The Land Degradation Based on Landslide Parameters in Clapar Area, Banjarnegara Regency, Central Java

Sugeng Raharjo[1*], Eko Teguh Paripurno[1], Joko Hartadi[1], Oktavia Dewi Alfiani[1] Megasari Widyastuti[2], Muflichatul Mardziah[2]

[1]Lecture at Geological Engineering Dept., UPN "Veteran" Yogyakarta

[2]Student at Geological Engineering Dept., UPN "Veteran" Yogyakarta

*Email: sugengrhj58@yahoo.co.id (Sugeng Raharjo)

ABSTRACT

Clapar village is the largest village that produce salak in Banjarnegara regency. The plants has fibrous root that control the properties of soil. The condition of loose soil causes the bonding between grains in the soil weaken. It makes the water easily infiltrate into the soil that causes increase the soil mass and can move easily. The aim of this observation is to identificate land degradation based on landslide parameters in research area.

The observation was conducted for 2 months to identificate the direction and speed of landslide movement at 3 point of observation. From observation of land movements for 3 periods around 3 months, indicating that this observation points (P1, P2, P3) was move. In the first to second period P1 moved 1.43 cm with direction N 043° E, P2 moved 1.17 cm with direction N 113° E, and P3 moved 0.56 cm with direction N 045° E. In the second to third period P1 moved 0.77 cm with direction N 094° E, P2 moved 0.42 cm with direction N 054° E, and P3 moved 0.28 cm with direction N 276° E. In the first to third period P1 moved 2.0 cm with direction N 060° E, point P2 moved 1.43 cm with direction N 098° E, and P3 moved 0.45 cm with direction N 015° E.

There are 1 soil samples on the slope of the landslide was taken to identificate the shear strength of soil. The results of geotechnical analysis of soil samples on the Clapar slope obtained the angle of direct shear is 27° with safety factor value is 1.045, included into critical class. The observation results above are the parameters of landslide that cause land degradation in research area.

Keywords: land degradation; landslide; Clapar

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. 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.

METHOD

Methods that use to collect the data for this research are survey along transect traversing through different vegetation on slope of Clapar area, geology observation, GPS geodetic measurement and soil sample direct shear test. The transect traversing used to find out how differentiation of vegetation affect land degradation. Geology observation used to collect lithology data in research area and along the transect. The data is needed for identificate the linkages between vegetation and lithology with land degradation. GPS geodetic measurements is used to

determine the speed of land movement. The soil sample and direct shear test is used to identificate the angle of shear stength and safety factor value from the slope.

RESULT AND DISCUSSION

Result

Geology

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.

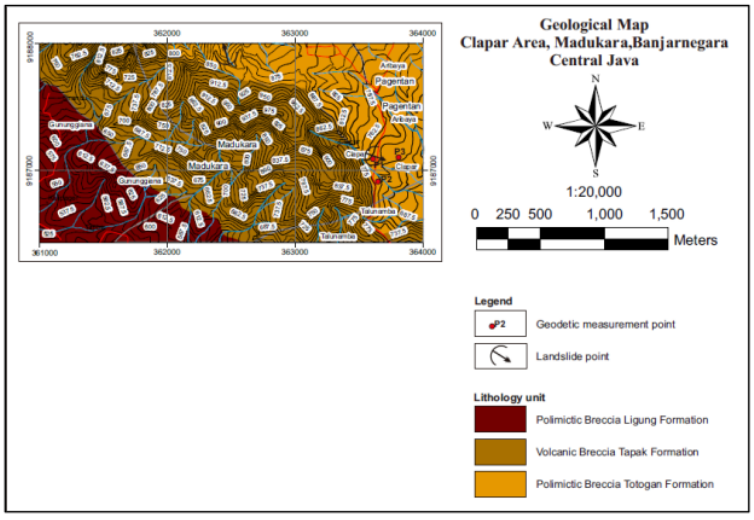

Figure 1. Geological Map of Clapar Area, Madukara, Banjarnegara.

