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Analysis Of Landslide Susceptibility In The Cugenang New Fault Area In The North Of Cianjur Regency

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ABSTRAK

Longsor adalah bencana yang sering terjadi di Indonesia khsusunya pada morfologi yang memiliki topografi kasar. Bencana ini disebabkan baik faktor tektonis berupa sesar, faktor alam seperti curah hujan, topografi, jenis tanah, jenis batuan, dan faktor aktivitas manusia seperti perubahan lahan yang tercakup dalam tutupan lahan atau faktor lain yang berhubungan dengan pemicu longsor. Penelitan ini berlokasi di kabupaten Cianjur bagian utara, wilayah terletak di antara pegunungan vulkanik aktif yang memiliki sebaran batuan sedimen dan batuan vulkanik, yang termasuk ke dalam zona fisiografi Bandung, dan memiliki sesar baru Cugenang. Unit analisisnya adalah kecamatan, yang berjumlah 10 kecamatan. Tujuan penelitian ini untuk menganalisis sebaran kerawanan longsor di kabupaten Cianjur bagian utara. Pendekatan yang digunakan adalah spasial dengan menggunakan metode weight overlay untuk semua parameter yang sebelumnya sudah dianalisis dan di interpolasi. Hasil penelitian ini adalah kerawanan sangat tinggi mencakup 0,06%, kerawanan tinggi 47,49%, kerawanan sedang 52%, dan kerawanan rendah 0,01%. Wilayah yang mempunyai mayoritas kerawanan tinggi adalah Kecamatan Sukaresmi, dan kecamatan yang memiliki mayoritas kerawanan sedang adalah Kecamatan Cikalong Kulon, sementara untuk kerawanan rendah dan tinggi relatif tersebar di semua wilayah dengan persentasi yang kecil. Berdasarkan parameter yang dianlisis, disimpulkan curah hujan dan lereng menjadi faktor pendorong yang dominan dalam kerawanan longsor di kabupaten Cianjur bagian utara, karena memiliki bobot yang besar. Penelitian ini memberikan klasifikasi terkait wilayah rawan longsor yang ada di Cianjur bagian utara.

Kata Kunci: *Longsor***,** *Lereng, Weight Overlay, Curah Hujan*

ABSTRACT

A landslide is a disaster that often occurs in Indonesia, especially in morphology that has rough topography. This disaster is caused by faults, natural factors such as rainfall, topography, soil type, rock type, and human activity factors such as changes in land covered by a land cover or other factors related to landslide triggers. This research is located in the northern part of the Cianjur residency, this area is located between active volcanic mountains which have a distribution of sedimentary rocks and volcanic rocks, which are included in the Bandung physiographic zone, and have the new Cugenang fault. The unit of analysis is districts, which consist of 10 sub-districts. The purpose of this study was to analyze the landslide hazard distribution in the northern part of the Cianjur regency. The study used a sptial approach by using the weight overlay method for all parameters that have previously been analyzed and interpolated. The results of this study are very high Susceptibility covering 0.06%, high Susceptibility 47.49%, moderate Susceptibility 52%, and low Susceptibility 0.01%. The most vulnerable area is Sukaresmi, and the sub-district with moderate Susceptibility is Cikalong Kulon, while the low and high Susceptibility is relatively scattered in all areas with a small percentage. Based on the parameters analyzed, it means that rainfall and slope are the dominant driving factors in landslide Susceptibility in the northern part of the Cianjur regency because they have a large weight. This study provides a classification related to landslide susceptibility mapping in the northern part of Cianjur.

Keywords: Landslide, Slope, Weight Overlay, Rainfall

INTRODUCTION

Indonesia is a country located between the Eurasian and Indo-Australian plates. Plate movement produces powerful earthquakes and triggers landslides (Fan *et al*., 2019). One such example is the city of Palu (Zhao, 2021) and the island of Lombok (Zhao *et al*., 2021). This disaster caused damage to facilities, the economy, health, and psychology (Burrows *et al*., 2021). Based on it is very important and a concern to overcome this disaster.

A landslide is a natural phenomenon in which the mass of soil or rock on the slope slides downward as a whole or spreads under the influence of rainfall, earthquakes, or other factors, and is also the deadliest and most detrimental natural disaster (Davies, 2015). Many factors cause landslides such as rainfall, topography, human activities, and soil type (Liao *et al*., 2022). Even rainfall is an important thing that must be considered (Zhao *et al*., 2022) of course with rainfall above 1000 mm/year. In addition, fault areas have a high Susceptibility (Delgado *et al*, 2022). Then these existing factors become very relevant and essential to be studied in Indonesia.

West Java is a province that has a unique landscape and a rough topography. (van Bemellen, 1946). Cianjur Regency is one of the regencies located in West Java, which has an altitude of 7 – 2900 meters above sea level. The Cianjur regency, especially in the northern region, is a tourism destination and agriculture area (Kompas, 2023) that encourages changes in land use (Li *et al*., 2020), for the conversion of buildings and non-forests (Chen *et al*., 2020). If this continues to occur, especially in the highlands, it will be possible to encourage landslides in the area.

