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Zoning potential areas of mass movement along Lampung-Panjang Fault, Bandar Lampung City

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Abstract. *Bandar Lampung is a densely populated urban area consisting of land and waters with several highlands and hills that lied in Bandar Lampung City. Population density supported by high infrastructure development has made Bandar Lampung become city with rapid growth. Supporting sustainable development in a city area, the concept of spatial planning which consider all aspects is needed to applied. One of them is potential disasters aspect. Disaster that could potentially occur in Bandar Lampung City, especially around Lampung-Panjang Fault area, was a mass movement. The aim of this study is mapping potential areas of mass movements zonation along Lampung-Panjang Fault in Bandar Lampung City. Method used in this study is remote sensing (ALOS PALSAR DEM 12.5 m) with Index Overlay Model (IOM) in relation to geological conditions, slope, land use and rainfall. Field checks were carried out at several points that prone with mass movements to determine geomorphological, geological conditions and estimate the characteristics of mass movement type in research area. Results of study were zoning maps of mass movement area along Lampung- Panjang Fault in Bandar Lampung City based on the parameters of weighting by Public Works Ministerial Regulation in 2007. Zoning map along Lampung- Panjang Fault consists of four categories: very low, low, medium and high. The map produced can be one of the mitigation guidelines and as a recommendation for regional development.*
Keywords*: Mass movement, Lampung-Panjang Fault, Zoning Area.*

INTRODUCTION

Bandar Lampung is a densely populated urban area consisting of land and waters with several highlands and hills that lied in Bandar Lampung City (Pemerintah Kota Bandar Lampung, 2017). Population density supported by high infrastructure development has made Bandar Lampung become city with rapid growth. Supporting sustainable development in a city area, the concept of spatial planning which consider all aspects is needed to applied. One of them is potential disasters aspect.

Based on Geological Map of Tanjungkarang sheet (Mangga et al., 1993), geological conditions of Bandar Lampung City are under influence of faults. On the map, there were clearly several faults that crossed Bandar Lampung City. The existence of these faults is reflected in morphological conditions consist of hills with steep slopes landform. Lithology that dominates research area is the former coastal sedimentary land and rivers that are scattered around Lampung Bay and around Tanjung Karang dominated by weathered land resulting from young volcanoes activities Lampung Formation which are generally tuff rocks. This geological condition risks caused occurrence of earth disasters, one of which is mass movements.

Mass movement is defined as movement down or out of the slope by mass of soil or slope constituent rocks, or mixing the two as rags, due to disturbance in the stability of the soil or rock making up the slope (Karnawati, 2005). Areas prone to mass movements are generally found in sub-districts in Bandar Lampung City. Based on data from the Center for Volcanology and Geological Disaster Mitigation (2018), in May 2018 the potential for medium ground movement dominated in Bandar Lampung City, while in Panjang District there was the potential for medium-high ground movements.

Lampung-Panjang Fault is another factor that triggers mass movements that occured in Bandar Lampung. Based on 30 m SRTM image, it shows that Bandar Lampung City is associated with the existence of the Lampung- Panjang fault is vulnerable to mass movements. Therefore, it is important to map zoning potential areas of mass movements along the Lampung-Panjang Panjang in Bandar Lampung City.

Risks facing natural disasters such as mass movements and community vulnerability indicate that disaster management plans are discourses that must be included in sustainable development plans (Setianto et al., 2013). Articles 35 and 36 Law Number 24 of 2007 concerning disaster management mandate that regions develop a Disaster Management Plan. One of the ways to overcome this disaster is by zoning the mass movement area.

Research on mass movements has been carried out with various methods, one of them is by utilizing remote sensing technology. This method has advantage of being able to map large areas and difficult to reach areas (Noor, 2005 in Yunarto, 2012).

Zoning potential areas of mass movement has been studied in Bandar Lampung City focused along Lampung-Panjang Fault. This study utilizes remote sensing method (ALOS PALSAR DEM 12.5 m) in relation to geological conditions, land use and rainfall. Furthermore, field checks were carried out at several points prone to mass movements to determine geomorphological, geological conditions and estimate the characteristics of mass movements type in the study area.

