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## Characteristics of landslides and mass wasting in south area of Lumajang District

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## Characteristics of landslides and mass wasting in south area of Lumajang District

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**Abstract.** The study aims to determine the types of landslides and mass wasting, characteristics of landslides and mass wasting, and the factors causing landslides and mass wasting in the southern region of Lumajang Regency. The method used in this study was carried out in three stages, namely determining the coordinates of landslide and mass wasting locations, determining landslide and mass wasting samples, determining landslide and mass wasting types, measuring slope, and measuring the dimensions of landslide and mass wasting infiltration. The results obtained were 8 landslide points and mass wasting impacts due to reduced land cover and soil texture type. Differences in soil types, infiltration rates, geology, vegetation, slope and rainfall have no impact on landslides and mass wasting.

### 1. Introduction

Natural disasters are events that can occur suddenly in areas with mountainous and hilly areas. Landslides and mass wasting are one of the disasters that occur especially in the rainy season. Changes in landscape and land clearing in the upstream area result in water flow being unable to filter and stagnate. Landslides and mass wasting have become recent topics. [11] Landslides and mass wasting are influenced by natural and management factors, which include: (1) three days of continuous daily rainfall; (2) land slopes, (3) geology or rocks, (4) the existence of faults, faults and escapes, (5) into the soil to impermeable layers, while management aspects include: (1) land use, (2) infrastructure, and (3) settlement density.

Serious problems from landslides and mass wasting can create material and non-material losses. The cause of landslides and mass wasting is more the existence of gravitational forces that affect the steepness of a slope with different land use and geological structures. [8] The higher a place the greater the ground strength which falls due to the influence of gravity. The slope and critical land especially in the southern part of Lumajang Regency is identical to the waterproof area and the absence of vegetation triggers landslides and mass wasting. [4] High rainfall determines whether or not landslides occur on steep land. [9,15] Natural disasters of landslides can occur due to land use patterns that do not follow environmental norms such as due to deforestation and conversion of forests to agricultural land and settlements on steep slopes.

Landslides and mass wasting need to be studied how the type of landslide caused in the Southern District of Lumajang. The lack of land cover and vegetation has an impact on landslides and mass wasting. Geologically, the southern Lumajang region belongs to the depressive zone of outcrops of the southern volcanic and karst areas. Identification of landslides and mass wasting causes needs to be done so that it can easily find out the condition of geohydrology in the South Lumajang Regency. Paddy fields, shrubs, and dry land farming are very fast in triggering landslides and mass wasting. [12] Land use such as rice fields and dry fields, especially in areas with steep slopes generally occur landslides and mass wasting. The role of forests is important in reducing landslides and mass wasting. [3,6,7,14] Forests have an important role in regulating management including water yields and floods and drought.

Issues of landslides and mass wasting need to be examined how the condition of geographic phenomena based on the location of disaster-prone points in the southern region of Lumajang Regency which borders Malang Regency. The study which is the focus of this research is included in the East Java geomorphology and karst sub study.



## 2. Methods

### 2.1 Location Researchs

This research was conducted in the southern route region of Lumajang Regency towards Malang Regency which is included in the karst region of Southern Mountains and South Depression Zone Mount Semeru.

### 2.2 Procedure Researchs

The initial stage study of the activities of determining the coordinates of the location of the location of landslides and mass wasting. The location landslide and mass wasting is obtained from the interpretation of remote sensing images based on patterns and characteristics, namely hue, color, and texture. The coordinated results of the interpretation are combined with facts in the field to find out the truth of landslides and mass wasting natural disasters. The research location points were determined using GPS as the basis for mapping the locations of landslides and mass wasting points. Data from each point of occurrence of landslides and mass wasting is known through measurements as follows:

#### 1) Determination of Sample Location of Landslides and Mass Wasting

Determination of sample location is based on the characteristics of slope conditions in the Lumajang and Malang pathways. The locations which become the locations of landslides and mass wasting locations then become the study of analysis and interpretation of the land conditions. In general in lowland areas the intensity of landslides and mass wasting is much smaller than in the highlands.

#### 2) Determination of Location Analysis of Landslide and Mass Wasting Samples

Determination of landslide and mass wasting sample locations based on the results of location plotting using GPS. This determination is to ensure the existence of landslide and mass wasting areas and points that have the potential to experience these symptoms in the southern paths of Lumajang and Malang regencies and to know the number of landslide locations.