The northern Cianjur regency is one of the areas at the foot of Mount Pangrango (BPS, 2020). The earthquake that occurred on November 21, 2022, with a magnitude of 5.6 on the Richer Scale (BMKG, 2022) had an extraordinarily destructive effect, especially in the wake-up area and loss of life (CNN Indonesia, 2022), and allowed it to affect the psychological conditions of people who experienced it (Wang, 2020). This area was also identified as having a new fault called Cugenang (BMKG, 2022), which allows disasters like this to recur. This is important because it caused landslides in several districts.

The impact of landslides can affect groundwater (Ibeh, 2020) reducing the quantity of agriculture, reducing income, forcing you to work harder, and increasing your daily needs (Pham *et al*., 2021). So with these excesses, preventive steps are needed to minimize losses. This study aims to analyze the Susceptibility of landslides in the northern area of Cinajur in an effort to see the distribution of landslides in ten districts, the research location.

In analyzing the potential for landslides, several very important parameters are used, namely rainfall, soil type, land cover, rock type, and slope (Rahmad *et al*., 2018). Rainfall is a very essential factor in influencing soil, and can affect soil permeability, thus triggering erosion (Chidi *et al*., 2022), especially if the ground above is bare due to human activity, it will greatly trigger landslides (Muñoz-Torrero *et al*., 2022). The type of soil will affect the Susceptibility of whether the soil is solid or not, and landslides affect soil quality (Li *et al*., 2023). Land cover can indicate the importance of the land, particularly in land conversion from vegetation to non-vegetation (Pisano *et al*., 2017). Rock types are greatly affected by tectonic conditions and rock deformation affects landslides (Delchiaro *et al*., 2023). The slope of the slope is an important factor besides rain because it can identify how much land is vulnerable to landslides (Shankar *et al*., 2022).

Thus, examining the parameters above will provide a detailed picture related to the potential for landslides in the future in the Cianjur residency area's north side. This study emphasizes susceptibility with several parameters, which is different from other studies. This is important, this area is an area with a very high earthquake Susceptibility due to the discovery of new faults, as well as follow-up disasters such as landslides. This study aims to see the distribution of landslide-prone areas or called landslide susceptibility mapping.

RESEARCH METHODS

Time and Location of Research

The research location is located in the Cianjur residency with an area of 67,407.802 hectares. The time for carrying out this research was two weeks from 1 to 14 December 2022. The research locations were in 10 sub-districts in the northern part of Cianjur residency, namely Cianjur, Cikalong Kulon, Cipanas, Cugenang, Gekbrong, Karang Tengah, Mande, Pacet, Sukaresmi, and Warungkondang (**Figure 1**). This area is an area with an altitude of 225 – 2,962 meters above sea level (BPS, 2022) with a rough topography of mountains and hills.

Cianjur Regency is an area that has a rough topography and high slope (Belousov et al., 2015) which has 169 natural disaster events in 2021, with landslides dominating these events (Kompas, 2021). Based on the geological structure, the northern part of Cianjur Regency is included in the physiography of Bandung, which borders the Bogor zone, has quarter mountains which dominated by young volcanic and alluvial deposits (van Bammelen, 1946) Weathering processes in volcanic rocks and soil erosion by rain encourage landslides (Noviyanto *et al*., 2020). Supported geological structures in the form of folds, joints, fractures, and faults have intensive movement causing easy landslides (Hawkins, 1985). In addition, joints and faults can be a path for water to seep, thus allowing landslides to occur. So that this area has a significant potential for landslides and good to make landslide suspectibility mapping.

Tools And Materials

The tool used in the analysis process in this study is the ArcGis 10.8 software (ESRI, 2019), which makes it easy to process data for each parameter. Microsoft Exel is used to analyze attribute data on the map, so that the results obtained are more accurate and by the conditions in the field, satellite imagery, is used to obtain information to see real conditions, cameras are used to take documentation and evidence that has occurred in the field.

While the material in this study was rainfall data from the Climate Hazards Group InfraRed Precipitation with Station or CHRIPS (data.chc.ucsb.edu) which were then interpolated using ArcGis 10.8 (Funk *et al*., 2015). To obtain a map of rainfall in the study area. Slope data taken from DEMNAS 2018 is accessed at https://tanahair.indonesia.go.id/demnas/ , then processed using ArcGIS, resulting in a slope class. Soil types is obtained from the Geonetwork (FAO, 2019) and then given a name according to the code listed on the map attribute. Land cover data were taken from the 1:25,000 Scale Map of Indonesia in 2018, published by the Geospatial Information Agency (BIG). Data on rock types obtained from Indonesia Geospatial can be accessed at https://www.indonesia-geospasial.com/. Administrative Boundary data was obtained from the 2019 population and civil registration or dukcapil data, this data is also taken as a measure of land area per sub-district in the Northern Part of Cianjur Regency.

