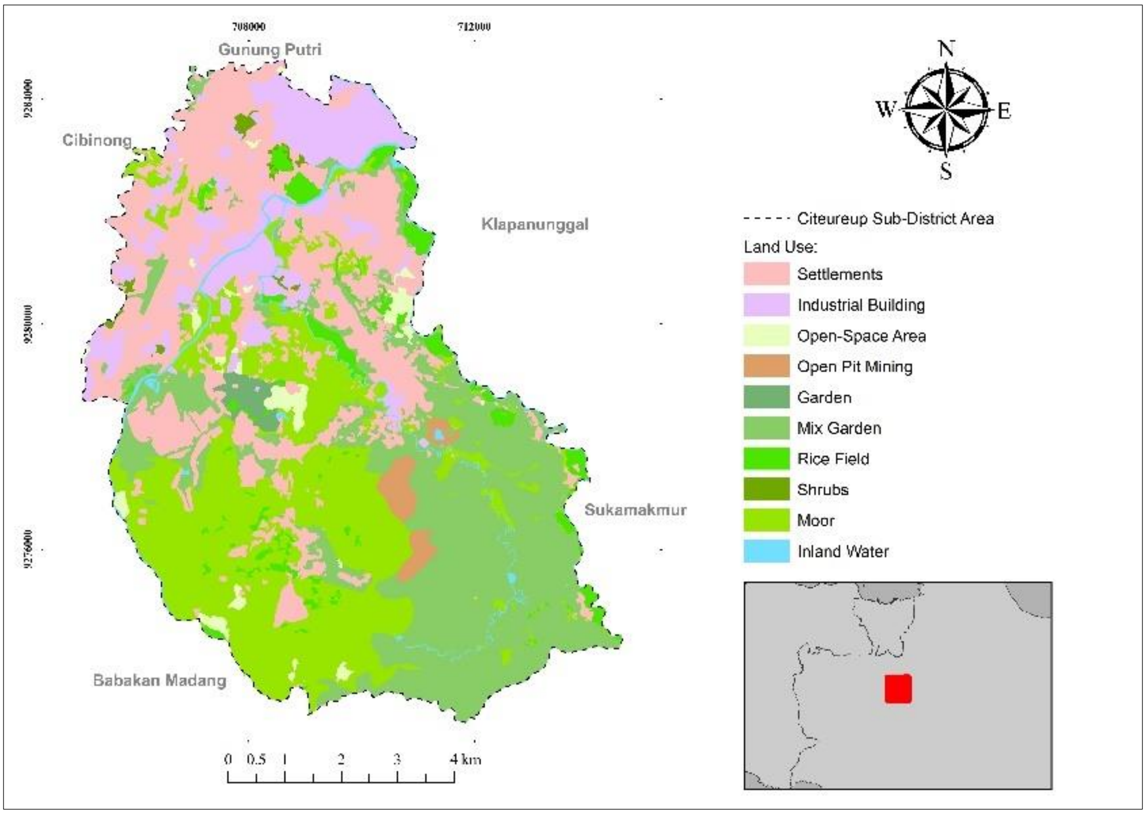

Figure 3. Land Use Map of Citeureup Sub-District
Source: Data Processing Results, 2022

Soil Type

Based on data obtained from the Center for Research and Development of Agricultural Land Resources (BBSDLP) that the soil in the Citeureup Sub-District consists of eight types of soil formed from various kinds of parent materials. The eight types of soil can be seen in the **Table 8** and **Figure 4** below.

Table 8. Soil Type of Citeureup Sub-District

No.	Soil Type	Area (ha)	Percentage (%)
1.	District Gleysol	528.2	7.7
2.	Haplic Latosol	615.9	9.0
3.	Haplic Mediterranean	1049.8	15.3
4.	District Cambisol	1341.3	19.5
5.	Eutric Cambisol	32.4	0.5
6.	Gleick Cambisol	56.1	0.8
7.	Oksic Cambisol	2731.1	39.7
8.	Litosol	526.3	7.6
	Total	**6881.1**	**100.0**

From the **Table 8**, it can be seen that the most dominant type of soil is Cambisol with an area of 4140.8 ha and the type of soil that has the least distribution is lithosol which only has an area of 526.3 ha. The district gleisol soil type at the study site is composed of clay deposit parent material with the landform in the form of a floodplain on the meandering river. This gleisol soil is on a flat topography with a slope of <1%. This soil has the characteristics of a deep soil solum with obstructed drainage, a smooth, slightly sour soil texture, as well as low CEC (Cation Exchange Capacity) and AS (Alkaline Saturation) (Typic Endoaquepts). The type of latosol haplic soil has the characteristics of being very fine, very deep soil solum, good drainage level, sour, medium CEC, and low TD (Typic Dystrudepts). This type of soil has a landform in the form of a fan leg composed of clay deposits. This soil can be found on choppy topography with a slope of 3 – 8%.

The next type of soil is the haplic Mediterranean. This soil is formed from the parent material of calcareous rock with tectonic hilly landforms. This soil has several characteristics, namely fine texture, deep soil solum, good drainage level, neutral soil properties, medium CEC and high AS (Typic Hapludalfs). This land is on a small hilly topography with a slope between 15 – 25%. The district's Cambisol soil type has characteristics including deep soil solum, good drainage level, fine texture, sour, low–medium CEC, and AS (Typic Dystrudepts). This soil is derived from the parent material of clay and andesite deposits with landforms resembling alluvial fans and old volcanic plains. This soil is on a choppy topography with a slope between 3 – 8%.

Furthermore, in Citeureup Sub-District, there is a type of Cambisol Eutric soil. This type of soil has characteristic characteristics, namely the soil is slightly acidic, slightly textured, has good drainage level, deep-watered, medium CEC, and has high AS (Typic Eutrudepts). This cambisol Eutric soil is formed from the parent material of calcareous limestone with its landform located on an undulating tectonic plain that has a slope between 8-15%. The Cambisol gleic soil type is composed of clay deposit parent material with a landform the form resembling a flow path. This type of soil has the characteristics of fine texture, deep soil solum, slightly inhibited soil permeability system, sour, medium CEC, and low AS (Aquic Dystrudepts). This land is on a flat topography with a slope of <1%.