RESEARCH METHOD

In general the methods carried out in this study include remote sensing with Index Overlay Model (IOM) from 12.5 m ALOS PALSAR DEM map, topographic maps, land use maps, rainfall maps and field observations. The process of making zoning maps of potential mass movement areas is carried out using the IOM weighting method which refers to Ministerial Regulation of Public Works No. 22 / PRT / M / 2007, then validated by field observation data at several points of mass movement.

Research Tools and Materials

The tools used in this study are: GPS (Global Positioning System), Compass Geological azimuth type (0º-360º), Geological Hammer, Loup, Sample bags, Cameras, Field notebooks, stationery, and Personal Computer. The materials used in this study are: Regional Geological Map of Tanjungkarang Sheet sourced from the Center for Research and Development of Geology, Topographic Maps obtained from the Geospatial Information Agency (BIG), Land use maps obtained from INAGEOPORTAL, rainfall data sourced from BMKG (Meteorology, Climatology and Geophysics Agency) and 12.5 m ALOS PALSAR DEM imagery sourced from USGS. Secondary data in the form of data from previous research results include the geological conditions of the study area from regional geological maps, other secondary data relating to the research area and literature as the basis of the theory.

Stages of Research

Literature Study

Literature studies were carried out to support research on regional and local geology of study area, topographic map data, 12.5 m ALOS PALSAR DEM images, land use maps, rainfall maps, lineament analysis, slope maps, zoning maps of potential landslide maps, and planning of field checks.

Studio Analysis

Data obtained from studio observations in the form of observations from geological maps, 1: 25,000 scale topographic maps and results of analysis and interpretation of satellite image data (ALOS PALSAR DEM 12.5 m), land use maps, and rainfall data. Studio analysis was carried out through lineament analysis of 12.5 m ALOS PALSAR DEM data and parameter analysis that influenced mass movements (geological structure, lithology, slope, rainfall, land use, and infrastructure) in the study area. Studio observations were carried out to analyze zoning potential areas of mass movements using Arc GIS 10 software and further proved by field data.

Field Observation

At this stage documentation and retrieval of field data is carried out by geological mapping method, namely by obtaining data on surface rock distribution include lithology, geological structure, topographic observations or slopes and geomorphological observations.

Data Analysis and Synthesis

At this stage, studio data integration with field data are carried out in the studio. This data analysis and processing must be based on geological concepts and also supported from reference studies on related topics. In the synthesis phase, data interpretation is carried out which aims to strengthen the results of the study. Furthermore, all of the data processed to make zoning map of mass movement area and estimate the characteristics of the type of mass movement in the study area.

RESULTS AND DISCUSSION

Studio Analysis

Studio analysis was carried out by using the Index Overlay Model weighting method which refers to Ministerial Regulation of Public Works No. 22 / PRT / M / 2007 concerning guidelines for spatial planning of landslide disaster areas (Table 1).

TABLE 1. Guidelines for Weighting Ministerial Regulation of Public Works No. 22 / PRT / M / 2007.

No.	Parameters/Weight	Target	Category	Score
	Human Activity Factors (30%)			
1	Land Use Weight (20%)	Natural Forests	Very Low	1
		Plantation / Plantation	Low	2
		Shrubs / Grass	Moderate	3
		Rice Fields / Settlements / Buildings	High	4
2	Infrastructure Weight (10%)	There is no road cutting the slope	Very Low	1
		Slopes cut off the road	High	4
	Natural Physical Factors (70%)			
3	Annual rainfall (mm/year) Weight (20%)	< 1000 mm	Very Low	1
		1000 – 1499 mm	Low	2
		1500 – 2500 mm	Moderate	3
		> 2500 mm	High	4
4	Slope (%) Weight (25%)	< 15%	Very Low	1
		15% - 24%	Low	2
		25% - 44%	Moderate	3
		> 45%	High	4
5	Presence of Fault / Scarpslope Weight (10%)	Nothing	Very Low	1
		Exist	High	4
6	Geology/lithology Weight (15%)	Alluvial plain	Very Low	1
		Limestone hills	Low	2
		Sedimentary Rock Hills	Moderate	3
		Volcanic Rock Hills	High	4