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 (Bowles, 1991). Angle of shear strength from direct shear test soil sample in Clapar slope is 27° with safety factor value is 1.045 included in the critical class.

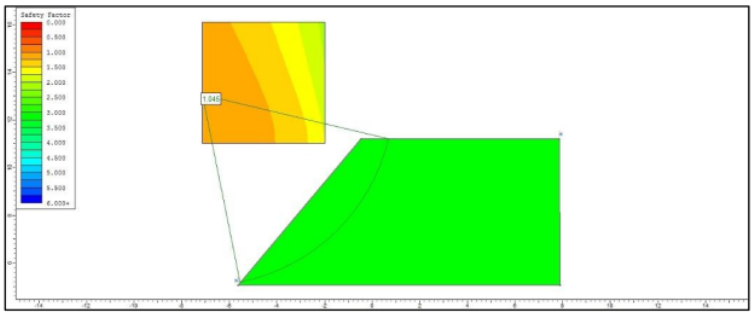

Figure 2. Slope stability analysis with Slide software.

Figure 3. Landslide slope in Clapar village.

Slope Steepness

Based on van Zuidam (1985) classification, the slope steepness on this research area divided into three classes. That are moderately steep class, steep class, and very steep class. Moderately steep class has slope 15 – 25 % cover 35% of region, steep class has slope 25 – 45% cover 15% of region, and very steep class has slope >45%, cover 50% of region. It can be said that Clapar area dominated with very steep area. This slope rate affects the speed condition of erosion and land movement.

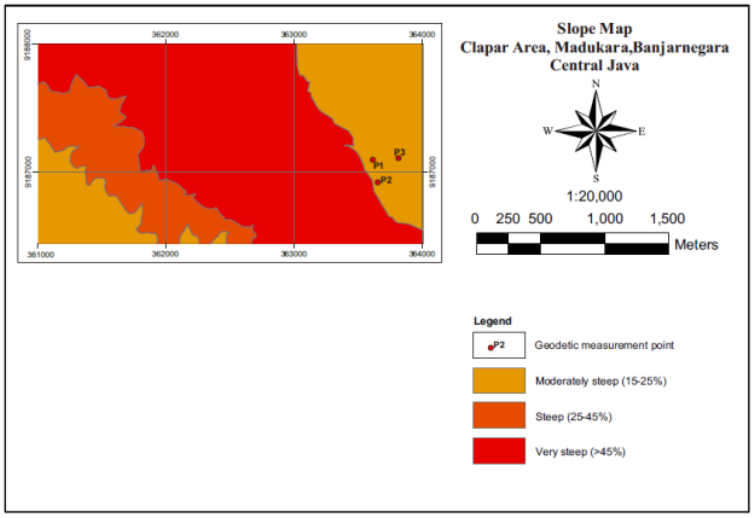

Figure 4. Slope Map of Clapar area, Madukara, Banjarnegara.

Land Use

One of the factor that controls the landslide is land usages. This research area divided into six land usages. That are scrub, forest, salak farm, settlement, rice field, and moor. Vegetation types in forest are pine trees and cocoa trees. Scrub and salak farm are vegetations that has fibrous root that contols the properties of soil. Meanwhile the soil type in research area is podzolic yellowish red.