The oxylic Cambisol soil type is formed from andesite parent material with a landform in the form of old volcanic hills. This soil can be found in hilly topographic areas with a slope of 25 – 40%. This soil has the characteristics of a very deep soil solum, good drainage level, fine texture, sour, low CTRK, and medium AS (Oxic Dystrudepts). The type of lithosol soil has the characteristics of a shallow soil solum, a good level of drainage, a slightly rough texture, slightly acidic soil properties, and medium CEC and AS (Typic Udorthents). This type of soil is formed from the parent material of limestone and andesite with tectonic hilly landforms and old volcanic mountains. The proportion for this soil is D = dominant. This type of soil can be found in hilly topographical areas with a slope between 25 – 40% to mountainous topography with a slope of >40%.The diversity of soil types at the research site also leads to varying levels of soil stability against landslides. The diverse soil types result in varying capacities of the soil to retain water, which in turn influences the soil structure at the research site. When it rains, the absence of vegetation on the soil surface can cause saturation of the soil because there are no plants to bind the soil and facilitate water infiltration. This leads to instability of the underlying slope materials along the sliding plane (Agustina, 2020)

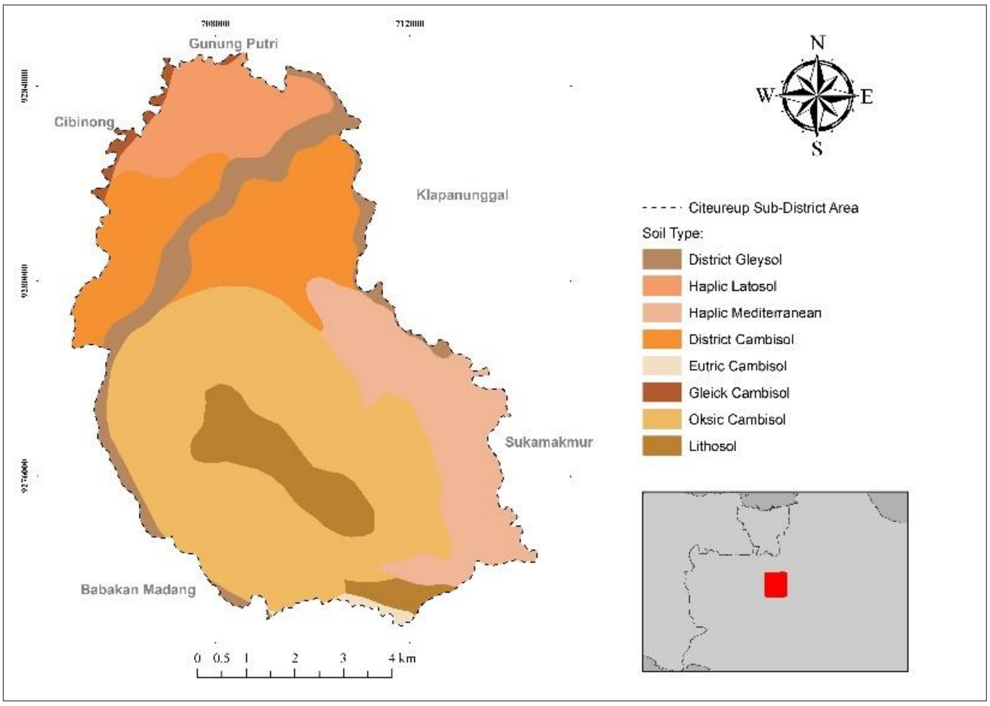

Figure 4. Soil Type Map of Citeureup Sub-District
Source: Data Processing Results, 2022

Types of Rocks

In the study area, the types of rocks that exist are generally volcanic and sedimentary rocks. This is influenced by the presence of various mountains in Bogor Regency. As stated by Yassar et al. (2020), Bogor Regency is located in the Bogor Zone, where there are many volcanic rocks and some sedimentary rocks.

The geological conditions at the study site consist of a wide variety of rocks of origin. It is recorded that there are 4 types of original rocks at the study site, namely limestone, surface deposits, young volcanoes, and old volcanoes (**Table 9**).

Table 9. Geology of Citeureup Sub-District

No.	Types of Rocks	Area (Ha)	Percentage (%)
1.	Limestone	3.8	0.1
2.	Surface Deposits	1934.5	28.1
3.	Younger Volcano	326.7	4.7
4.	Older Volcano	4616.2	67.1
	Total	**6881.1**	**100.0**

From the *Table 9*, it can be seen that the type of rock that dominates the most at the study site is the old volcanic origin rock which has an area of 4616.2 ha while the type of rock that has the least coverage area is limestone which only has an area of 3.8 ha. Various rocks of this origin are also composed of several rocks, such as clastic sedimentary rocks, intermediates, claystone, alluvium, limestone, and clay (**Figure 5**).

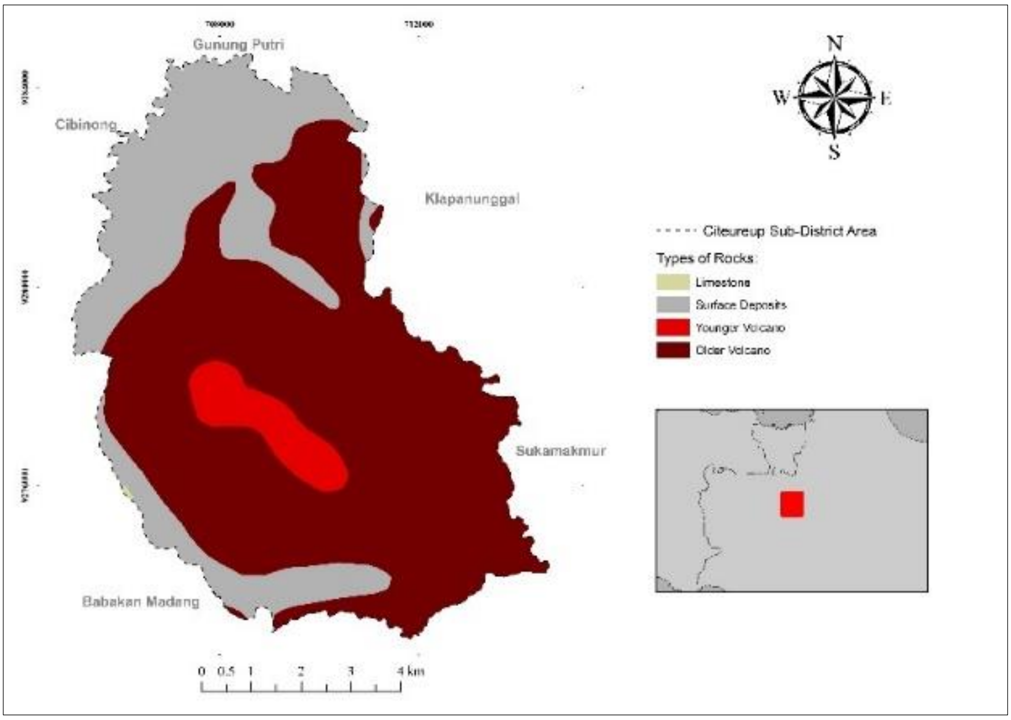

Figure 5. Geological Map of Citeureup Sub-District
Source: Data Processing Results, 2022

Rainfall

Rainfall is one of the biggest factors in the occurrence of landslides. This is also in line with the opinion of Rahmad et al. (2018), that one of the main factors causing landslides is high rainfall intensity. When there is high rainfall intensity, it can be determined to what extent an area is at high risk of experiencing landslides. In the dry season, the water in the soil will experience very large evaporation that gives rise to fracturing on the soil surface. When it rains with high intensity, rainwater will enter the fracturing of the soil, causing the soil to become saturated in a relatively short time. This can trigger landslides because the water that enters the soil fracturing will collect at the bottom of the slope and result in lateral movement, especially in areas with steep marbles.

