LAND MOVEMENT VULNERABILITY ZONING IN THE HILLY AREA OF NORTHERN CILACAP, CENTRAL JAVA

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ABSTRACT

The northern part of Cilacap has an area with hilly morphology with slopes that are relatively gentle to steep. The geological setting in this region is quite complex, the combination of tectonics and the physical properties of the rocks means that this region is strongly deformed. This has an impact on areas prone to land movement as one of land movement types. To what extent can this area be classified based on the vulnerability of its land to land movement is the problem be studied. There are five aspects used in this research, namely rock type, soil type, slope, land cover, and rainfall. The spatial distribution of land movement-prone zones is supported by a multi-aspect overlay method. Geographic Information System-based software support makes the data analysis process easier. The results of the spatial analysis of the five aspects then concluded that the hilly area of northern Cilacap can be grouped into 3 land movement vulnerability zones, namely the low vulnerability zone with a score of 8-17, the medium vulnerability zone with a score of 18-27, and the high vulnerability zone with a score of 28-37. The complex tectonic order is the main controller of land movement events in this region.

Keyword: Cilacap, land movement, landslide, morphology, spatial analysis

INTRODUCTION

In general, the research area and its surroundings are hilly areas with heights ranging from 140 meters to 550 meters above sea level (Nurfadli, 2023). The research area is at coordinates 261250-267250 mN, 9179150-9188150 mE, included in Zone 49 in the UTM projected coordinate system (Figure 1). This area is known as a landslide-prone area, based on previous research results. This research aims to zone land movement areas based on rainfall, slope, land cover, soil type and rock type aspects.

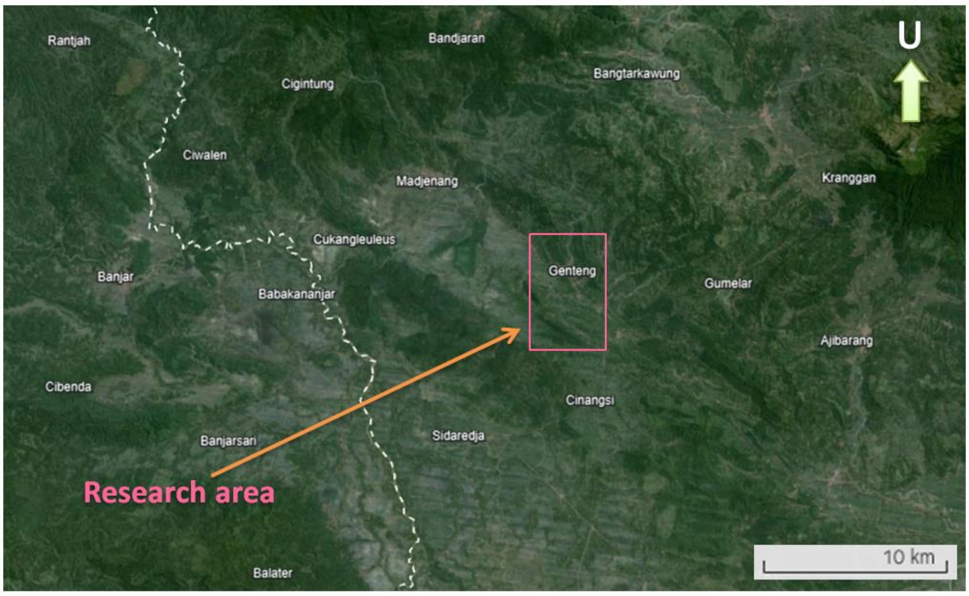

Figure 1. The location of the research area is a folded and faulted hilly area in the northern part of Cilacap Regency, Central Java (https://earth.google.com).