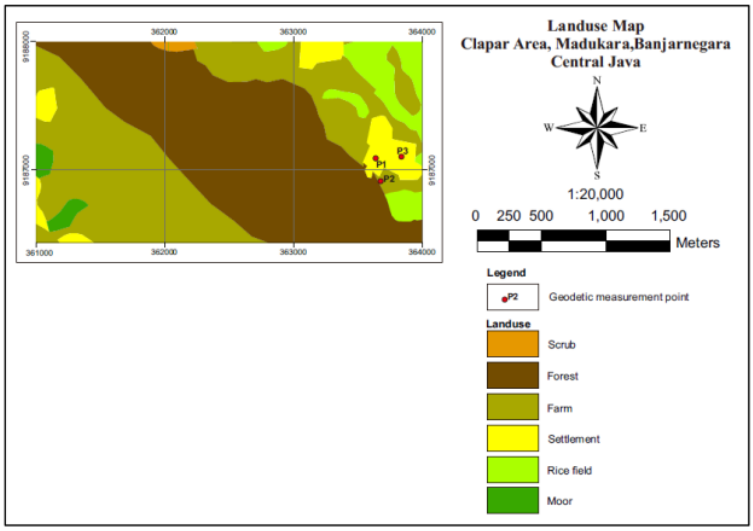

Figure 5. Land Use Map of Clapar area, Madukara, Banjarnegara.

Geodetic GPS Measurement

The geodetic GPS measurement did around 3 months for 3 periods. From this measurement indicating that this observation points (P1, P2, P3) was move. In the first to second period P1 moved 1.43 cm with direction N 043° E, P2 moved 1.17 cm with direction N 113° E, and P3 moved 0.56 cm with direction N 045° E. In the second to third period P1 moved 0.77 cm with direction N 094° E, P2 moved 0.42 cm with direction N 054° E, and P3 moved 0.28 cm with direction N 276° E. In the first to third period P1 moved 2.0 cm with direction N 060° E, point P2 moved 1.43 cm with direction N 098° E, and P3 moved 0.45 cm with direction N 015° E.

Table 2. Value and direction in first to second period of measurement

POINTS	HORIZONTAL MOVEMENT (CM)	VERTICAL MOVEMENT (CM)	DIRECTION (DEGREES)
P1	1,433404975	-3,000	43,07767
P2	1,167578707	2,400	113,0955
P3	0,564278254	-5,700	44,71281

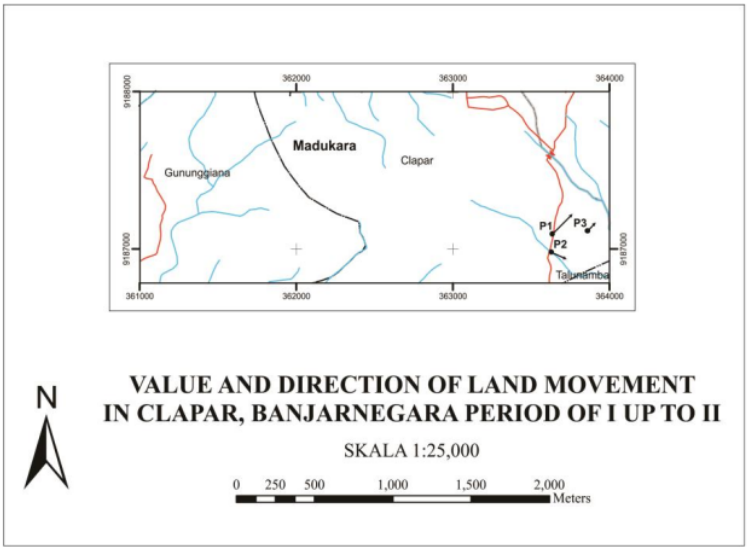

Figure 6. Direction of Land Movement Map periode I-II in Clapar area, Madukara, Banjarnegara

Table 3. Value and direction in second to third period of measurement

POINTS	HORIZONTAL MOVEMENT (CM)	VERTICAL MOVEMENT (CM)	DIRECTION (DEGREES)
P1	0,768346283	6,60000	94,4787815
P2	0,417825305	-4,40000	53,7609095
P3	0,277625662	4,20000	276,203476