Data Collection, Processing, And Analysis Methods

The collection of research data consists of secondary data. The data were collected from several institutions and websites that provide them, specifically in the form of parameters such as rainfall, slope, soil type, land cover, rock type, and administrative boundaries. The secondary data was then overlaid to produce a hazard map for the northern part of the Cianjur residency. Data processing used Arcgis 10.8. software with basic geoprocessing tools, which could be described: 1. Clip to cut each data, using the administrative boundaries of the northern part of Cianjur residency which consists of 10 sub-districts, 2. Then, each parameter is weighted according to Central regulations for Soil and Agro-climate Research or Puslittanak see **Tabel 1** (Diana *et al.*, 2020). After each map was weighted, it was then analyzed using the overlay method, resulting in an analysis of landslide hazards.

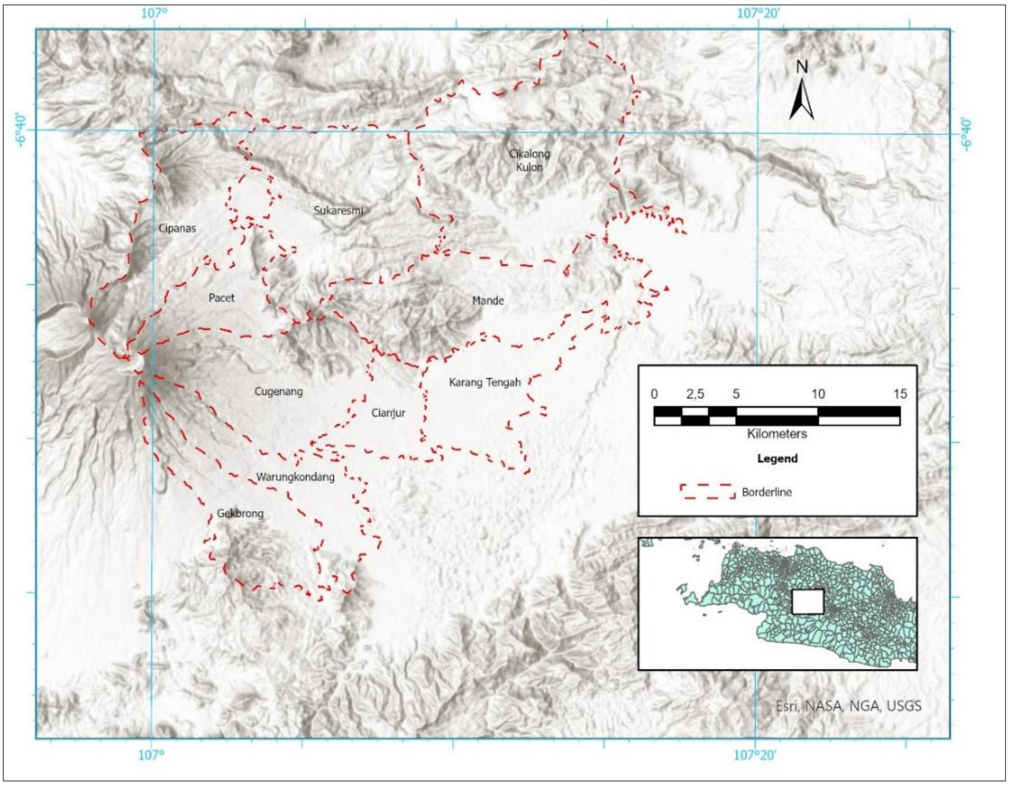

Figure 1. Map of Research Locations

Table 1. Classification of Parameters on Every Variable which explain 1) Very Low, 2) Low, 3) Middle, and 4) High

Variable	Parameter	Score	Value of Weight
Rainfall	High (>3000)	4	
	Middle (1500-3000)	3	30%
	Low (1000-1500)	2	
	Very Low (<1500)	1	
Soil	Regosol, Litosol, Organosol	5	
	Andosol, Laterit, Grumosol	4	10%
	Brown Forest Soil, Mediteran	3	
	Latosol	2	
	Aluvial, Planosol, hidromoft	1	
Land Use	High (Rice Field and Settlement)	4	
	Middle (shrubs and grass)	3	20%
	Low (plantations and fields)	2	
	Very Low (Natural Forest)	1	
	Non-land cover	0	
Rock	Vulcanic	3	
	Sediment	2	20%
	Alluvial	1	
Slope	High (> 45%)	4	
	Middle (30-45%)	3	20%
	Low (15-30%)	2	
	Very Low (>15%)	1	

Sources: Bălteanu *et al.,* (2020)

RESULT AND DISCUSSION

Rainfall Distribution

The condition of the northern part of the Cianjur residency is an area with a mountainous landscape, which allows it to have high annual rainfall. If we look at **Figure 2**. It can be explained that all districts have rainfall above 3500 mm/year. With a distribution of 3500 – 3800 mm/year covering 25% of the area, which stretches from east to south, a distribution of 3800 – 4100 mm/year covers 44% of the area which forms the majority of the area from north to south which includes the Gekbrong area, Warungkondang, Cugenang, a small part of Cianjur, Mande, Sukaresmi, and Cikalong Kulon.

