International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Identification of Landslide Disaster Zones Using Geographical Methods (GIS) in Cipatat and Surrounding Areas, West Java Province

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Abstract**—** *The Bandung zone has a relatively perpendicular movement with a speed of 6 - 7 cm/year so it becomes a factor in the frequent occurrence of earthquakes after a certain period at the plate contact boundary, resulting in landslides in several areas. The research area is administratively located in the Cipatat area and its surroundings, geographically it is at coordinates104^0 17' 30" E – 107^0 23' 0" E and 6^0 46' 0" S – 7^0 53" 30" S. The purpose of this study is to identify and describe disaster-prone areas by applying the Geographic Information System (GIS) method as a method of managing secondary data in the use and arrangement of information that produces the result of making a map of the land movement susceptibility zone. Making a map of the land movement susceptibility zone based on other basic maps based on Geographic Information System (GIS) research. At the data analysis stage, starting from digitizing the base map into ArcGIS into a digital map, then the data needed on the map is made into several thematic maps and combined by overlaying, to obtain zoning to limit areas prone to landslide disaster in the area. The zoning of land movement vulnerability in the research area is divided into 4 (four), starting with the very low vulnerability zone, medium vulnerability zone, high vulnerability zone to very high vulnerability zone.*

Keywords**—** *Landslide Disaster*.

I. INTRODUCTION

Land movement or landslide is a process of equilibrium that results in moving soil masses and rocks from high places to lower places (Mubekti and Fauziah, 2008). Such movement occurs due to the presence of a force factor located on an uneven ground plane or with a slope. Movement on the slopes can occur due to various factors, including natural factors such as the physical properties of the soil, the mechanical properties of the soil, the intensity of rain, the constituent lithology, the steep contours, and humans (improper land use, etc). Land movement is a common geomorphological event on a relatively steep slope. This natural phenomenon causes the most property losses and casualties, especially if it occurs in cultivated areas where humans carry out activities.

Geomorphology is a landscape that can indicate tectonics, from the science of geomorphology provides geomorphic, morphogenetic, and tectonic information in the area. This will provide information about the landscape of an area. (Keller and Pinter, 1996). Investigations related to geomorphic records provide the necessary information to understand the role of tectonics. Tectonic geomorphology is a science that studies the interaction between tectonic and geomorphic processes of an area where the earth's crust is actively deformed (Huggett, 2011).

Land movement occurs in areas that have relatively steep slope geomorphology. This natural phenomenon belongs to one of the disasters that cause the most losses, and casualties, especially if it occurs around human activity. Landslides cannot be prevented, but there are human efforts to reduce the consequences of this disaster. The high level of landslide vulnerability is caused by the conversion of land functions for uncontrolled development without considering existing geological conditions, causing various problems such as declining environmental quality (Adimas, 2013).

The research area is included in the physiography of the Bandung Zone, West Java (Van Bemmelen, 1949), filled by young volcanic deposits of surrounding volcanoes. The research area is included in the Regional Geological Map of Bandung, West Java (Silitonga, 1973). The stratigraphic order from old to young is Undifferentiated Old Volcanic Products (Qvu), Undifferentiated Young Volcanic Products (Qyu), and Lake Deposits (Ql).

The research area is in Cipatat, West Bandung Regency, West Java. The area of the study is + 140 km2. Geographically it is on 107°180" E - 107°240" E dan 6°47'0'' S - 6°53'0'' S. This study aims to identify and describe disaster-prone areas by applying the Geographic Information System (GIS) method as a method of managing secondary data into the use and regulation of information and producing the result of making a zoning map of avalanche vulnerability

II. METHODOLOGY

The method in determining avalanche zoning is a system for identifying the magnitude of an area's vulnerability to landslides, by dividing those areas based on the factors that cause the avalanche. The methodology to be used is the analysis of secondary data and primary data using Geographic Information System (GIS) software, i.e., producing a map of the vulnerability of land movements in the Citatah area.

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In the implementation of the research, several stages were carried out, that is acquisition, laboratory analysis, sitesis, and GIS analysis. The acquisition stage is the acquisition of initial data or materials used as research support. This study used secondary data (Geological Map of Bandung, Topographic Map, land use of West Bandung Regency, West Java Province, rainfall data) and primary data obtained directly in the field.

