Landslide Zoning and Mitigation in Clapar Area, Madukara District, Banjarnegara Regency, Central Java

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Landslide Zoning and Mitigation in Clapar Area, Madukara District, Banjarnegara Regency, Central Java

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Abstract. Landslide disaster is one of the most frequent disasters in Clapar, Banjarnegara. Landslide is a recurring event and there is no suitable method to respond the threat until now, so that preventive stage have not been maximized. The scienstist explains that the movement of land in the area is very active, but the level of activity that can cause landslides can't be known qualitatively or quantitatively. The method that used to achieving these purposes is geology and landscape morphology mapping in areas that have been and have possibility landslide disaster. Factors that controls the landslide motion are geomorphology, rock type, geological structure and land use, while the triggers are water infiltration and rock fractures. Slope in Clapar is 30 - 70% and the rock type is clay with quarzite and chert fragments from Totogan Formation, volcanic breccia from Tapak Formation, and polimictic breccia from Ligung Formation. Geological structure that found is right slip fault (Rickard, 1972) with the strike and dip of fault is N 359oE/79o. The land usage are pine forest, salak farm, and settlement. Angle of shear strength from direct shear test soil sample in Clapar slope is 27o with safety factor value is 1.045 included in the critical class. According to those existing datas, Clapar included into area that are very vulnerable to landslides. It is because this area was affected by major slip fault and steep angle. The most land usages is salak farms which is the plants has fibrous root that control the properties of soil. It makes the water easily infiltrate into the soil that causes increase the weight of the soil and make the plane become slippery.

1. Introduction

The research area is located in Clapar, Madukara, Banjarnegara District, Central Java. Physiographically, this research area l in the North Serayu basin. This research is based on the morphology that has the potentially slope to occur landslides. And proved by the existence of landslide that happened in March 24th 2016. The catastrophic effect caused 9 houses to be severely damaged and

destroyed, 34 houses are threatened, and 237 people were evacuated[1]. This study specifically analysis the potential of soil movement and the factors that influence it, then make a landslide zoning and inform it to do a disaster mitigation. The important aim of this research is able to give final result of quantitative analysis which is a combination data of landslide parameter values by scoring method. The analysis of landslide zonation using Geographic Information System (GIS) to scoring the factors that affect soil movement. In addition, several soil samples were taken to determine the shear strength of the soil.

2. Method

The methods that use in this research is scoring and overlaying methods with Geographic Information System (GIS) analysis. The factors that affect the landslide distribution is slope, lithology, structure of geology and landuse. Those parameters will be scored according to their relation to the landslide. Then each of parameter will be overlayed to obtained landslide zonation. The shear strength data taken from soil sample in high risk landslide zonation to identificate angle of direct shear and safety factor value.

3. Result and Discussion

3.1. Result

3.1.1. Geomorphology

The morphology in research area can divide into 3 landform based on Van Zuidam (1979) classification:

1. Faults hills landform. The landform is located in middle of research area. The morphography of landform is hills with steep slope. This landform has elevation 612.5-987.5 meters and river pattern is rectangular, it means that the landform controlled by joints and faults.
2. Fault valley landform. The landform is located in north east of research area. The morphography of landform is a valley with moderately steep slope. This landform has elevation 650-850 meters with rectangular river pattern, it means that this valley is formed and controlled by fault.
3. Cuesta landform. The landform is located in south east of research area. The morphography of landform is a dip slope with moderately steep slope. This landform has elevation 525 – 675 meters with sub dendritic river pattern, it means that this valley is controlled by lifting [2].

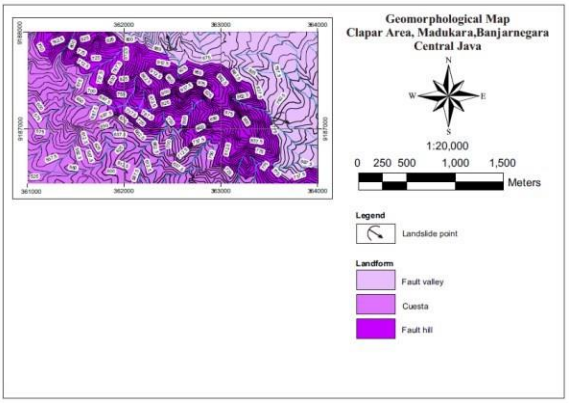

Figure 1. Geomorphological Map of Clapar area, Madukara, Banjarnegara.

3.1.2. Lithology

The lithology in this research area consist of 3 lithostratigraphy units. This lithostratigraphy unit divide by characteristic of each lithology and fossil content to identificate the relative age.

1. Polimictic Breccia Totogan Formation. This unit lithostratigraphy consist of mud supported breccia with clay to boulder grain size and interbedded claystone and sandstone. The fragment of breccia consist of andesite, basalt, quartz and chert. From microfossil analysis, the relative age of this unit lithostratigraphy is Oligocene to Early Miocene and the depositional setting is upper to lower bathyal. Based on lithology characteristic Polimictic Breccia Totogan Formation is an

olistostrom deposit caused by gravity flows sedimentation was influence by uplifting and rapid erosion of the source rock (Lexicon, 2003). This unit lithostratigraphy is located in north east of research area.