Rainfall data in the study area were obtained from data from 4 rain post stations located around the study site, namely Ciriung, Dayeuh, Staklim Bogor, and the Botanical Garden. The rainfall data used in this study is rainfall in 2021. The data obtained is then processed through the IDW interpolation method. The following rainfall data can be seen in the Table 10.

Table 10. Rainfall of Citeureup Sub-District

No.	Rainfall	Are (ha)	Percentage (%)
1.	3001 - 3500	1879.1	27.3
2.	3501 - 4000	5002.0	72.7
	Total	**6881.1**	**100.0**

From the **Table 10**, rainfall in the most dominant study area ranges from 3500 - 4000 mm with a coverage area of 5002.0 ha. This dominant amount of rainfall is more common in hilly areas or high-top areas compared to low-to-geographic areas. The following is a map of the rainfall distribution of the study location area.

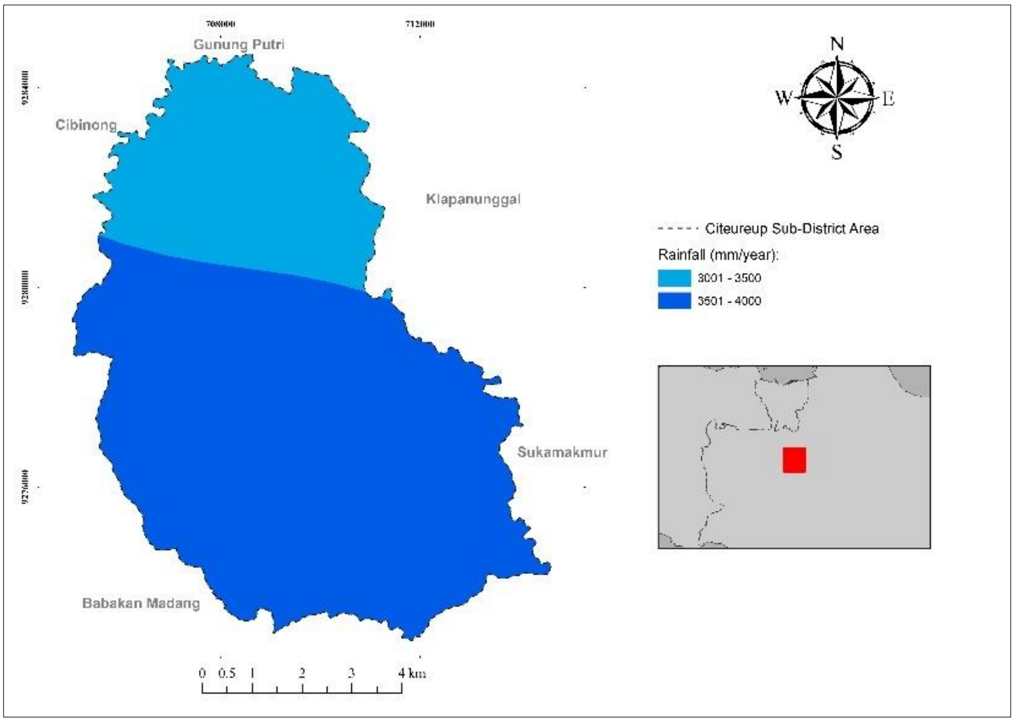

Figure 6. Citeureup Sub-District Rainfall Map
Source: Data Processing Results, 2022

Based on the rainfall map image **Figure 6**, it can be seen that the high rainfall covers several villages in the hilly area, such as Tangkil, Hambalang, and Tajur Villages. This high rainfall is caused by the sea breeze coming from the Java Sea which carries a lot of water vapor, especially in the area where the study site is located there is a hilly area that causes the water vapor brought directly to condense and become rain.

Landslide Incidents in the Research Area

Landslide events at the study site can be caused by several factors, such as physical or human factors. Physical factors can include the slope of the slope, the type of soil, as well as the type of rock. Meanwhile, the human factor can be caused by the use of land that is used for the benefit of the community at the location. In addition to physical and human factors, another supporting factor is the high rainfall conditions in the study area causing many landslides to occur. There were 21 landslide events recorded throughout 2017 – 2021 spatially can be seen in **Figure 7** the following.

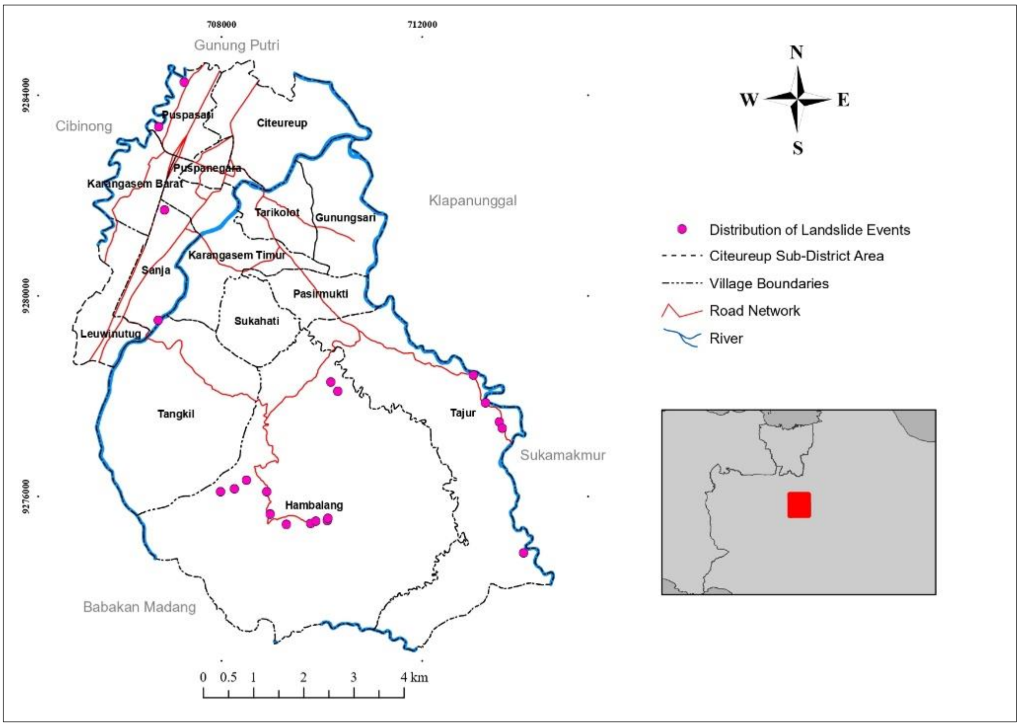

Figure 7. Distribution of Landslide Events in Citeureup Sub-District (2017 -2021)
Source: Data Processing Results, 2022

Land Units in the Research Area

In drawing samples in this study, the concept of land units was used. This concept is used to make it easier to find information that is assumed that each unit of land has homogeneous or similar characteristics. The land units in the study area were obtained from the results of overlaying several types of maps, namely slope maps, soil types, and land use (Setiawan, 2005). From the results of the overlay, 120 units of land were obtained spread across the study area. The following is a map of land units in the research area as follows (**Figure 8**).