Further analysis using geographic information system (GIS) methods which is a hardware and software system designed to analyse, process, and overlay various data parameters with GIS Software. The data that has been collected and then entered the GIS Software in digital form produces a map of the land movement zone. Landslide-prone zoning carries out weighting and rating. The basic reference used is the Anbalagan method (1992). The factors used as a reference for classification in Anbalagan (1992) are lithology, slope, discontinuity, land wetness, elevation, and land cover (Table .1). In this research, the factors used were lithology, slope, land cover, rainfall, and elevation.

III. Result and Discussion

The research area has diverse geology and is controlled by tectonics which in general the vulnerability zonation of the land movement compatible with the condition in the field.

In areas identified as areas with high to very high levels of vulnerability, there were several avalanche events. In areas with those identified as intermediate levels, critical slopes are probably for landslides. Meanwhile, in areas with low levels, stable slopes are seen, and only have a small probability of land movement occurs.

The effect of slope on the incidence of land movement is quite dominant in the research area, it can be seen from the distribution of land movement events on each slope of in Cianjur and its surroundings including the research area (Table 1). Distribution of land movement events on each slope (Source: Map of the vulnerability zone of land movement in the Cianjur area and its surroundings (Bustami Usman, et al., 1997).

TABLE I. Land movement events on each slope in the Cianjur regional area

Land movement	Slope					
	0–5 % (0-3^0)	5–15% (3-9^0)	15–30% (9-17^0)	30–50% (17-27^0)	50–70% (27-36^0)	>70% (36-90^0)
Land slide	-	-	2	4	17	20

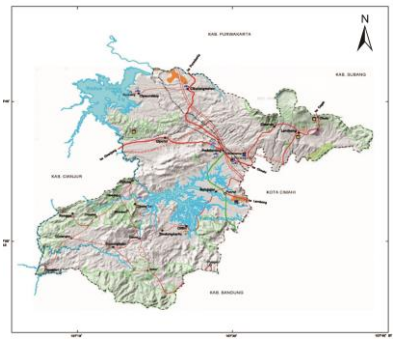

Fig. 1. Map of the vulnerability zone of land movement in the Cianjur area and its surroundings. Bustami Usman, et al., 1997

Land movement occurs a lot from the angle of inclination of the slope between 30 - 50% to greater than 70%. This shows that the slope factor is one of the triggering factors for land movement in Cianjur regional area, the greater the angle of inclination of the slope, the greater the probability of land movement.

Slope data processing, slopes 0 - 15 % belong to the low grade. Slopes between 30 - 50% to greater than 70% belong to the high grade (Table 2). The research area that has a slope of >70% is a structural mountainous area, in the area, there are many faults, such as the strike-slip fault, and normal fault to Reverse fault. It is in the north and south of the research area.

TABLE II. Slope class classification

No	Slope	Classifying Value
1	0% - 15%	1
2	15% - 30%	2
3	30% - 50%	3
4	50% - 70%	4
5	>70%	5

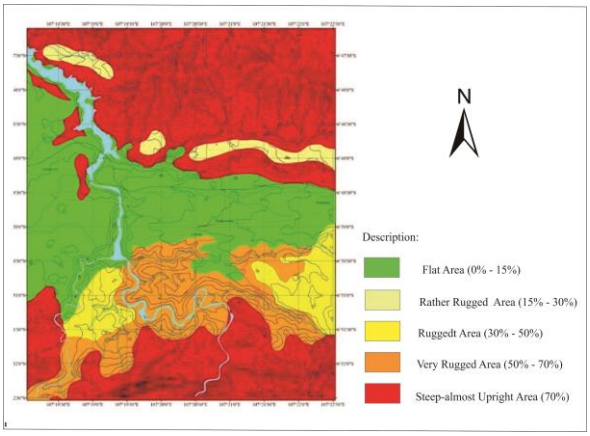

Fig. 2. Slope class-map.