Several problems that are often encountered in the research area related to land movement are the result of poor technical properties of the soil, including

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being characterized by high water content which can accelerate the occurrence of ground movement and has several controlling factors including high levels of weathering, the relatively steep morphology of the research area, developed geological structure, land use, and high rainfall (Hardiyatmo, 2010). This increase in danger will be higher if researchers are completely unaware of the potential response to land movement at that location. This research shows that natural disasters have caused quite a lot of loss and suffering, both human and material, as a result of the combination of landslide hazards and the complexity of other problems. Efforts that can reduce the risk of land movement disasters include carrying out mitigation activities, namely efforts to minimize the impact of land movement vulnerability.

Based on information obtained from the local community, the level of land movement vulnerability zones in the area under study is not yet known, therefore it is necessary to create a map of land movement vulnerability zones, which is a form of disaster management, so this research refers to standard methods or general guidelines. One general guideline that can be used is the Indonesian National Standard 13-7124-2005 concerning the preparation of land movement vulnerability zone maps (BSN, 2005). This guideline is one of the minimum standards for disaster management organizers. Therefore, the Geographic Information System (GIS) method is very important to minimize damage and loss both physically and socially in the research area so that we can carry out various ways of preventing it (Aronoff, 1989).

RESEARCH METHOD

The type of research carried out is mix-methods research, namely research that combines two forms of approach, namely, qualitative and quantitative. Quantitative research is a mathematical modeling that uses a model that refers to Soil and Agroclimate Research Center (Puslittanak) as a tool for analyzing the information you want to know (Puslitanak, 2004). Meanwhile, qualitative research is a method that is descriptive or provides a clear picture and is in accordance with the facts in the field. The model used to analyze land movement vulnerability is an estimation model that refers to research with the formula (Puslitanak, 2004):

$$TS = 0.3R+0.2Br+0.2S+0.2Lu+0.1So$$

Explanations:
TS = Total Score
R = Rainfall Factor
Br = Rock Type Factor
S = Slope Factor
Lu = Land Cover Factor
So = Soil Type Factor
0.3;0.2;0.1 = Value weight

Table 1. Weights and values of the controlling factors of land movement (Nurfadli, 2023)

Control Factor	Parameter	Weight	Parameter Value
Rainfall	Very Wet (>3000) Wet (2501-3000) Medium (2001-2500) Dry (1501-2000) Very Dry (<1500)	30%	5 4 3 2 1
Slope	very steep (>70%) steep (30-70%) moderately steep (15-30%) sloping (8-15%) flat - almost flat (0-8%)	20%	5 4 3 2 1
Land cover	moorland, rice fields shrubs forests and plantations city/settlement ponds, reservoirs, waters	20%	5 4 3 2 1
Soil type	regosol, andosol podzolic chocolate latosol yellowish brown latosol association Alluvial	10%	5 4 3 2 1
Rock type	Volcanic rock Sedimentary rock Alluvial rock	20%	3 2 1

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Classification of final results using score analysis is carried out by overlaying the 5 parameters obtained in the field. Then 4 classes of landslide susceptibility were created, namely: low, medium, high and very high based on the final score, the greater the score, the higher the level of vulnerability (Yunianto, 2011).

RESULT AND DISCUSSION

The data used in this study consists of primary and secondary data. Primary data was obtained from field observation activities, while secondary data was obtained from various sources including BMKG (BPS Kab. Cilacap, 2023), Nurfadli (2023), Puslitanak (2004), Kastowo & Suwarna (1996). Before carrying out a slope stability analysis, the data required in this research is first collected in the form of primary data and secondary data sourced from direct observations in the field, these data are in the form of. Secondary data collected through measurements in the field is in the form of data from 4 landslide points, then measurements and soil samples are taken, then a sample code is given at each landslide point as follows:

The results of observations at four ground movement measurement locations are shown in Table 2. The recorded data includes location coordinates, elevation, type of ground movement, slope height, slope width, slope azimuth, slope inclination.

Secondary data is data that has been sourced from archives and literature relating to previous research studies. This data relates to factors controlling land movement events, including rainfall, soil type, rock type, slope, and land use (Table 2).