Selected Land Units

After obtaining 120 units of land in the study area through the results of overlaying maps of slope slopes, soil types, and land use, only a few units of land units were selected that had certain conditions. This is because there are too many units of land obtained, so the sampling is too much. Therefore, only units of land where there is a landslide event are taken as research samples. In this case, there are 12 units of land units that can be used as samples in this study spread across several areas in the Citeureup Sub-District with an overall area of 2132.15 ha (table 11). The following is the distribution of selected land units which can be seen below (**Figure 9**).

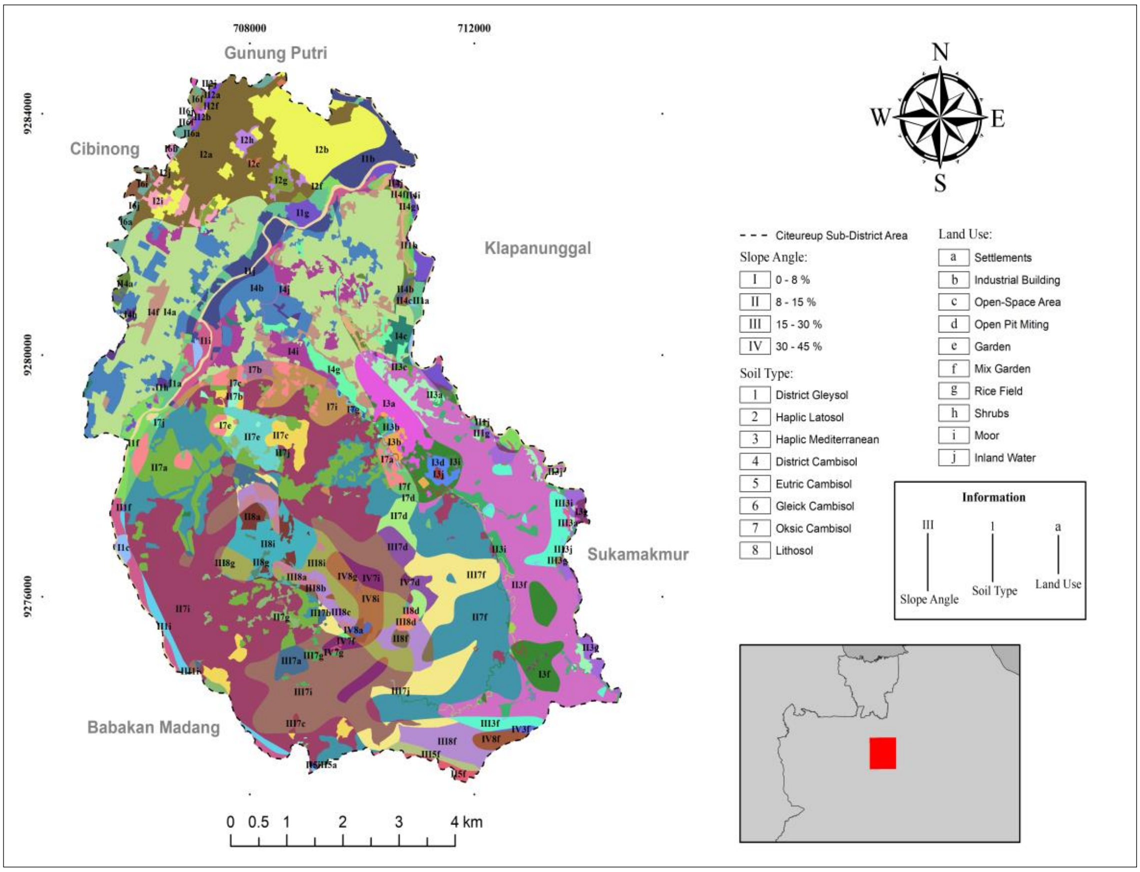

Figure 8. Map of Land Units in Citeureup Sub-District
Source: Data Processing Results, 2022

Table 11. Selected Land Units

No.	Land Units	Area (ha)	Percentage (%)
1.	I1a	16.33	0.77
2.	I2a	293.73	13.78
3.	I4a	342.46	16.06
4.	II2a	4.11	0.19
5.	II3a	11.59	0.54
6.	II3f	485.93	22.79
7.	II7a	22.04	1.03
8.	II7i	652.24	30.59
9.	III3f	35.58	1.67
10.	III7i	258.53	12.13
11.	III8i	5.02	0.24
12.	IV8a	4.59	0.22
	Total	**2132.15**	**100.00**

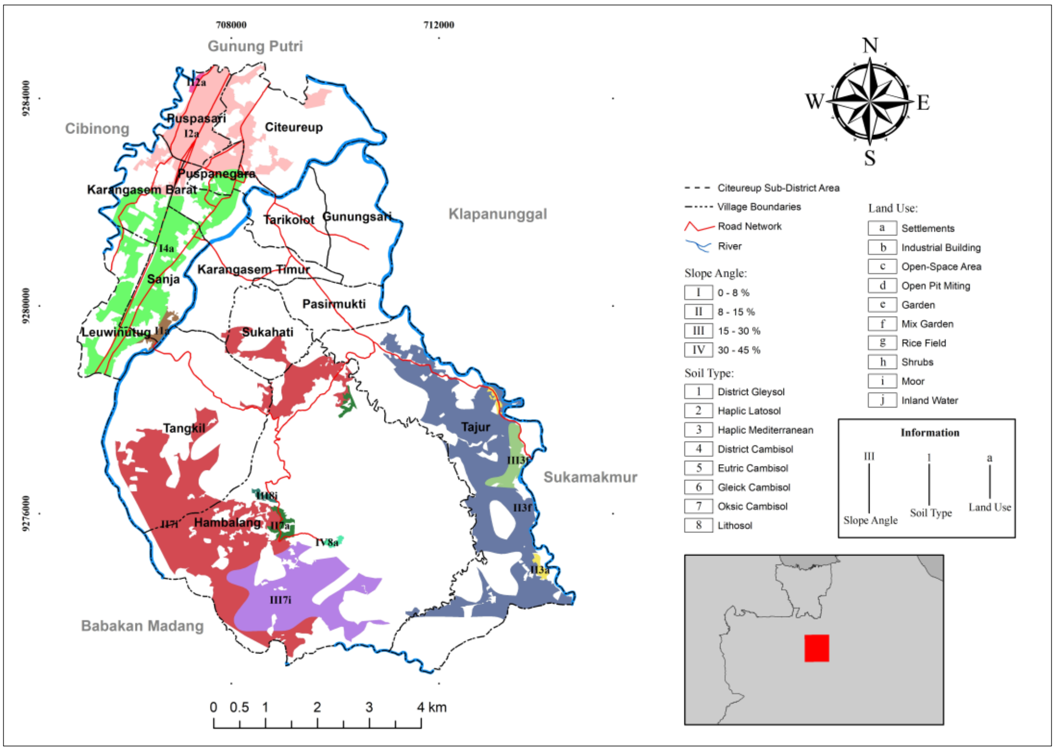

Figure 9. Map of Selected Land Units in Citeureup Sub-District
Source: Data Processing Results, 2022

Landslide Suscaptibility in Research Areas

In determining landslide-prone areas, it was carried out with the Puslittanak estimation model in 2004. This model uses five map parameters, namely the slope map, land use, soil type, rock type, and rainfall that have been given their respective Scores and Weights. Then the maps were overlaid so that four classes of landslide susceptibility were obtained with the following intervals of each class's Score (**Table 12**).