#### 3) Sampling of Soil, Rock and Vegetation

Sampling of soil, rock and vegetation was carried out for analysis in the geography laboratory. The aim is to determine the texture and structure of the soil at the location and types of rocks and vegetation. At all points of landslides and mass wasting there were 8 samples of soil, rock and vegetation observed.

#### 4) Determination of Types of Avalanches and Mass Wasting

Determination of types of landslides and mass wasting by looking the material in landslide area. Types of landslides and mass wasting are known in the following ways: 1) Types of landslides and mass wasting are known by looking at the slip plane at bumpy ramps with soil and rock material; 2) The type of rotational avalanche is known by looking at the hollow slip-shaped plane with soil and rock material; 3) The type of block movement by looking at the displacement of the stone from the inclined plane such as a fracture; 4) The type of rock collapse is known by looking at free falling material; 5) Soil crawl is known by looking at objects that are embedded in the soil over a long period of time undergoing a change in the form of sloping due to shifting soil with soil material, rock, vegetation, electricity poles, houses, etc. 6) Flow of razed material by viewing the meterial landslide and mass wasting originating from the upper slope and extending to the sloping area. [9] The level of landslide and mass wasting are divided into five classes, namely 1) Not prone, 2) Low vulnerability, 3) Medium vulnerability, 4) High vulnerability, and 5) very vulnerable.

#### 5) Slope Measurement

Slope is measured using the abney level in degrees and then converted to percent. Measurements were made in areas that have not yet dug in the landslide for the original slope.

#### 6) Measurement of Hydrological Infiltration

Infiltration rate measurements using flooding methods in landslides and mass wasting. The tool used is a double ring infiltrometer. The mounting point is cleaned of grass and hyacinth plants, then the ring is immersed in the ground until half of the height of the tool is kept straight not to damage or break. Before pouring water into the middle cylinder, the outside cylinder is filled with water so that the outward permeation can be reduced, the middle ring must be filled with water during the observation process. Observation of water drop is done every 10 minutes until the water

drop in the cylinder is constant. Lack of water is always added and always maintained so that the ring is not empty and the addition is constant.

**3. Results and Discussion**

*3.1 Location Landslides and Mass Wasting*

Data from research conducted found 15 locations of landslides and mass wasting locations in the southern region of Lumajang Regency. The results of the distribution of landslide and mass wasting plot plots are presented in Table 1 below:

**Table 1. Coordinate Location Altitude of Landslides and Mass Wasting**

No.	District Location Distribution	Coordinate Point		Place Height (Meters)	Information Place
		X	Y		
1	Location 1 Candipuro	8 <sup>0</sup> 10'45"	113 <sup>0</sup> 01'19"	1900	Hulu
2	Location 2 Candipuro	8 <sup>0</sup> 10'50"	113 <sup>0</sup> 01'07"	1900	Hulu
3	Location 3 Candipuro	8 <sup>0</sup> 10'56"	113 <sup>0</sup> 00'42"	1780	Hulu
4	Location 4 Candipuro	8 <sup>0</sup> 11'18"	113 <sup>0</sup> 00'45"	1036	Hulu
5	Location 5 Candipuro	8 <sup>0</sup> 11'26"	113 <sup>0</sup> 00'35"	1580	Hulu
6	Location 6 Pronojiwo	8 <sup>0</sup> 10'45"	113 <sup>0</sup> 00'20"	1820	Hulu
7	Location 7 Pronojiwo	8 <sup>0</sup> 11'21"	113 <sup>0</sup> 00'53"	1114	Hulu
8	Location 8 Pronojiwo	8 <sup>0</sup> 11'26"	113 <sup>0</sup> 00'51"	1036	Hulu
9	Location 9 Pronojiwo	8 <sup>0</sup> 11'31"	113 <sup>0</sup> 00'49"	1100	Hulu
10.	Location 10 Pronojiwo	8 <sup>0</sup> 34'30"	113 <sup>0</sup> 00'04"	942	Central area
11.	Location 11 Pronojiwo	8 <sup>0</sup> 24'11"	113 <sup>0</sup> 00'22"	939	Central area
12.	Location 12 Pronojiwo	8 <sup>0</sup> 12'00"	113 <sup>0</sup> 00'09"	928	Central area
13.	Location 13 Tempursari	8 <sup>0</sup> 34'30"	113 <sup>0</sup> 00'03"	875	Central area
14.	Location 14 Tempursari	8 <sup>0</sup> 17'02"	112 <sup>0</sup> 17'02"	699	Central area
15.	Location 15 Tempursari	8 <sup>0</sup> 16'44"	112 <sup>0</sup> 55'53"	685	Central area