Table 2. Observations of land movement phenomena at four locations in the research area

Observation aspect	Observation area			
	Mandala Village	Cidadap Village	Kutasari Village	Babakan Village
Location	262000 mN 9187000 mE	262500 mN 9181000 mE	262000 mN 9183000 mE	267000 mN 9186000 mE
Elevation	117 Meters	75 Meters	175 Meters	225 Meter
Type	Rockfall	Rotational landslide	Rotational landslide	Rotational landslide
Slope Height	± 9 Meters	± 7 Meters	± 12 Meters	± 30 Meter
Slope Width	± 21 Meters	± 25 Meters	± 21 Meters	± 25 Meter
Slope azimuth	N 275° E	N 275° E	N 275°E	N 275°E
Slope inclination	55°	45°	51°	52°

Figure 2. Appearance of land movement phenomena at several observation locations in the hilly areas in the north of Cilacap Regency; (a) Mandala Village, (b) Cidadap Village, (c) Kutasari Village, (d) Babakan Village

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Rainfall based on data obtained from BMKG (BPS Kab. Cilacap, 2023). The northern part of Cilacap tends to show an average annual rainfall intensity of medium, namely in the range of 2000 - 2500 mm (Table 2).

The orthic acrisol and feralic combisol soil types are in the research area. They have a good level of porosity and a water content of more than 50%. Therefore it can be concluded that the research area is an area that is very susceptible to land movement. Laterally distributed, feralic cambisols occupy 80% of the research area; the rest is occupied by orthic acrisols.

Sedimentary rocks make up the research area, namely alternating sandstone, claystone, and silt (Kastowo & Suwarna, 1996). The proportion of sandstone is relatively high and relatively porous. The presence of claystone and silt becomes a significant slip plane so that when there is high intensity rain, it will cause a load on the rocks so those land movements easily occur.

The research area was classified into five slope classes based on modification from van Zuidam (1983). They are flat-almost flat, sloping, moderately steep, steep, and very steep (Table 2).

The number of changes in vegetation as land use in the forest stand area or dense vegetation into mixed gardens, bushes, settlements, or becoming empty land will have a big impact on land movement. The impact is significant, especially in forest areas that have been converted into mining land. The results of spatial data analysis show that the land cover in the research area are forest (65%), plantation (2.4%), rice field (2.6%), shrubs (6%), moor (12%) and settlement (12%).

Based on the results of the analysis of the total scores resulting from the overlap of the five parameters at the research location, a classification of vulnerability classes was obtained with score intervals for each level of vulnerability where the higher the total score, the higher the level of landslide vulnerability in the research area.

The calculation results of the total score of the overlay results of the five parameters at the research location obtained a range between 8 and 37. Furthermore, the total score as a reflection of land vulnerability is classified into three classes. The classification of land vulnerability is low zone with a score of 8 to 17, medium zone with a score of 18 to 27, and high zone with a score of 28 to 37. The spatial distribution of land vulnerability classification in the research area is shown in Figure 3. The dominance of high land movement - prone areas is caused by complex geological seting. Alternating sandstone and claystone controlled by intensive tectonics support the results of the analysis.

CONCLUSION

The results of spatial analysis of five parameters suspected of influencing land movement showed that the research area is divided into three zones of land movement vulnerability; i.e. low, medium and high. High land movement vulnerability dominates the research area. This is due to high tectonic control. In addition, the lithology of the composition, namely the alternation of sandstone and mudstone, also increases the occurrence of landslide phenomena.

Table 3. Recapitulation of data related to land movement controlling factors in the research area

Control Factor	Parameter	Weigh	Parameter Value
Rainfall	Medium (2001-2500)	30%	3
Slope	Very steep (>70%) Steep (30-70%) Moderately steep (15-30%) Sloping (8-15%) Flat - almost flat (0-8%)	20%	5 4 3 2 1
Land Use	Moorland & rice fields Shrubs Forests and plantations City/settlement Ponds, reservoirs, waters	20%	5 4 3 2 1
Type of soil	ferulic combisol orthic acrisols	10%	3 2
Rock Type	Sedimentary rock	20%	2