Based on the explanation above, it can be concluded that the higher the altitude, the more rainfall. Thus, slopes that are bare or have weak soil structures may have the potential for landslides (Raimondi *et al*., 2023). Rainfall is very influential on landslides (He *et al*., 2022), so it is necessary to pay attention to the condition of rainfall in this region, especially with the addition of the new Cugenang fault.

Soil Type Distribution

The types of soil found in the North of Cianjur Regency are quite diverse, and are very closely related to volcanoes, because they are right at the foot of Mount Pangrango. Based on **Figure 3**. It can be explained that alluvial land has a percentage of 19% or around 12,823 hectares of the total area of Northern Cianjur Regency, which incidentally is good for agriculture. Then Andosol is the largest soil type, around 63% or 42,406.53 hectares of the total area totality. While the rest is Planosol with a percentage of 18% or 12,823 hectares of the entire area spread to the north in the Cikalong Kulon District, and the south a small portion of Warungkondang and Gekbrong.

Based on the explanation above, alluvial soil that is right above the fault geological structure is mobile soil (McClain *et al*., 2021) coupled with this area having rainfall above 3500, this area is very prone to landslides.

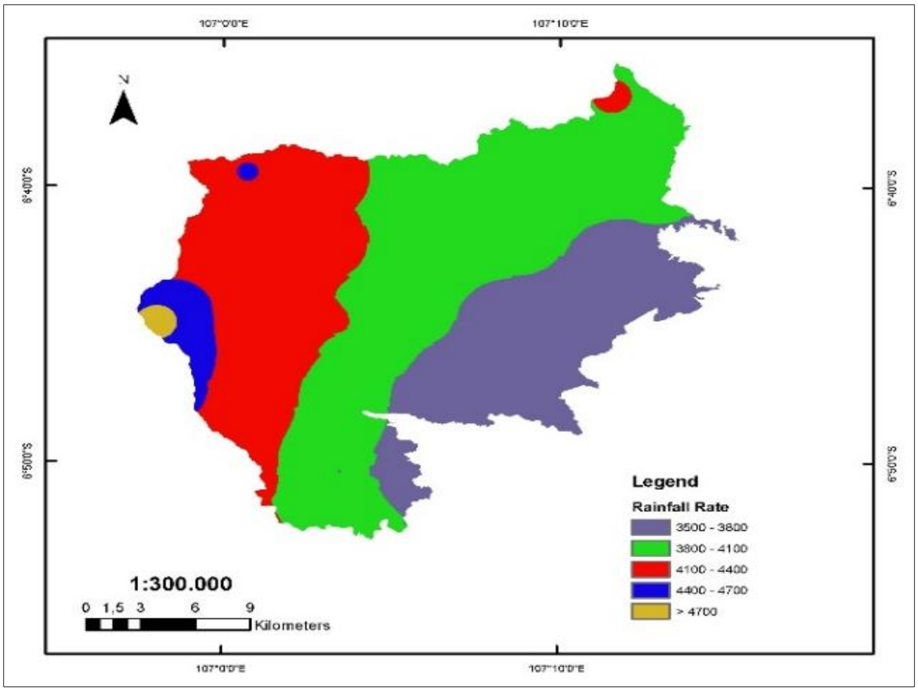

Figure 2. Map of Rainfall Distribution

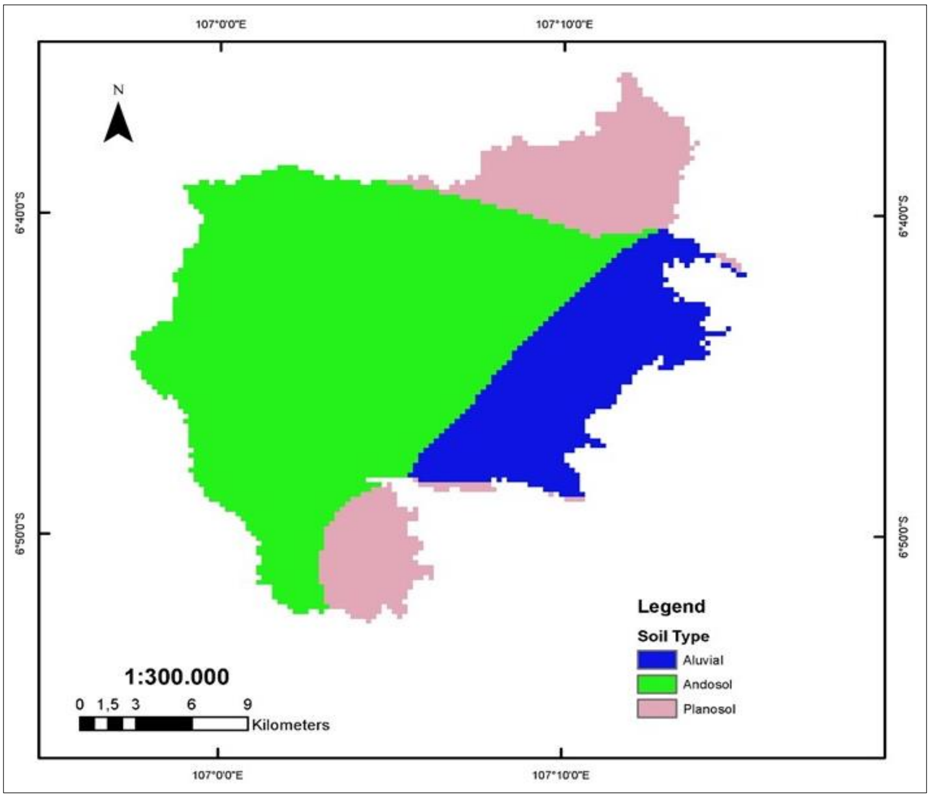

Figure 3. Map of Soil Type Distribution

Landuse Distributin

Land use in the north of Cianjur Regency can be seen in **Figure 4**. This land use weights 20%, it can be explained that the largest land used is plantations which have a total area of 22,383.29 hectares or 33%, followed by rice fields with a total of 17,09 .51 hectares or around 26% of the total area, while for settlements and places of activity, it has an area of 4,833.48 hectares or 7% of the total area. If you add up the Settlements and Rice Fields, you will get 33% which is the same value as plantations or gardens. As is known, these plantations are divided into two, namely hard plantations such as rubber and tea which are not easily changed, and soft plantations, such as banana plantations which are relatively volatile, and cause easy land shifts. While the forest has a value of 15% or has an area of 9,927.95 hectares which is spread to the west which is the slope of Mount Pangrango.

Thus it can be concluded that areas with low ratios of non-vegetation or vegetation land cover (Quiquerez *et al.*, 2022), deforestation (Muñoz-Torrero Manchado *et al.*, 2022), and settlements that are in the rather steep class (Gao *et al.*, 2022) and steep ar has the potential for greater ground movement. So this factor is very important to note.