Lineament Analysis and Structural Geology

According to Davis (2007) in Dalimunthe (2016), the shape of the earth's surface is influenced by three main factors, namely structure, process and stages. Thornbury (1969) in the basic concept of geomorphology states that the structural geology is the most dominant factor controlling in the evolution of landforms and will be reflected in appearance of landforms. Appearance of landforms from structural geology can be seen from lineament. Morphostructural lines show straight line features in line with the alignment of mountains and river valleys (O'Leary et al., 1976). Lineament has a significant element for determining landscape characterization because lineament has good equivalence with morphological structures, such as faults and fractures in an area (Morelli and Piana, 2006).

In this study, lineament analysis was used to estimate the area affected by active fault by looking at trend of direction and analyze the direction of alignment of an area. Lineament analysis in this study produces lines of trend lines that are in line with the Lampung-Panjang fault on the geological map. This indicates that the area is affected by the Lampung- Panjang fault activity (Figure 1a).

Lithology and Geomorphology Analysis

Based on Geological Map (Mangga et al., 1993), the research areas included in the Lampung Formation (Qtl), Young Pesawaran Volcano Deposits (Qhvp), Alluvium (Qa), Campang Formation (Tpoc), Tarahan Formation (Tpot) and Inseparable Gunung Kasih Complex (Pzg) which consists of Quarsit Sidodadi (Pzgk). The lithology condition of an area is closely related to the potential of a landslide disaster. In addition to lithological parameters, geomorphological aspects are one of the factors that greatly affect landslides. The research area is included in the terrain and hilly geomorphological conditions.

At this stage, lithology conditions are associated with geomorphology of the study area. Based on Table 1, these parameters are divided into 4 classifications, alluvial and volcanic plains are in the very low category, calcareous hills in the low category, hills of sedimentary rocks in the medium category, and volcanic rock hills in the high category. The research area only covers 3 categories, namely the very low, moderate and high categories (Figure 1b).