Table 12. Landslide Susceptibility Class Score Interval

Score Interval	Landslide Suscaptibility Class
2.2 – 2.75	Low
2.75 – 3.3	Intermediate
3.3 – 3.85	High
3.85 – 4.4	Very High

Based on the four existing landslide susceptibility classes, the high landslide prone category is the most dominant category with an area of 2445.1 ha or about 35.5%, followed by the medium landslide prone category covering an area of 1704 ha or about 24.8%. Then there is a very high landslide-prone category covering an area of 1407 ha or around 20.4% and finally, a low landslide-prone category covering an area of 1325 ha or about 19.3%. There are only a few areas that fall into the category of low landslide-prone, the rest are dominated by areas that fall into the category of medium to very high landslide prone (**Figure 10**).

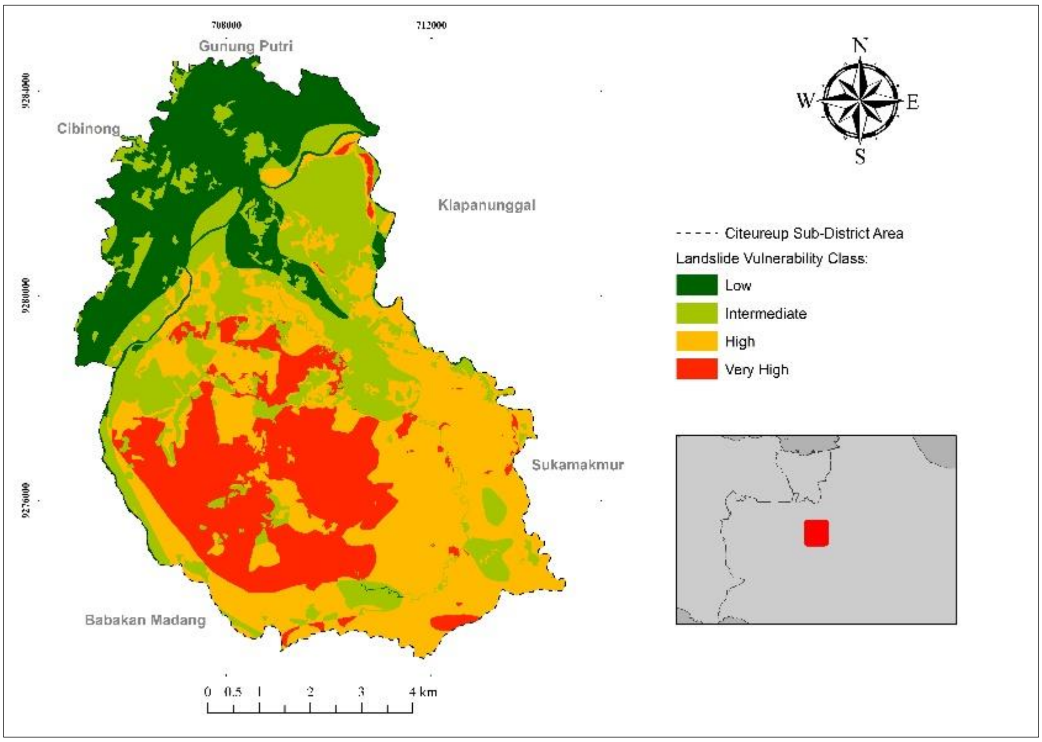

Figure 10. Landslide *S*usceptibility Map in Citeureup Sub-District
Source: Data Processing Results, 2022

Landslide *S*usceptibility Areas in Selected Land Units

a) Low Landslide Prone Category Areas

Basedn on 12 samples of selected land units that exist, three land units fall into the category of low landslide prone are units of: I2a, I4a, and II2a with coverage areas located in Citeureup, Leuwinutug, Puspanegara, Puspasari, Sanja, and West Karangasem and East Karangasem Villages. In the low landslide-prone category, it has a total area of 613.84 ha with details of the I2a land unit having an area of 293.73 ha, the II2a land unit has an area of 4.11 ha, and the I4a land unit has an area of 342.46 ha.

The three land units in this category are predominantly located on a slope of 0-8% which indicates that the topography at the location is flat. For rainfall in these three land units, it is more dominant in the range of 3001 - 3500 mm / year. This type of rock is in the form of surface deposits with constituent rocks such as clastic sediments and intermediates deposited around the river. While the soil type is in the form of haplic latosol and dystric cambisol. This type of soil has the characteristics of a deep soil solum and a good level of drainage. The land at the site of this land unit is unstable because it is adjacent to the river flow. This happens because water enters the soil, thus making the soil unstable. Land use dominated settlements and industrial buildings. This is because these three land units are located in a flat topography and are close to road and toll road access, making it very possible to build industrial buildings and settlements.

b) Moderate Landslide Prone Category Areas

For the medium landslide-prone category, there are four land units, including land units I1a, I4a, II3a, and II7a. These four land units cover areas in

Hambalang, Leuwinutug, and Sanja Villages, as well as a small part of the Tajur Village and East Karangasem Village areas. The total area of these four land units is 76.43 ha. The land units that have the widest coverage area are the I4a land unit with an area of 26.47 ha and the smallest land unit with an area of II3a with an area of only 11.59 ha. This land unit has rainfall that ranges from 3001 – 4000 mm / year with a slope that ranges from 0 - 15%. This indicates the topography of the place is flat to thoping area. These four land units consist of various types of soil, such as haplic latosol, Mediterranean Haplic, dystric cambisol, dystric gleysol, and oksic cambisol with the fifth characteristic being a deep, finely textured, and neutral to sour soil.