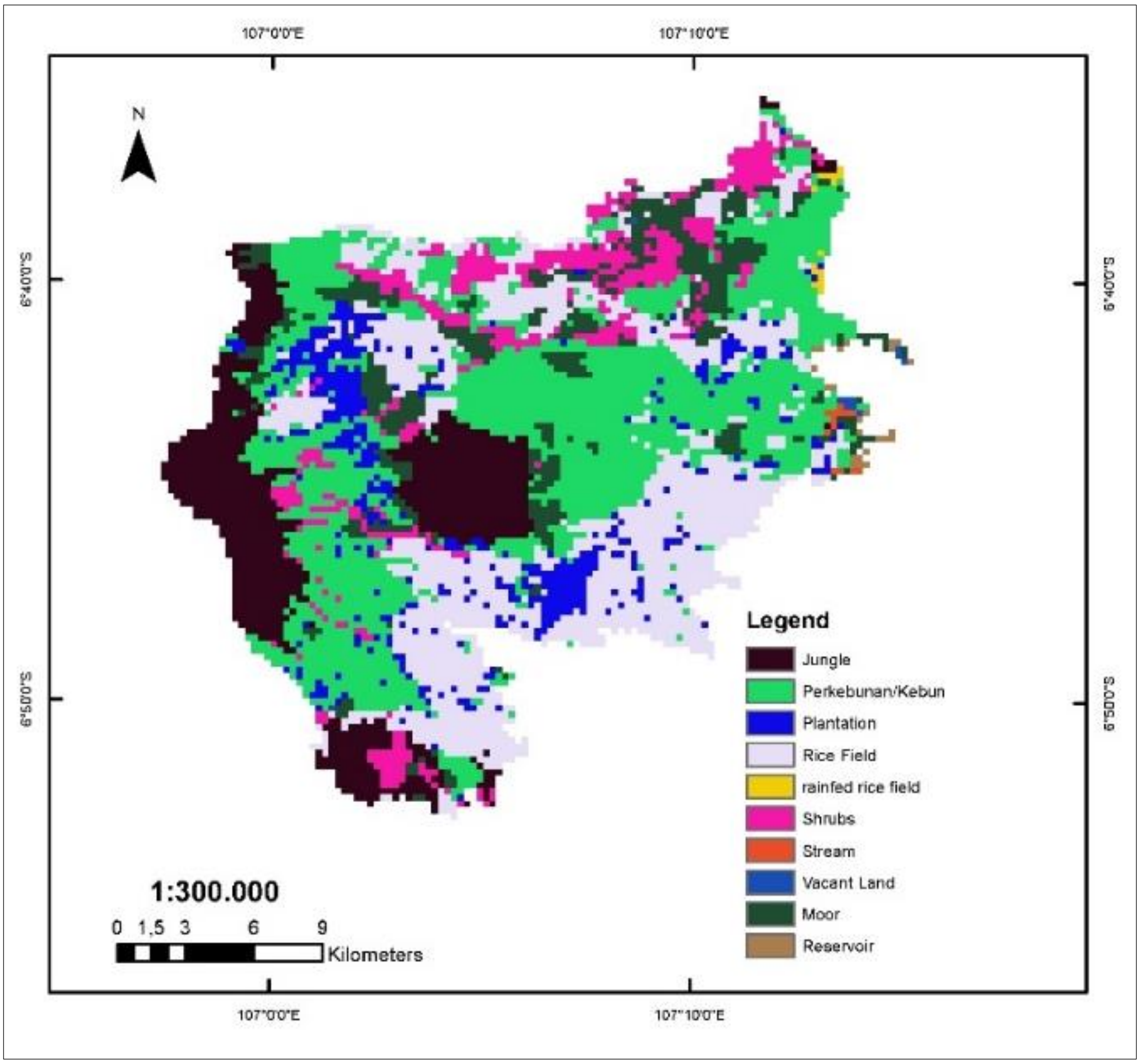

Figure 4. Land Use Map

Rock Type Distributin

There are three types of rocks in Ciajur Regency in the north, namely Volcanic Rocks, Young Sediments and Old Sediments (**Figure 5**). Volcanic rocks cover 82% of this area or around 55,334 hectares, which has a weight of 3, meaning it is very vulnerable. Whereas for young sedimentary rocks it has 4,940 hectares or only 7%, the rest is old sediment with an area of 7,175.04 hectares or 11%.

It can be concluded that volcanic rocks are rocks that are easily saturated when exposed to rainwater, especially if there is no vegetation on the surface (Sinarta et al., 2021) meaning that it is very easy for soil movement in the form of landslides to occur in this area (Hardianto et al., 2020). Volcanic rocks, in general, this area is a prone area where mass movement of soil can occur at any time.