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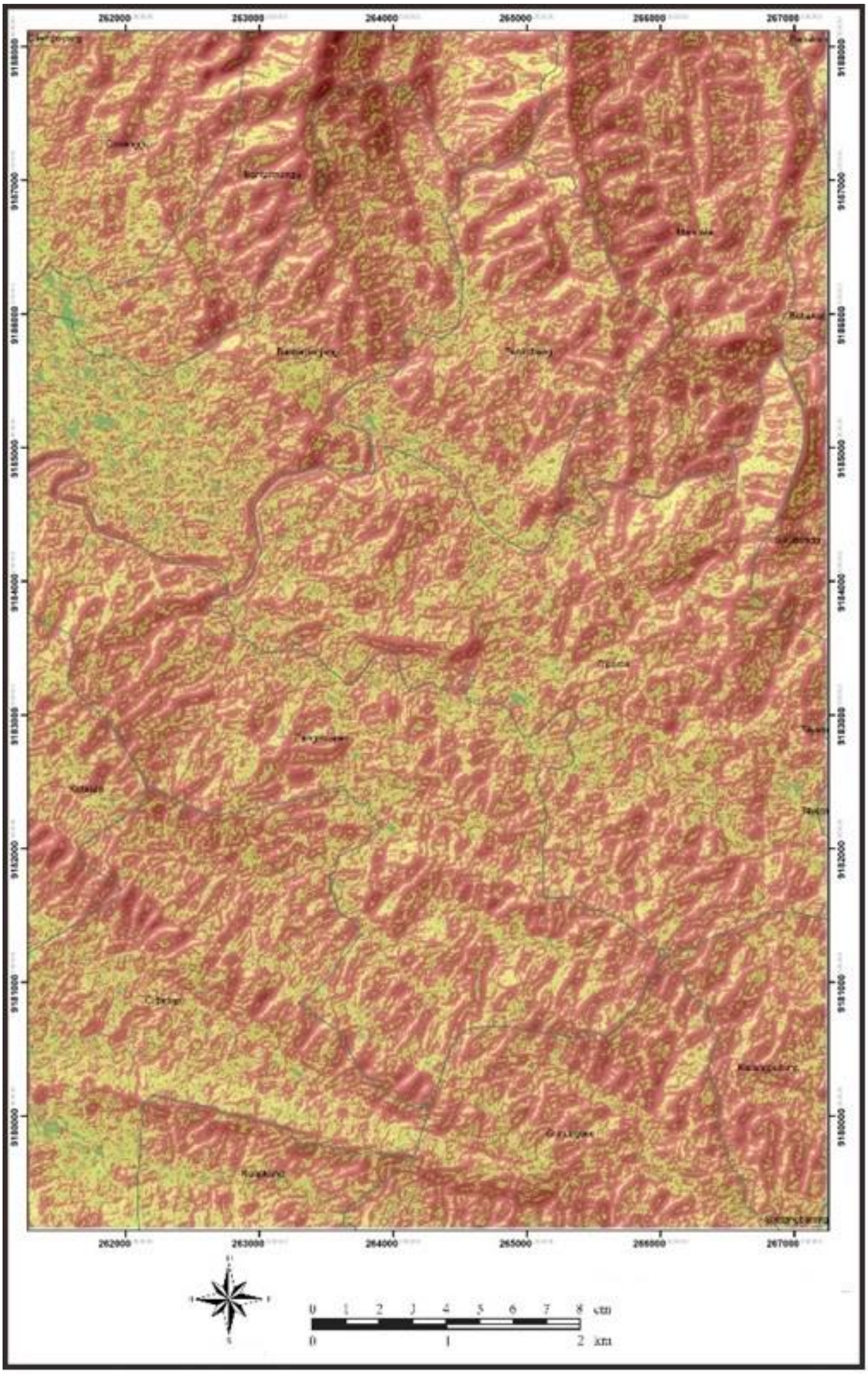

Figure 3. The spatial distribution of land vulnerability zones at the hilly area of northern Cilacap, Central Java; low zone is indicated by green areas, middle zone by yellow, and high zone by red.

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