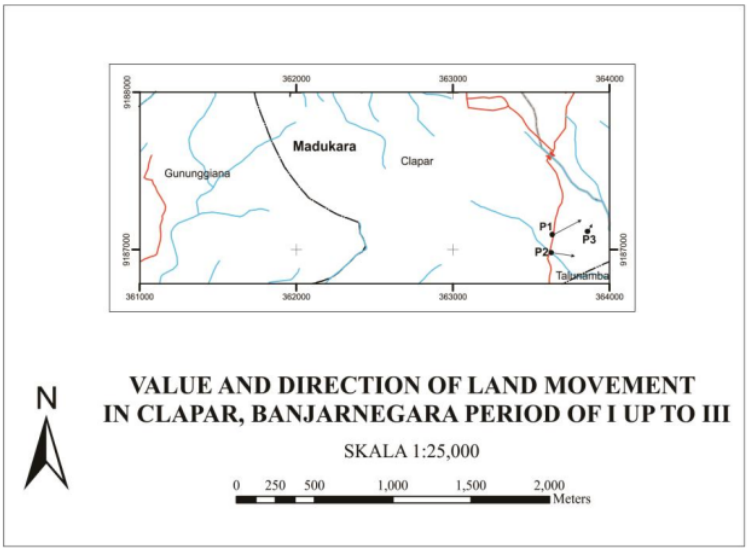

Figure 7. Direction of Land Movement Map periode II-III in Clapar area, Madukara, Banjarnegara

Table 4. Value and direction in first to third period of measurement

POINTS	HORIZONTAL MOVEMENT (CM)	VERTICAL MOVEMENT (CM)	DIRECTION (DEGREES)
P1	2,004792673	3,60000	60,50681
P2	1,426689184	-2,00000	98,50495
P3	0,447662886	-1,50000	15,68168

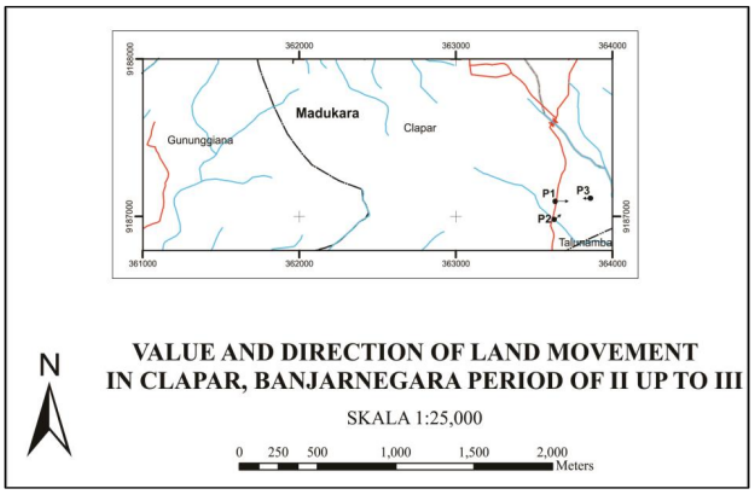

Figure 8. Direction of Land Movement Map periode I-III in Clapar area, Madukara, Banjarnegara

Linkages Between Vegetation and Land Degradation

In order to assess the magnitude of land degradation in different zone and vegetation types, a criterion was set based on field observation along transect traversing. In this case land degradation divided in 3 types that it no visible evidence of land degradation, slight land degradation and severe land degradation. Based on field observation along traverse, land degradation in Clapar Area varied with vegetation. Severe land degradation was in salaka and shrub vegetation. Slight land degradation was in pine tree and it was no visible land degradation in cocoa tree and paddy field.

Table 5. Vegetation types and land degradation zone

Vegetation	Land degradation
Pine tree	Slight land degradation
Salaka	Severe land degradation
Shrub	Severe land degradation
Cocoa tree	No visible evidence of land degradation
Paddy field	No visible evidence of land degradation

Discussion

The other factor of severe land degradation in this area is probably due to the high steepness of slope (30 – 70%) and the dominant lithology consist with clay. In area with high steepness of slope, clay lithology and low safety factor value, salak and shrub that have fibrous root can make soil loosen and creating chance for water and wind caused degradation to take place. Those data above can be strengthened with geodetic measurement data. The measurement point that moved took place in very steep slope with the lithology consist of clay, the vegetation consist of salak farm and shrub.