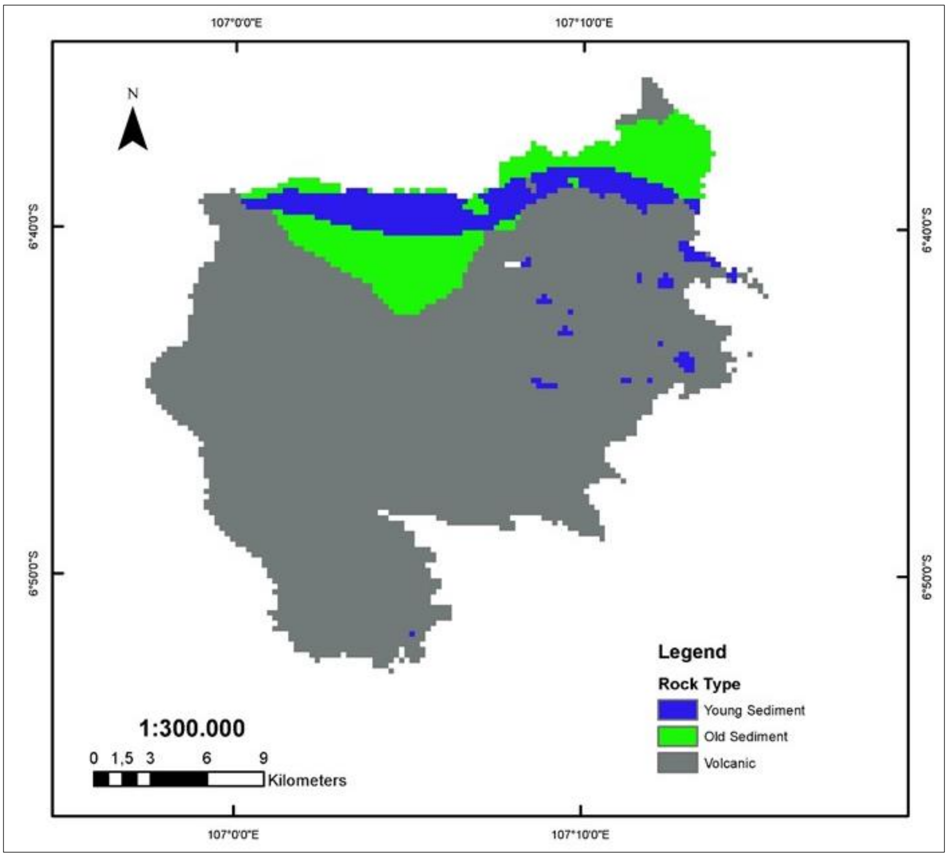

Figure 5. Rock Type Map

Slope

The northern part of the Cianjur is located residency in the mountains, and the slopes of the existing slopes are quite diverse. With the majority of a flat percentage of 51% of the total area, then Sloping at 21%, rather steep at 17%, steep at 9%, and very steep at 2% (**Figure 6**). The flat areas are concentrated in the east to south areas in almost all districts with the majority being in Karang Tengah and Cianjur. Meanwhile, the slopes of the gentle slopes are spread throughout the sub-district, while the steep slopes are most concentrated in Cikalong Kulon and Mande. The steep and very steep areas are in the area bordering Mount Pangrango and Mande District.