Types of rocks, there are 2 types, namely surface sedimentary rocks and old volcanoes with their constituent rocks such as clastic sediments and intermediate rocks. These rocks have undergone an advanced weathering process that causes the texture in these rocks to become irregular, there are large and small chunks. In addition to physical factors, there are human factors from land use in the form of shrubs, settlements, mixed gardens, moor and industrial buildings.

c) High Landslide Prone Category Areas

Five land units fall into the category of high landslide-prone, including land units II3f, II7i, III3f, III7i, and IV8a with a total area of 769.34 ha. The distribution of areas in the high landslide-prone category is found in Hambalang, Tajur, and Tangkil Villages. Of these five land units, the most extensive land unit is found in the II3f land unit with an area of 485.93 ha, while the IV8a land unit is the land unit that has the narrowest coverage area, which is only 4.59 ha. Rainfall in these five land units is very high ranging from 3501 – 4000 mm/year. The soil type at the site of this land unit consists of oksic cambisol, Mediterranean Haplic, and lithosol. The three types of soil have different characteristics, such as the soil solum which is shallow to very deep. Shallow soil solum can make the soil not optimal in absorbing water. In addition, a less dense and coarse soil texture causes the cohesion of soil aggregates to be less. This leads to the appearance of fracturing on the surface of the soil. This fracturing is one of the factors causing landslides because rainwater with a large intensity will enter the fracturing and fill the soil material to make the soil saturated and unable to withstand the load on it, especially since e solum on the soil is shallow.

The type of rock at the site of this land unit consists of surface deposits and old volcanoes with constituent rocks such as limestone, calcareous, and andesite. Rural communities are still massive in carrying out land processing efforts even though they are in a rugged marbled area. The land use at the study site is more widely used for mixed gardens and moor, and some of it is used for settlements. The construction of settlements on the site of this land unit is still around a steep slope. The slope of the slopes on these five land units starts from 8–45%. This indicates that the topography of the high landslide-prone category varies, ranging from sloping to steep.

d) Very High Landslide Prone Category Area

Finally, the category of landslide-prone is very high which includes three land units, including II7i, III7i, and a small part of the III8i land unit with a total area of 672.55 ha. The distribution of areas in the landslide-prone category is very high in Hambalang, Sukahati, and Tangkil Villages, as well as a small part in East Karangasem Village. The largest land unit is found in II7i with an area of 512.79 ha, while the smallest land unit is occupied by an III8i land unit with an area of 5.02 ha. Rainfall in these three land units is very high, reaching 4000 mm / year. The slope of slope at the location of this land unit ranges from 8-30% which indicates that the topography in the category of prone to very high landslides is included in the category of gentle to rather steep slopes. The soil types in this land unit are Mediterranean Haplic, oksic cambisol, and lithosol with shallow soil solum, as well as coarse texture – fine.

The type of rock in this land unit consists of young and old volcanic rocks with their constituent rocks such as clastic sediments, claystone, and intermediate extrusive rocks with an intensive degree of weathering. Land use at the location of the land unit is used by the surrounding community as a moor with the use of a single planting pattern. The pattern of moor land use managed by the community makes the vegetation cover above the surface open or very minimal, so this causes the soil surface to be gradually eroded by rainwater that falls. This results in the ground surface becoming cracked. Cracks or acturing arising from erosion and rough soil texture make rainwater enter the fracturing and make the soil saturated. This is exacerbated by the condition of the steep slope causing the soil and saturated material to be unable to withstand the gravitational force of the slope so that it can cause landslides to occur. The following is each landslide-prone information on selected land units which can be seen in **Table 13** and spatially can be seen in **figure 11**.

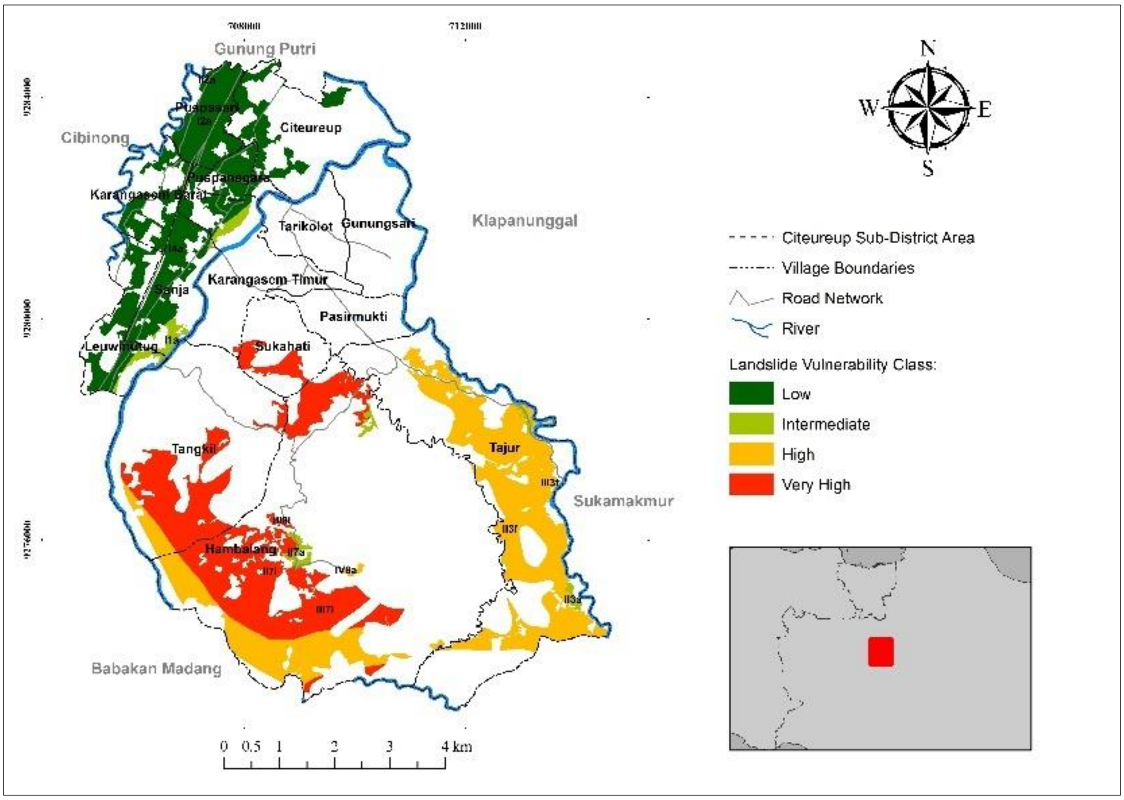

Figure 11. Landslide Suscaptibility Map of Selected Land Units
Source: Data Processing Results, 2022