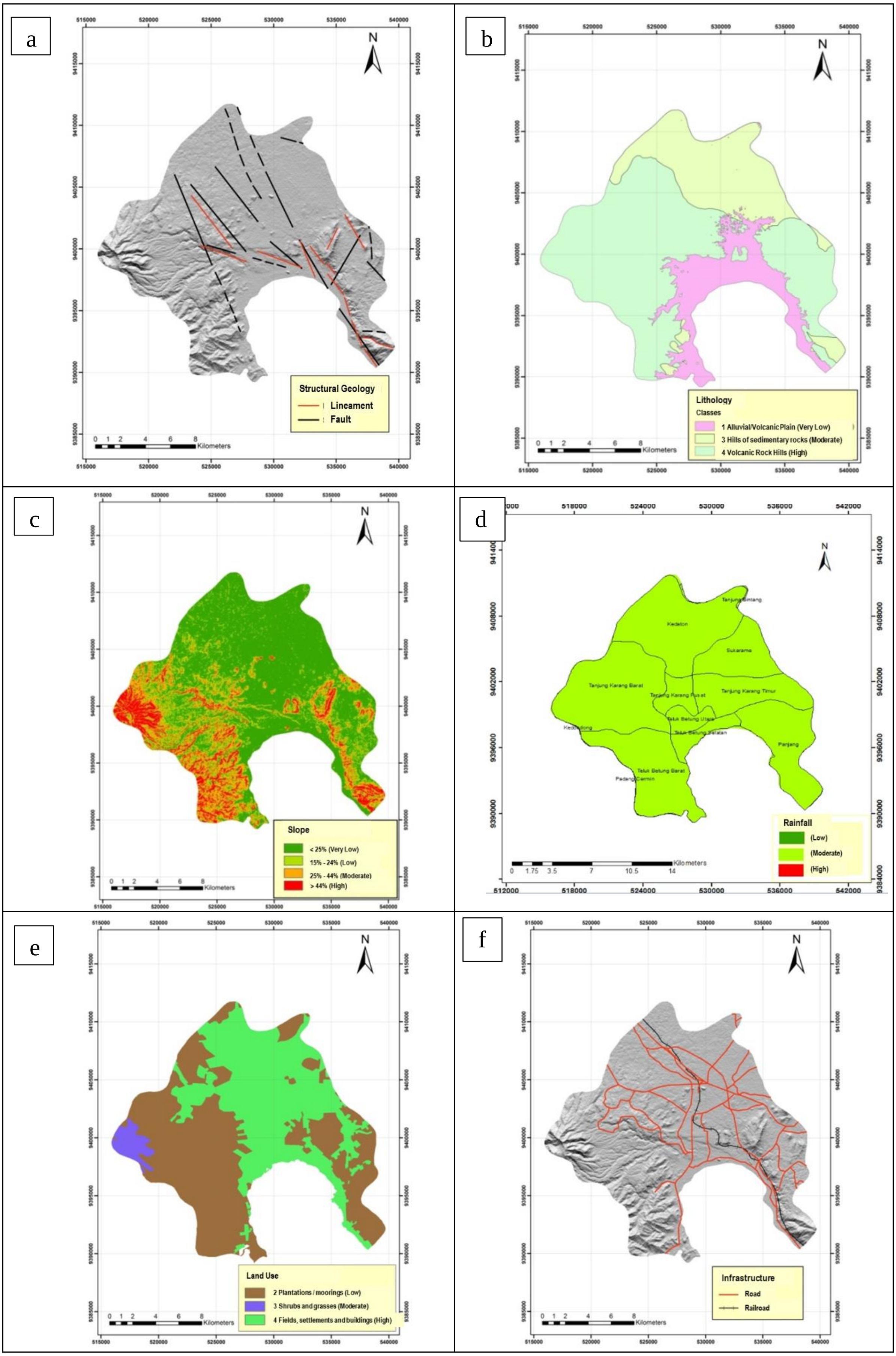

FIGURE 1. (a) Lineament and structural geology map (b) Lithology map (c) Slope map (d) Rainfall map (e) Land use map (f) Infrastructure map.

Slope Analysis

Slope analysis was analyzed based on 12.5 m ALOS PALSAR DEM data using Arc GIS 10. Slope is a very important parameter in determining landslide hazard zoning. The research area is divided into 4 categories of slope, <15% with very low categories, 15-24% with low categories, 25-44% with moderate categories and >45% with high categories (Table 1). The results of the analysis are shown in Figure 1c.

Rainfall Analysis

Rainfall maps are made from rainfall data sourced from BMKG using the krigging method. The research area is in moderate category with 1500-2500 mm / year rainfall parameters (Figure 1d).

Land use Analysis

Land use analysis was taken from data sourced from INAGEOPORTAL. From these data, the study area consisted of 3 categories, namely plantations / moorings in the low category, shrubs and grasses in the moderate category, and fields, settlements and buildings with high categories (Figure 1e).

Infrastructure Analysis

Infrastructure maps that are taken into account in relation to determining landslide zones include roads and railroads. If the road or railroad cuts the slope, it is included in the high category, but if it does not cut the slope, it is included in the low category (Figure 1f).

Field Observation

Checking the landslide points in the field was carried out at 7 points along the Lampung-Panjang Fault (Figure 2). In general, the point of mass movement is in the middle-high slope, with dominant rock lithology sediment-pyroclastic rocks of Tarahan Formation (Tpot), type of landslide is debris type mass movements. At stopsite 2 it is found joint on the rocks. At point 5 cliffs with steep slopes were found, based on the results of field observations, in the area there had been a landslide in 2012 with 15 houses damaged.