The slope of the slope greatly influences landslide activity, especially slopes that have a slope angle below the average (Williams *et al*., 2021) in Cianjur.

In addition, slopes with steep conditions, lots of rainfall, and large soil erosion encourage landslides (Zou *et al*., 2021) and also fault activity in the ground (Tseng *et al*., 2021). It can be concluded that the condition of the slopes in the northern part of the Cianjur residency, especially in areas with slopes above 30%, has a significant potential for landslides.

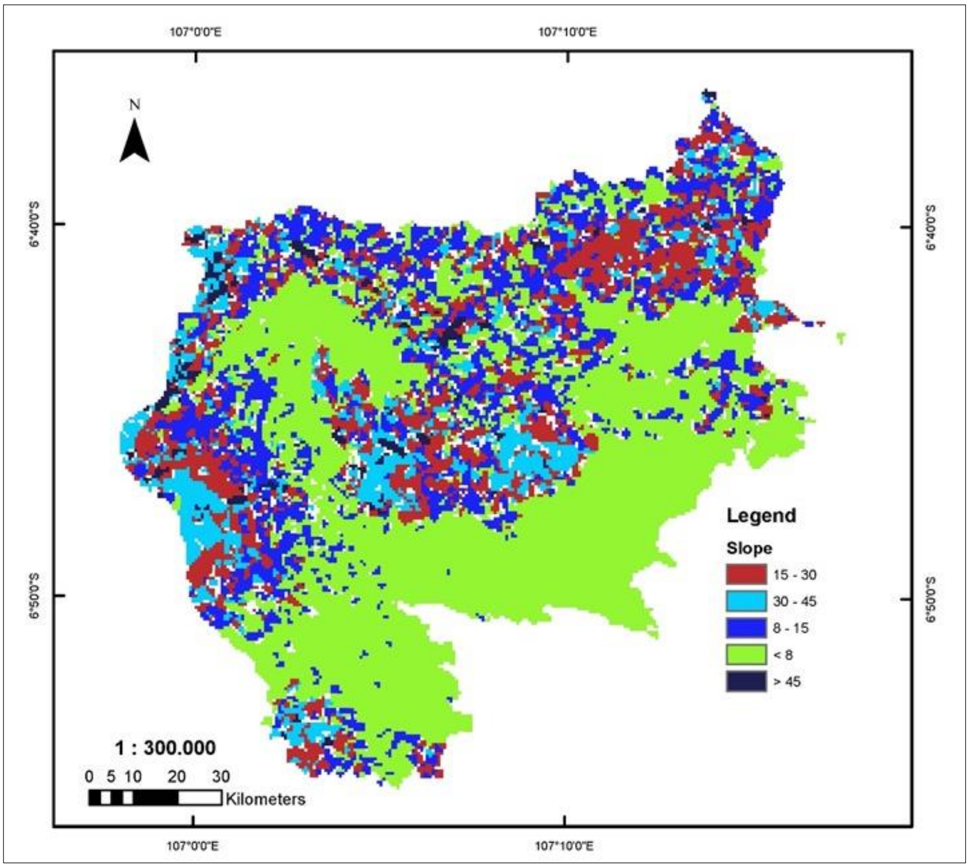

Figure 6. Slope Map

Susceptibility Level Distribution

The level of Susceptibility obtained from the map analysis of each parameter shows that only 10 hectares or 0.01% have low Susceptibility. Then around 34,535 hectares have moderate Susceptibility or around 52% which are spread in almost every district with the majority being in Karang Tengah, Cianjur, and Mande Districts. While the high Susceptibility, with an area of 31,273 hectares or equal to 47.49%, is relatively spread in each sub-district with the majority being in Cikalong Wetan, Sukaresmi, Cipanas, Pacet, Cugenang, and Warungkondang. This area with high Susceptibility must be the center of attention in applying spatial planning so that development does not go wrong. While it is very high, only 39 hectares, or equal to 0.06%, which are spread over the districts of Pacet, Cugenang, and Cikalong Wetan (**Figure 7**).

Based on **Figure 8**, The area that has the greatest high Susceptibility is Sukaresmi. This happens because this area has rainfall above 3500 mm/year, old sedimentary and volcanic rock structures, andosol soil types, the majority of land uses are settlements and rice fields, and slopes above 8%. Then for moderate Susceptibility, the highest is the Cikalong

Kulon District, and has the second high Susceptibility after Sukaresmi.

This is because the Cikalong Kulon region has the largest area compared to the 10 districts, and has a wide variety of slopes, has Alluvial, Planosol, and Andosol soil types, as well as high rainfall above. Thus it can be explained that the parameters of rainfall, soil type, land cover, rock type, and slope are effectively used to analyze landslide Susceptibility.