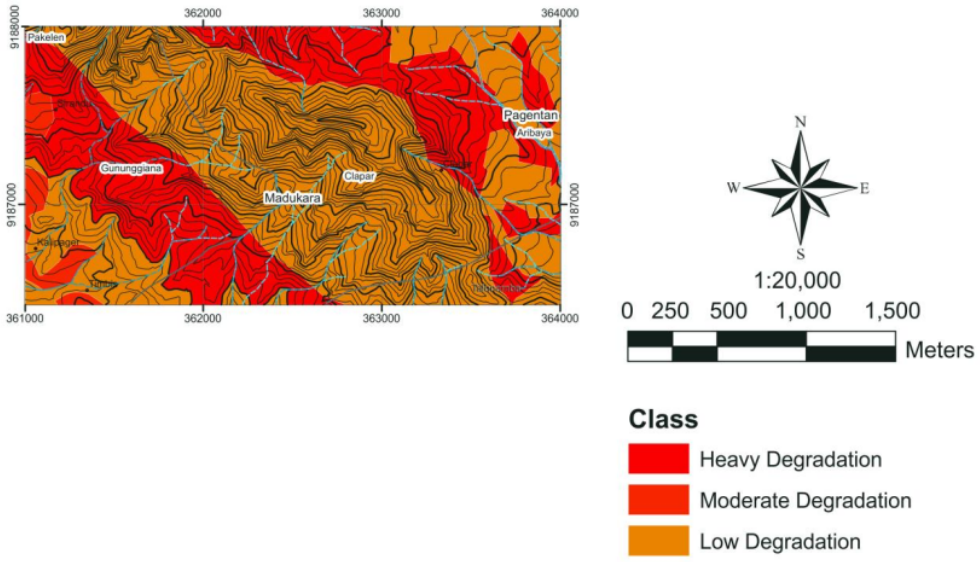

Figure 9. Classification land degradation in Clapar Area

CONCLUSION

- The research area divided into three slope class, that are moderately steep (15 – 25%), steep (25 – 45%), and very steep (>45%).
- The dominant lithology in land degradation area is clay breccia.
- The land usages are settlement, salaka farms, moor, shrub, and paddy field. Severe land degradation was in salaka farms and shrub.
- Rearrangement of slope into terraces with angle of slope <30°, and cultivate tap root plant in landslide slope area.
- Build waterways around steep slope to manage rainwaters to decrease the water saturation of soil.

ACKNOWLEDGEMENT

This research was supported by Geological Engineering Department UPN "Veteran" Yogyakarta and DIKTI. We are thankful to our colleagues who provided expertise that greatly assisted this research.

REFERENCES

Badan Perencanaan Pembangunan Daerah Kabupaten Banjarnegara. (2015) *Banjarnegara Dalam Angka*. Banjarnegara.

Bowles, Joseph E. Johan K. Helnim. (1991) *Sifat-Sifat Fisis dan Geoteknis Tanah (Mekanika Tanah)*. PT Erlangga: Jakarta.

Nugroho, Sutopo Purwo. (2016) *Sembilan Rumah Tertimbun Longsor di Banjarnegara, 237 Orang Mengungsi*. (website: http://www.bbc.com/indonesia/berita_indonesia/2016/03/160328_indonesia_longsor_banjarnegara).

Pramono, I.B. (2014) Mitigation of land degradation at Juana Watershed, Central Java. *Journal Of Degraded And Mining Lands Management*. Volume 2. Number 1. Pg. 235-242

Van Zuidam, R.A. (1983) *Guide to Geomorphologic Aerial Photographic Interpretation and Mapping*. ITC Enschede: Netherlands.