Source: Primary Data on Landslide and Mass Wasting Location Points, 2019

Based on table 1 shows that there are 9 locations of landslides and mass wasting in the upstream and 6 in the downstream. The distribution of upstream locations is in Candipuro and Pronojiwo Districts, while in the middle there are 3 locations in Pronojiwo District and 3 locations in Tempusari District. The landslide location is mostly found in the upstream part where it is more dominated in Candipuro and Pronojiwo Districts. In the downstream, including the undulating area only topographically the area is smaller than 7%.

*3.2 Analysis Rock, Soil, and Vegetation*

The results of research on landslides and mass wasting locations show the unit of geological processes and landscape consisting of andesite rocks and volcanic tuffs. Alluvial, regosol, latosol, and andosol soil types can be found in areas with frequent landslides and mass wasting. Soil fractions in the form of sand, clay, dust, and clay affect the type of plant or vegetation that grows. Types of vegetation rooted riding and fibers are often found in areas that are spread landslide and mass wasting. Following are the results of research into rock, soil and vegetation types:

**Table 2. Types of Rocks, Soil and Vegetation of Lumajang Area**

Distribution Location of District	Type Rock	Type Soil	Vegetation
Location 1 District Candipuro	Andesite	Regosol	Grass, Sengon, and Recession
Location 2 District Candipuro	Andesite	Andosol	Grass, Sengon, and Recession
Location 3 District Candipuro	Andesite	Andosol	Grass, Sengon, and Recession
Location 4 District Candipuro	Andesite	Andosol	Grass, Sengon, and Recession

Location 5 District Candipuro	Tuff	Andosol	Grass, Sengon, and Recession
Location 6 District Pronojiwo	Andesite	Andosol	Grass, Sengon, and Recession
Location 7 District Pronojiwo	Andesite	Andosol	Grass, Sengon, and Recession
Location 8 District Pronojiwo	Andesite	Andosol	Grass, Sengon, and Recession
Location 9 District Pronojiwo	Tuff	Andosol	Grass, Sengon, and Recession

Source: Research Result Data, 2019

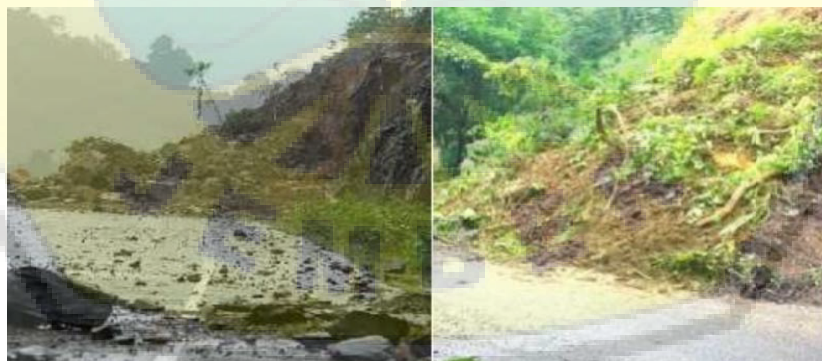
Mount Semeru volcanic deposits cause rock mass to increase during the rainy season which causes landslides and mass wasting in the southern region of Lumajang Regency. Based on observations of rock types that are widely available in andesite type landslides. This type of rock is impermeable to water and cannot hold water or pass water flow making it easier for landslides and mass wasting to slip.

Strong rocks in the form of volcanic rocks and sedimentary rocks with sand, gravel, and clay material are not strong enough to resist landslides and mass wasting during the rainy season. This also has an effect on the type of soil found around the landslide site. Slope and watertight slope increases the intensity of landslides and mass wasting. [4] Water resistant rocks at certain slopes have the potential for landslides. Soil types that are weighted in the event of landslides and mass wasting have an effect in the process of infiltration and release of material from surface runoff. Chemical and physical properties of the soil determine the amount of land erosion which can also be a trigger for landslides and mass wasting. Types of fibrous vegetation such as grass accelerate landslides and mass wasting. Therefore, there is a need for conservation, especially in the slope areas which are areas of landslides and mass wasting in the Lumajang Regency.