2. Volcanic Breccia Tapak Formation. This unit lithostratigraphy consist of grain supported volcanic breccia with massive structure and coarse sand-boulder grain size. The fragment consist of andesitic igneous rock, pumice and tufaceous sandstone, matrix consist of volcanic glass and clay with silica cement. The statement from previous research by Condon et.al. (1996) said that Volcanic Breccia Tapak Formation deposited in Pliocene. The depositional setting from this formation is tidal – marine zone in island arc tectonic setting (Lexicon, 2003). This unit lithostratigraphy is located in middle of research area.
3. Polimictic Breccia Ligung Formation. This unit lithostratigraphy consist of mud supported breccia with massive structure and coarse sand-cobble grain size. The fragment consist of andesite, tuffaceous sandstone, siltstone and matrix consist of clay with silica cement. The relative age of this unit lithostratigraphy is Late Pliocene – Pleistocene (Condon et al, 1996). The depositional setting is terrestrial in volcanic arc tectonic setting (Lexicon, 2003). This unit lithostratigraphy is located in south west of research area.

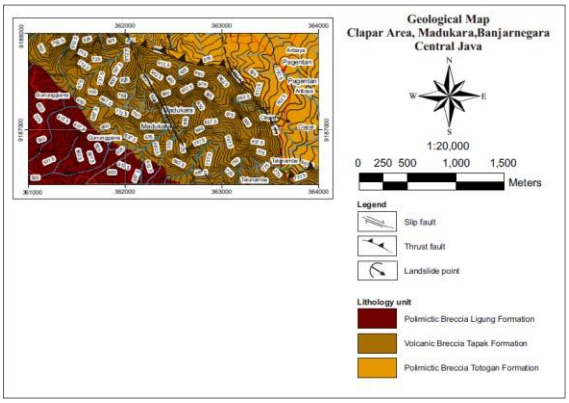

Figure 2. Geological Map of Clapar area, Madukara, Banjarnegara

3.1.3. Structure of Geology

The structure that controlled this reasearch area are joint and fault. There are two faults that found in this research area, slip fault and thrust fault.

1. Slip Fault. There are two slip faults that found. The first one is located in the middle of research area in Gunung Sewu, with the strike and dip of fault is N 317oE/29o and rake 7o classified into right slip fault . The second is located in north east of research area in Clapar, with the strike and dip of fault is N 359oE/79o and rake 9o classified into right slip fault.
2. Thrust Fault. This fault is located in Sinajir and become the boundary between Totogan Formation and Tapak Formation. The strike and dip of fault is N 350oE/78o and rake 24o, classified into reverse right slip fault. [3]

3.1.4. Landslide

- Landslide 1

Landslide 1 is located in Clapar with rock and debris flow type. This landslide is occured in Polimictic Breccia Totogan Formation which this rock has matrix supported texture with a lot of clay and sand composition. This characteristic make the grain properties of the rock is not compact. This area is controlled by structure geology that is right slip fault and shear joint, this structure is the factors that controll the landslide. From slope measurement in the field obtained the slope is 15%-25% that included in steep slope. The landusage in this area is salak farm and settlement. The landusage also affect this landslide because salak vegetation has fiber roots and make the meteoric water can infiltrate easily into the soil that causes increase the weight of the soil.

• Landslide 2

Landslide 2 is located in Sinajir with rock and debris flow type. This landslide is occured in margin of Volcanic Breccia Tapak Formation and Polimictic Breccia Totogan Formation. Lithology in this area consist of sandstone with fine grain size and siltstone. The soil and rock in this area has strong weathering and low compactness that can make the rock move easily. Joints and thrust fault control this area that affect landslide occured. From slope measurement in the field obtained the slope is 15-25% that included in steep slope. The landusage in this area is grass, scrub and salak farm. This vegetation also have fiber roots that can reduce compactness of the soil.

Based on observation of several landslide that found can be concluded that the main landslide factor in research area is lithology. This can be seen from landslide distribution in this area occur in fine grain size with matrix supported texture and low compactness characteristic. Beside that the second factor is geology structure. The fault zone causes rock strength more decrease. Another factors is slope and land usage. The steep and long slopes more triggered a larger landslide than flat slope. From land use factor, the salak farm and scrub in steep slopes can occur landslides because their fibrous roots.