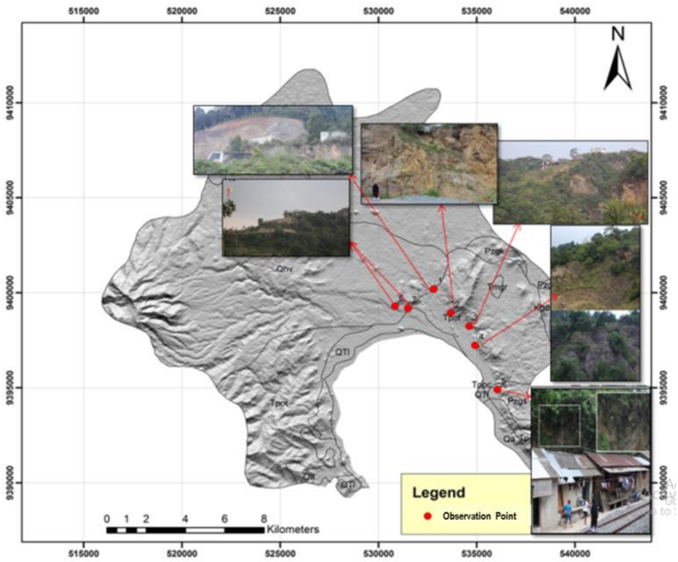

FIGURE 2. Field observation.

Landslide Zonation Map along Lampung-Panjang Fault

After analyzing studio and checking mass movements in the field, a zoning map of landslide prone areas in Bandar Lampung City was made, focused along Lampung-Panjang Fault area. Zoning maps are made by compiling lithology parameters, slope, rainfall, fault / scarpslope, infrastructure and land use. Weighting is done referring to Table 1 with the Index Overlay Model. From the results of the analysis using ArcGIS obtained 4 classes of zoning along the Lampung-Panjang Fault, areas with potential for mass movement are very low, low, moderate and high (Figure 3).

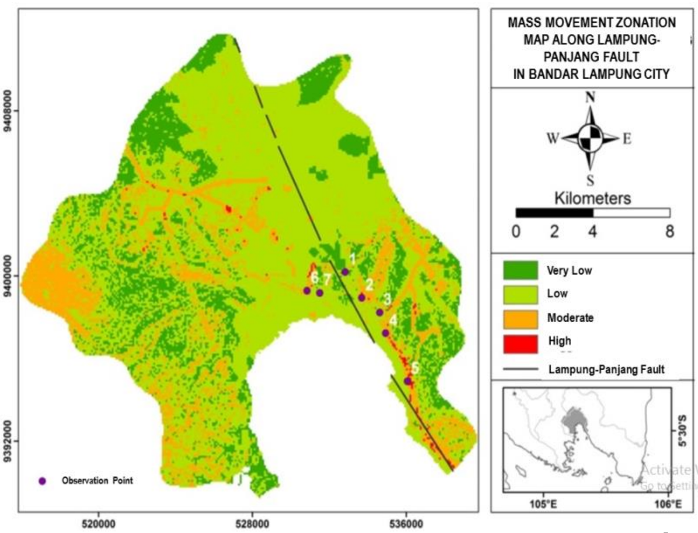

FIGURE 3. Mass movement Zonation Map in Bandar Lampung City, black line shows Lampung-Panjang Fault.

Based on results of validation with field data, the landslide points found in the field are on moderate-high zoning on the map. The map produced can be one of the initial mitigation guidelines and as an initial recommendation for regional development.

CONCLUSION

Based on results of study it can be concluded that the determination of zoning maps of potential mass movements can be done by remote sensing techniques with the Index Overlay Model as evidenced by field observation data. The results of the analysis show that the area along Lampung-Panjang Fault is in the dominant moderate zoning class, then low, high and very low class. The map produced can be one of the mitigation guidelines and as a recommendation for regional development.

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