Table 13. Landslide Suscaptibility of Selected Land Units

Land Unit	Village/Urban Village	Parameter of Landslide Prone					Prone to Landslides	Area (ha)
		Rainfall	Types of Rocks	Soil Type	Land Use	Slope Angle (%)		
I4a	Citeureup	3001 - 3500	Surface Deposits	Dystric Cambisol	Settlements	0 – 8	Low	0.76
I2a	Citeureup	3001 - 3500	Surface Deposits	Latosol Haplic	Settlements	0 – 8	Low	86.92
I4a	Karangasem Barat	3001 - 3500	Surface Deposits	Dystric Cambisol	Settlements	0 – 8	Low	48.53
I2a	Karangasem Barat	3001 - 3500	Surface Deposits	Latosol Haplic	Settlements	0 – 8	Low	28.12
I4a	Karangasem Timur	3001 - 3500	Surface Deposits	Dystric Cambisol	Settlements	0 – 8	Low	34.78
I2a	Karangasem Timur	3001 - 3500	Surface Deposits	Latosol Haplic	Settlements	0 – 8	Low	12.76
I4a	Leuwinutug	3001 - 3500	Surface Deposits	Dystric Cambisol	Settlements	0 – 8	Low	17.93
I4a	Leuwinutug	3501 - 4000	Surface Deposits	Dystric Cambisol	Settlements	0 – 8	Low	74.8
I4a	Puspanegara	3001 - 3500	Surface Deposits	Dystric Cambisol	Settlements	0 – 8	Low	25.01
I2a	Puspanegara	3001 - 3500	Surface Deposits	Latosol Haplic	Settlements	0 – 8	Low	28.81
I2a	Puspasari	3001 - 3500	Surface Deposits	Latosol Haplic	Settlements	0 – 8	Low	137.13
II2a	Puspasari	3001 - 3500	Surface Deposits	Latosol Haplic	Settlements	8 – 15	Low	4.11
I4a	Sanja	3001 - 3500	Surface Deposits	Dystric Cambisol	Settlements	0 – 8	Low	58.14
I4a	Sanja	3501 - 4000	Surface Deposits	Dystric Cambisol	Settlements	0 – 8	Low	56.03
II7a	Hambalang	3501 - 4000	Old Volcano	Oksic Cambisol	Settlements	8 – 15	Intermediate	22.04
I4a	Karangasem Timur	3001 - 3500	Old Volcano	Dystric Cambisol	Settlements	0 – 8	Intermediate	13.19
I1a	Leuwinutug	3501 - 4000	Old Volcano	Dystric Gleysol	Settlements	0 – 8	Intermediate	4.04
I4a	Leuwinutug	3501 - 4000	Old Volcano	Dystric Cambisol	Settlements	0 – 8	Intermediate	7.38
I4a	Sanja	3001 - 3500	Old Volcano	Dystric Cambisol	Settlements	0 – 8	Intermediate	1.12
I1a	Sanja	3501 - 4000	Old Volcano	Dystric Gleysol	Settlements	0 – 8	Intermediate	12.29
I4a	Sanja	3501 - 4000	Old Volcano	Dystric Cambisol	Settlements	0 – 8	Intermediate	4.78
II3a	Tajur	3501 - 4000	Old Volcano	Mediterranean Haplic	Settlements	8 – 15	Intermediate	11.59
III7i	Hambalang	3501 - 4000	Surface Deposits	Oksic Cambisol	Moor	15-30	High	103.79
II7i	Hambalang	3501 - 4000	Surface Deposits	Oksic Cambisol	Moor	8 - 15	High	108.47
IV8a	Hambalang	3501 - 4000	Old Volcano	Lithosol	Settlements	30-45	High	4.59
II3f	Hambalang	3501 - 4000	Old Volcano	Mediterranean Haplic	Mixed Garden	8 – 15	High	3.82
III3f	Tajur	3501 -	Old Volcano	Mediterran	Mixed	15-	High	35.58

Land Unit	Village/Urban Village	Parameter of Landslide Prone					Prone to Landslides	Area (ha)
		Rainfall	Types of Rocks	Soil Type	Land Use	Slope Angle (%)		
		4000		ean Haplic	Garden	30		
II3f	Tajur	3501 - 4000	Old Volcano	Mediterran ean Haplic	Mixed Garden	8 – 15	High	482.11
II7i	Tangkil	3501 - 4000	Surface Deposits	Oksic Cambisol	Moor	8 – 15	High	30.98
II7i	Hambalang	3501 - 4000	Young Volcano	Oksic Cambisol	Moor	8 – 15	Very High	0.34
III7i	Hambalang	3501 - 4000	Old Volcano	Oksic Cambisol	Moor	15-30	Very High	154.74
II7i	Hambalang	3501 - 4000	Old Volcano	Oksic Cambisol	Moor	8 – 15	Very High	270.18
III8i	Hambalang	3501 - 4000	Old Volcano	Lithosol	Moor	15-30	Very High	5.02
II7i	Karangasem Timur	3501 - 4000	Old Volcano	Oksic Cambisol	Moor	8 – 15	Very High	1.82
II7i	Sukahati	3501 - 4000	Old Volcano	Oksic Cambisol	Moor	8 – 15	Very High	38.51
II7i	Tangkil	3501 - 4000	Young Volcano	Oksic Cambisol	Moor	8 – 15	Very High	12.45
II7i	Tangkil	3501 - 4000	Old Volcano	Oksic Cambisol	Moor	8 - 15	Very High	189.49
	Total							2132.15

Source: Data Processing Results, 2022

CONCLUSION

Landslide insecurity in Citeureup District is divided into four categories, namely low, medium, high, and very high. The distribution of areas that fall into the category of low landslide prone is in the villages of Citeureup, Leuwinutug, Puspanegara, Puspasari, Sanja, as well as West Karangasem and East Karangasem Villages. Then, the distribution of landslide-prone category areas is in a small part of Hambalang Village, Leuwinutug, Sanja, and East Karangasem Village. The areas that are included in the category of high landslide prone are most of Hambalang, Tajur, and Tangkil Villages. While the category of landslide prone is very high, there are areas of Hambalang, Sukahati, Tangkil Villages, and a small part in East Karangasem Village.

The distribution of areas in the category of low and medium landslide prone has almost similar characteristics, namely dominated by a slope of 0-15%, deep soil solum, fine texture, and high rainfall. Land use is used for settlements and industrial buildings. The distribution of areas in the high landslide-prone category has slope characteristics ranging from 8-45% with shallow to deep soil solum, rough to fine texture, very high rainfall, and dominated by mixed garden land use and moor. Meanwhile, the distribution of areas in the category of prone to landslides is very high, has the characteristics of a slope ranging from 8-30% with a shallow soil solum, coarse texture, very high rainfall, and dominated by the use of moor land.

REFERENCE

Agustina, L.K., Danni, G. H., & Bilal A. F. 2020. Identifikasi Kawasan Rawan Longsor Berdasarkan

Karakteristik Batuan Penyusun di Kota Bandar Lampung. *Jurnal Geodesi dan Geomatika*, 03(1), 30-37. ISSN 2621-9883

BNPB. 2020. *Kejadian Bencana Tahun 2020.*

Damanik, M. R. S., & Restu, R. (2012). Pemetaan Tingkat Risiko Banjir dan Longsor Sumatera Utara Berbasis Sistem Informasi Geografis. *Jurnal Geografi*, 4(1), 29-42. DOI: https://doi.org/10.24114/jg.v4i1.7926.

Danil, E. A. (2008). *Identifikasi Kejadian Longsor dan Penentuan Faktor-faktor Utama Penyebabnya di Kecamatan Babakan Madang Kabupaten Bogor* (Doctoral dissertation, IPB).