The formula that use in scoring method is:

$$Total=(A\times 0.35)+(B\times 0,3)+(C\times 0,2)+(D\times 0.15) \quad (1)$$

Explanation:

A = lithology B = structure of geology
C = slope D = landuse

Table 1. Slope Classification by BBSDLP 2009

Slope (%)	*Score*	Degree of Value
<8	1	Very Low
8-15	2	Low
15-25	3	Moderate
25-45	4	High
>45	5	Very High

Table 2. Rock Type Classification by BBSDLP 2009

Slope (%)	*Score*	Degree of Value
Alluvial	1	Very Low
Limestone	2	Low
Granite	3	Moderate
Sedimentary rock	4	High
Basalt clay-shale	5	Very High

Table 3. Land use Classification by BBSDLP 2009

Slope (%)	*Score*	Degree of Value
Surface water	1	Very Low
Settlement	2	Low
Forest	3	Moderate
Scrub	4	High

Field and moor	5	Very High

Table 4. Distance from geology sctucture by Husein, 2009

Distance from geology structure	*Score*	Degree of Value
<100 m	1	Very Low
100-200 m	2	Low
200-300 m	3	Moderate
300-400 m	4	High
>400m	5	Very High

3.1.5. Landslide zoning

From the scoring method, obtained four zones that were low risk level zone, moderate risk level zone, high risk level zone, and very high risk level zone.

1. Low risk level zone, this zone has score 2. The lithology composed by polimictic breccia from Ligung Formation with slope 15-25% classified into moderately steep. The land usage are settlement and a little moors. Relatively landslide spot and structure of geology were not found in this area.
2. Moderate risk level zone, this zone has score 3. The lithology composed by polimictic breccia from Ligung Formation, volcanic breccia from Tapak Formation, and polimictic breccia from Totogan Formation. The slope is 15-25 % classified into moderately steep, 25-45% classified into steep, and >45% classified into very steep. The land usage are settlement, forest, farm, and rice field. Relatively it was did not found a landslide spot in this area. The structure of geology that found is shear joint.
3. High risk level zone, this zone has score 4. The lithology composed by volcanic breccia from Tapak Formation and polimictic breccia from Totogan Formation. The slope is 25-45% classified into steep and >45% classified into very steep. The land usage are settlement, forest, farm, and rice field. The structure of geology that found is right slip fault.
4. Very high risk level zone, this zone has score 5. The lithology composed by polimictic breccia from Totogan Formation. The slope >45% classified into very steep. The land usage are forest, farm, and scrub. There are two landslides that found in this zone. The structure of geology that found is right slip fault and thrust fault. [4]

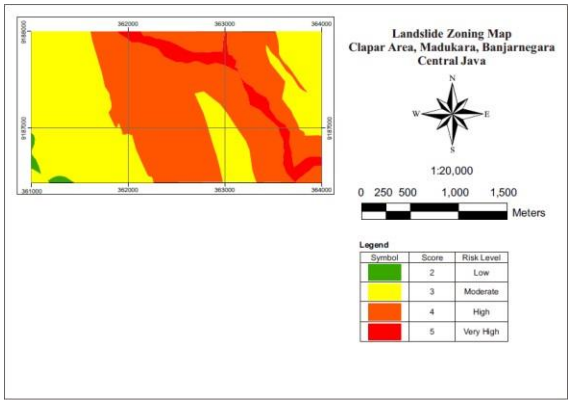

Figure 3. Landslide Zoning Map of Clapar Area, Madukara, Banjarnegara

3.1.6. Slope Stability

This analysis is obtained by landslide slope geometry measurement and taking soil sample from top and bottom of landslide slope in research area. Furthermore, this soil sample analyzed with direct shear test to obtaining the angel of shear strength and cohesion of soil. Those data then modeled to get the safety factor value and classification of landslide slope condition [5]. Angle of shear strength from direct shear test soil sample in Clapar slope is 27o with safety factor value is 1.045 included in the critical class.

3.2. Discussion

Factor that controlled the landslide from the biggest impact to smallest impact in research area are lithology, structure of geology, slope, and land usage. Lithology in research area divided into three unit lithology, from the youngest to oldest that are polimictic breccia from Ligung Formation, volcanic breccia from Tapak Formation, and polimictic breccia from Totogan Formation. The structure of geology that controlled the research area are right slip fault and thrust fault. Slope that can occur the landslide are 25-45% (steep slope) and >45% (very steep slope). For example landslide 1 and landslide 2 that occur because it was located on lithology that moved easily, near the structure of geology, and very steep slope. The land usage that mostly occur the landslide are salak farm and scrub, because of their fibrous roots. From direct shear test obtained angle of shear strength is 27o with safety factor value is 1.045 included in the critical class. From GIS analysis, obtained four risk level zone. That are low risk level zone (5% from research area), moderate risk level zone (40% from research area), high risk level zone (40% from research area), and very high risk level zone (15% from research area).

4. Conclusions

•Factor that controlled the landslide from the biggest impact to smallest impact in research area are lithology, structure of geology, slope, and land usage.

• From GIS analysis, obtained four risk level zone. That are low risk level zone (5% from research area), moderate risk level zone (40% from research area), high risk level zone (40% from research area), and very high risk level zone (15% from research area).

• Mitigation efforts that can be used in this research area are rearrangement land usage from salak farm and scrub into taproot plants that can hold up the land movement, decreasing surface water and settlement on high risk zone of landslide, village development should be on low risk level of landslide.

5. Acknowledgements

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