### 3.3 Characteristics of Types of Landslides and Mass Wasting

The characteristics of landslide and mass wasting types at the study site are included in the characteristics of the sliding ground motion which slides on the slip plane. Types of landslides and mass wasting are more in the form of rotation so that they form concave scars. The landslide and mass wasting locations in Candipuro and Pronojiwo sub-districts were types of landslide material in the form of soil and stones, sengon vegetation, shrubs, grass, and sandy loam.

Characteristics of types of landslides and mass wasting that move on bumpy and gentle slopes. The locations of landslides and mass wasting are more intensive in the locations of Candipuro and Pronojiwo Districts. The type of material that has landslides has similarities considering that the area of the two districts is part of the Semeru Mountain Area. The following is a picture of the dimensions of the landslide that occurred in the southern region of Lumajang Regency.



**Figure 1.** Dimensions of Landslides and Mass Wasting during the Rainy Season at the Research Location

Based on Figure 1 above shows the types of landslides and translational mass wasting cover road infrastructure facilities. The area of the study site which has steep and hilly slopes affects the intensity of landslides and mass wasting where vegetation is sparsely grown due to slope rates of

60% to 100%. Dominant material that slips in the form of soil and andesite stone that can reach a height of 7 meters closes the lane from Lumajang to Malang.

### 3.4 Slope

The results of observations at the study site showed the level of slope from 61.4% to 100%. Based on observations at each point the location of landslides and mass wasting can be classified as gentle until steep. The location of distribution points of landslides and mass wasting is included in class 5 with steep classification. The following is the classification of the study site slopes which are the locations of landslides and mass wasting:

**Table 3.** Slope Shape Classification of Research Locations in Lumajang Regency

District Location Distribution	Slope (%)	Class	Classification
Location 1 District Candipuro	61,4	5	Steep Slope
Location 2 District Candipuro	92,3	5	Steep Slope
Location 3 District Candipuro	100	5	Steep Slope
Location 4 District Candipuro	100	5	Steep Slope
Location 5 District Candipuro	86,7	5	Steep Slope
Location 6 District Pronojiwo	96,5	5	Steep Slope
Location 7 District Pronojiwo	93,5	5	Steep Slope
Location 8 District Pronojiwo	80,9	5	Steep Slope
Location 9 District Pronojiwo	83,7	5	Steep Slope

Source: Data from the Study of Landslides and Mass Wasting, 2019

The shape of the slope and topography greatly affect the occurrence of landslides and mass wasting. The level of steep and steep slopes gives a risk of landslides and mass wasting. The greater potential for slopes occurs in areas with higher landscape shape. The intensity of landslides and mass wasting is greatly influenced by the type of vegetation that has root fibers. The choice of plant species greatly influences the process of landslides, especially in the rainy season. The slope character has an effect especially when the rainfall is high.

The area's topography has the most influence on landslides and mass wasting. The slope will affect the volume and size of the area experiencing landslides and mass wasting. Increased water velocity on the surface causes the intensity of the water to flow swiftly so that the slope is unable to hold. [2] This finding is supported that the slope and slope length are two topographic elements that influence the pattern of surface water flow and erosion.

### 3.5 Hidrological Infiltration

The infiltration process studied in the area where landslides and mass wasting occur is observed based on two main aspects, namely the infiltration rate and rainfall. Observations and measurements were made at 9 locations of landslide and mass wasting distribution points in Lumajang Regency. The following is the classification of infiltration rates and rainfall that occurred at the study site:

**Table 4.** Classification of Infiltration Rates and Rainfall

District Location Distribution	Cm/ Hour	Criteria	Rainfall (mm/ year)	Classification
Location 1 District Candipuro	130,8	Very Fast	3.931	Very High
Location 2 District Candipuro	598,2	Very Fast	3.931	Very High
Location 3 District Candipuro	378,6	Very Fast	3.931	Very High
Location 4 District Candipuro	386,5	Very Fast	3.931	Very High
Location 5 District Candipuro	212,4	Very Fast	3.931	Very High
Location 6 District Pronojiwo	630,8	Very Fast	6200	Very High

Location 7 District Pronojiwo	659,3	Very Fast	6200	Very High
Location 8 District Pronojiwo	798,2	Very Fast	6200	Very High
Location 9 District Pronojiwo	539,4	Very Fast	6200	Very High

Source: Research Result Data, 2019

Based on the infiltration rate criteria for each occurrence of a landslide and mass wasting in table 3 above, it occurs quickly given the high rainfall intensity. The form of the slopes in the form of sandy soil and clay makes it easier to infiltration water when it rains. The level of hydrological infiltration of landslides and mass wasting is greatly influenced by soil conditions. The structure of the soil composition layer, the type of forming material, the soil aquifer layer, and the capacity of rain can accelerate or slow down the infiltration process. This is supported by the findings of stating that the topography and nature of the land surface affect the functional processes of landscapes that are affected by water capacities that move through the system in response to other forces [1,17].