Faizana F. 2014. *Pemetaan Risiko Bencana Tanah Longsor Kota Semarang*. Skripsi. Universitas Diponegoro. Semarang.

Faizana, F., Nugraha, A. L., & Yuwono, B. D. (2015). Pemetaan risiko bencana tanah longsor Kota Semarang. *Jurnal Geodesi Undip*, 4(1), 223-234. ISSN: 2337-845X.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). How to design and evaluate research ineducation.

Hardiyatmo, H. C. 2012. *Tanah Longsor & Erosi*. Yogyakarta: Gadjah Mada University Press.

Hidayat. R. (2018). Analisis Stabilitas Lereng Pada Longsor Desa Caok, Purworejo, Jawa Tengah. *Jurnal Sumber Daya Air*, 14 (1), 63 - 74.

IRBI, 2013. *Indeks Risiko Bencana Indonesia*. Kabupaten Bogor: Gedung INA DRTG.

Khafid, M. A. 2019. Analisis Penentuan Zonasi Pemukiman Risiko Bencana Tanah Longsor Berbasis Sistem Informasi Geografis: Studi Kasus Kecamatan Gedangsari, Kabupaten Gunung Kidul, Daerah Istimewa Yogyakarta. *Jurnal Meteorologi Klimatologi Dan Geofisika*, 6(1), 49-57.

Leng, M., Tanesib, J. L., & Warsito, A. (2017). Pemetaan Daerah Rawan Longsor dengan Penginderaan Jauh dan Sistem Informasi Geografis di Kabupaten Timor Tengah Utara Provinsi Nusa Tenggara Timur. *Jurnal Fisika: Fisika Sains dan Aplikasinya*, 2(1), 24-28.

Nandi. 2007. *Longsor*. Bandung. FPIPS-UPI

Naryanto, H. S. (2011). Analisis Risiko Bencana Tanah Longsor di Kabupaten Karanganyar, Provinsi Jawa Tengah. *Jurnal Dialog dan Penanggulangan Bencana*, 2(1), 21-32.

Naryanto, H.S., Wisyanto, Sumargana, L., Ramadhan, R. & Prawiradisastra, S. 2016. Kajian Kondisi Bawah Permukaan Kawasan Rawan Longsor dengan Geolistrik untuk Penentuan Lokasi Penempatan Instrumentasi Sistem Peringatan Dini Longsor di Kecamatan Talegong, Kabupaten Garut. *Jurnal Riset Kebencanaan Indonesia (JRKI)*, 2(2): 161-172. ISSN: 2443-2733.

Nirwansyah, A. W., & Nugroho, A. (2015, June). Pengembangan Model Pembelajaran Mitigasi Bencana Gunungapi Slamet Bagi Siswa MI Muhammadiyah Singasari. In *Prosiding Seminar Nasional Pendidikan Geografi FKIP UMP 2015*, 6(13): 36-40. ISBN 978.

Nugroho, S. P., 2015. *Relevansi Bencana Hidrometeorologi dan Kerusakan Das di Indonesia*. Surakarta: Badan Nasional Penanggulangan Bencana.

Noor, Djauhari, 2010. *Geomorfologi*. Unversitas Pakuan: Bogor.

Pangaribuan, J., Sabri, L. M., & Amarrohman, F. J. (2019). Analisis daerah rawan bencana tanah longsor di kabupaten Magelang menggunakan sistem informasi geografis dengan metode standar nasional Indonesia dan analythical hierarchy process. *Jurnal Geodesi Undip*, 8(1), 288-297. ISSN :2337-845X.

Pusat Penelitian dan Pengembangan Tanah dan Agroklimat. (2004). Laporan Akhir Pengkajian Potensi Bencana Kekeringan, Banjir dan Longsor di Kawasan Satuan Wilayah Sungai Citarum-Ciliwung, Jawa Barat Bagian Barat Berbasis Sistem Informasi Geografi.

Pusat Vulkanologi dan Mitigasi Bencana Geologi. (2015). *Prakiraan Wilayah Potensi Terjadi Gerakan Tanah/Tanah Longsor dan Banjir Bandang di Seluruh Indonesia*. Jakarta: Kementerian ESDM.

Rahmad, R., Suib, S., & Nurman, A. (2018). Aplikasi SIG untuk Pemetaan Tingkat Ancaman Longsor di Kecamatan Sibolangit, Kabupaten Deli Serdang, Sumatera Utara. *Majalah Geografi Indonesia*, 32(1), 1-13. DOI: https://doi.org/10.22146/mgi.31882.

Ramadhan, T. E., Suprayogi, A., & Nugraha, A. L. (2017). Pemodelan Potensi Bencana Tanah Longsor Menggunakan Analisis SIG di Kabupaten Semarang. Jurnal Geodesi UNDIP, 6(1), 118-127. ISSN:2337-845X.

Ramdani, D., Kresnawati, D. K., & Apriyanti, D. (2021). Analisis dan Pembuatan Peta Daerah Potensi Longsor di Kabupaten Bogor Tahun 2019 Menggunakan Metode Pembobotan Pada Sistem Informasi Geografis. *Jurnal Teknik| Majalah Ilmiah Fakultas Teknik UNPAK*, 21(2).

Setiawan, Cahyadi. 2005. *Arahan Penggunaan Lahan Daerah Rawan Gerakan Massa di DAS Tinalah Kabupaten Kulonprogo*. Tesis. Universitas Gadjah Mada. Yogyakarta.

Sitorus, D. A. P., Bejo, S., & Muzambiq, S. (2021). Analisis Sebaran Spasial Kerentanan Longsor Sebagai Upaya Mitigasi Bencana di Kecamatan Berastagi Kabupaten KaroProvinsi Sumatera Utara. *Jurnal Serambi Engineering*, 6(3). DOI: https://doi.org/10.32672/jse.v6i3.3040.

Undang-Undang No.24 Tahun 2007 tentang Penanggulangan Bencana.

Wang, F., Xu, P., Wang, C., Wang, N., & Jiang, N. (2017). Application of a GIS-based slope unit method for landslide susceptibility mapping along the Longzi River, Southeastern Tibetan Plateau, China. *ISPRS International Journal of Geo-Information*, 6(6), 172. DOI: https://doi.org/10.3390/ijgi6060172.

Yassar, M. F., Nurul, M., Nadhifah, N., Sekarsari, N. F., Dewi, R., Buana, R., & Rahmadhita, K. A. (2020). Penerapan Weighted Overlay Pada Pemetaan Tingkat Probabilitas Zona Rawan Longsor di Kabupaten Sumedang, Jawa Barat. *Jurnal Geosains dan Remote Sensing*, 1(1), 1-10. DOI:https://doi.org/10.23960/jgrs.2020.v1i1.13.

Yuniarta, H., Saido, A. P., & Purwana, Y. M. (2015). Kerawanan bencana tanah longsor Kabupaten Ponorogo. *Matriks Teknik Sipil*, 3(1).