Land Movement Zoning

The resulting land movement vulnerability zonation map shows conditions that are suitable for conditions in the field. In areas identified as areas with high to very high levels of vulnerability, there were several avalanche events. In areas with those identified as intermediate levels, it is seen that critical slopes are probably for landslides. In areas with low levels, slopes are visible that are stable and have only a small probability of land movement occurring (Figure 3).

From the resulting avalanche zonation map, the research area is generally included in three zonings, including very low, high, and very high vulnerability. Some areas are at low and medium land movement zonation levels, but with relatively few. The research area is divided into five zonation of land movement vulnerability, which are:

1. Very low vulnerability zone, this zone has a distribution of 20% of the research area. in general, this area has a flat to the very gentle slope (0 - 15%) and is controlled by breccia lithology, although this area has a land cover in the form of rice fields, fields, and settlements, no potential land movement as the area is flat. The potential for land movement is only found in the cliffs of the river in the

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form of collapses, occupying the eastern, central, and western parts of the research area.

2. Low vulnerability zone, this zone has a distribution of 5% of the research area. It is generally controlled by hard rocks such as limestone. Land cover in the form of forests and plantations that are very dense. The potential for land movement is only in the form of rock collapses with a small scope, occupying the northwest to north, south, and slightly in the southeastern part of the research area.
3. Moderate vulnerability zone, this zone has a distribution of 15% of the research area, generally controlled by sandstone lithology, has a slope of 17 - 27% with the land cover of plantations, fields, and shrubs, occupying the central, northeastern, and southwestern parts of the research area.
4. High vulnerability zone, this zone has a fairly wide distribution, covering 35% of the research area, generally controlled by breccia lithology, has a slope of 27 - 36% with land cover in the form of plantations, fields and shrubs.
5. Very high vulnerability zone, this zone has a distribution of 20% of the research area, controlled by claystone and siltstone lithology, has a slope of 27 - 90% with land cover in the form of fields and shrubs occupying a little in the central, northwestern part of the research area.

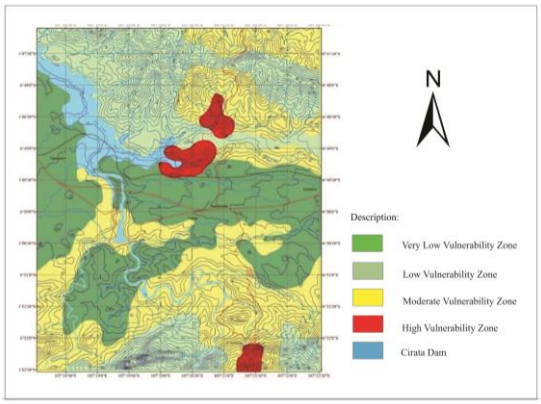

Fig. 3. Land movement vulnerability zone map.

IV. CONCLUSION

The zone of susceptibility of land movement in the research area is influenced by the factors: lithology, slope, land cover, precipitation, and elevation. The dominant factors in the research area are lithology and slope. Geographic Information Systems (GIS) can be relied upon to facilitate the processing of spatial data so that it becomes more efficient and easier. The research area is divided into 5 (five) zones, the most dominant is the low vulnerability zone to high zone.

1. Very low vulnerability zoning: This zone has a distribution of 20% of the research area. Generally, has flat to very gentle slopes (0 - 15%) controlled by breccia, although this area has land cover in the form of rice fields, fields, and settlements, there is no potential for land movement due to its flat area. The potential for land movement is only found in the cliffs of the river in the form of collapses.
2. Low vulnerability zoning: This zone has a distribution of 5% of the research area. It is generally controlled by limestone. The land cover is in the form of forests and plantations that are very dense. Potential land movement in the form of rock collapses with a small scope.
3. Moderate vulnerability zoning: This zone has a distribution of 15% of the research area, controlled by sandstone, and has a slope of 17 - 27% with land cover in the form of plantations, fields, and shrubs.
4. High vulnerability zoning: This zone has a fairly wide distribution, covers 35% of the research area, is controlled by breccia, and has a slope of 27 - 36% with land cover in the form of plantations, fields, and shrubs.
5. Very high vulnerability zoning: This zone has a distribution of 20% of the research area, controlled by structures, lithology of claystone and siltstones, and has slopes of 27 - 90% with land cover in the form of fields and shrubs.

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