The speed of infiltration during the rainy season is due to the saturation of water that seeps into the soil with high intensity where vegetation is very rare. Vegetation density determines the rate of occurrence of hydrological infiltration. [10,16] The surface run off, connectivity of structural results from micro-topography in connectivity to saturated area space, infiltration, vegetation, and flow resistance. Structural and functional connectivity are inseparable which become the infiltration path when the intensity of rainfall is high. The diversity of vegetation types, thickness, and canopy layer impacts the surface water movement to go down in the upstream area in particular. [5] The five types of plants with different rooting architecture showing that type R has a stronger impact on soil shift compared to other types. [13] There is a difference between surface water with short horizontal distances caused by (1) the size of the volume of water flowing in slope crevices, (2) the hydrological nature of ground water, and (3) the change in the steepness of slope bedrock slope. The amount of flow, speed, and volume of ground water control the occurrence of landslides and mass wasting in Lumajang Regency.

#### 4. Conclusion

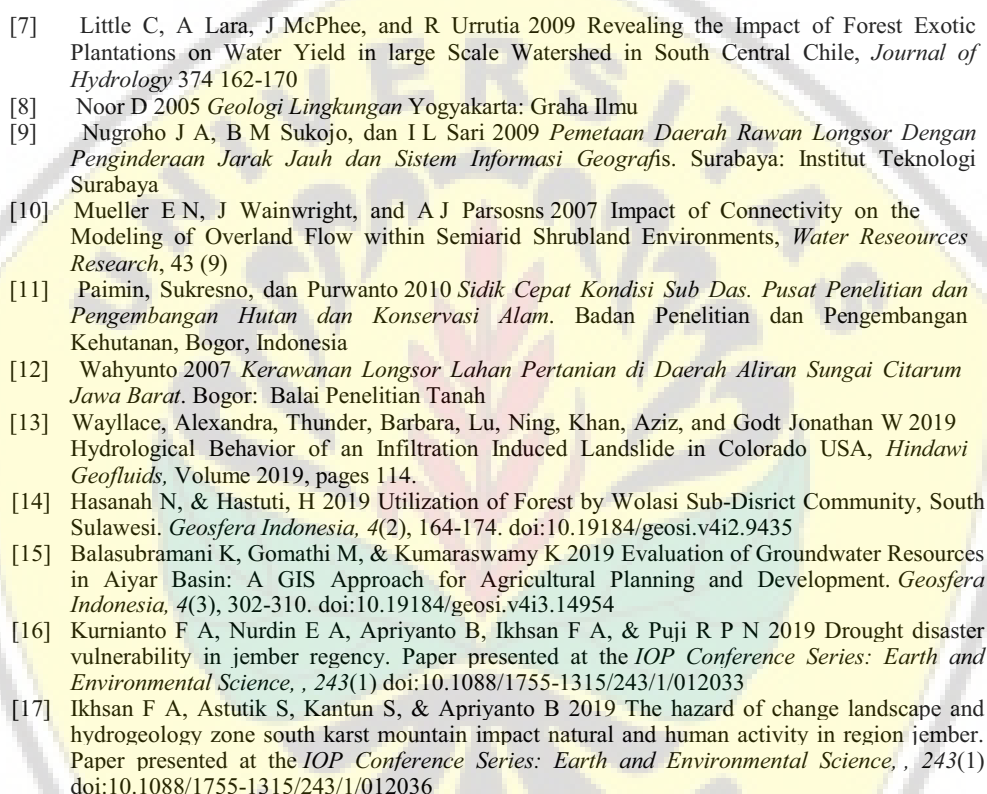
The results obtained can be concluded that the process of landslides and mass wasting is influenced by the shape of the slope. The type of landslide that occurred in South Lumajang Regency was translational and rotational. There is no difference in soil type, infiltration rate, vegetation, geological processes, slope shape, and rainfall from landslides and mass wasting in the southern region of Lumajang Regency. These findings support process conservation land for agriculture and settlement residents.

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