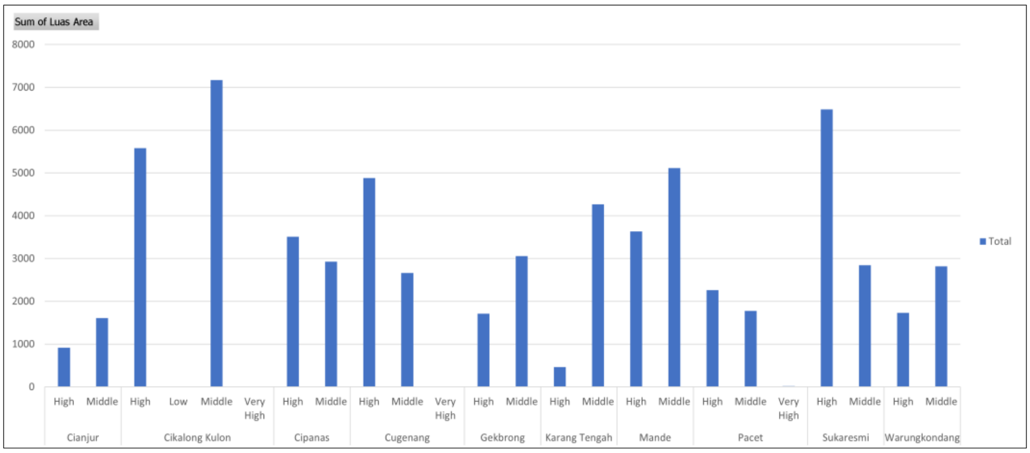

Figure 7. Graph of Landslide Susceptibility

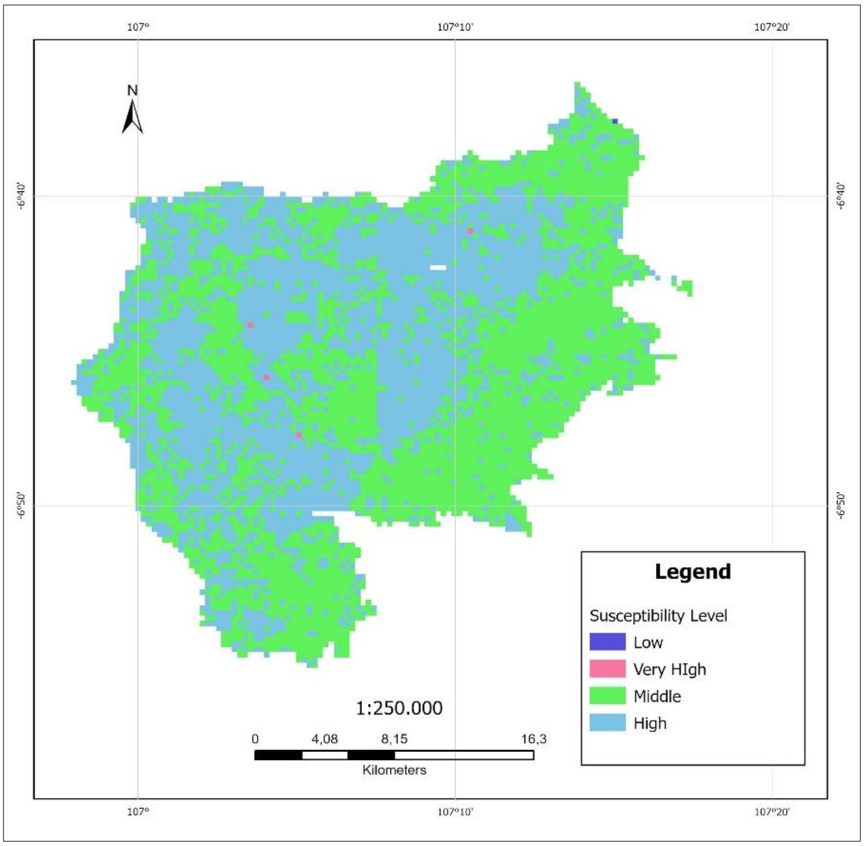

Figure 8. Landslide Hazard Map

CONCLUSION

Based on research in the 10 districts, it can be concluded that the districts that have very high Susceptibility are Pacet, Cugenang, and Cikalong Wetan. Then the areas with high Susceptibility are Cikalong Kulon, Sukaresmi, Cipanas, Pacet, Cugenang, and Warungkondang. Moderate Susceptibility is almost spread over all districts, and no areas with very low Susceptibility are found.

From the parameters that have been tested, the rainfall factor is the highest factor affecting the level of Susceptibility, meaning it is the dominant factor. So, if the rainfall changes, it is possible that the Susceptibility map will also change. Some of the landslide points are greatly affected by steep slopes, and erosion-prone soil types that are sensitive to rain.

So this study it is a stimulus for related parties, especially in the preparation of regional spatial layouts or even basic spatial planning that can be considered wisely so that undesirable events do not occur. Engineering and vegetative engineering can also be used to reduce the risk of landslides such as by planting hard-rooted trees in areas prone to landslides.

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