Geomorphology Approach as Landslide Assessment in the Gede Catchment Malang Regency

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ABSTRACT

Gede catchment is the part of Bromo Volcano System. It is located in the Malang Regency, East Java Province. The wide of Gede Catchment is around 17 Km^2. Landslide prone area mapping shows this area has high potential landslide around 52,9%. There were several landslides which had been occurred in this area. Based on the physical condition, this area is rather not appropriate for living. The aim of this research is to elaborate geomorphology approach as landslide assessment in the Gede Catchment. The method of this research is descriptive qualitative with survey technique. We assessed landslide based on the geomorphological approach and combined with the survey of landslide site. Based on the result shows that geomorphology is necessary factor for considering landslide assessment. Geomorphological approach is consist morphology, morphostructure, morphocronology, and morphoarrangement. The component of morphology is slope, component morphostructure and morphoarrangement is geomorphic process and for the component morphocronology is surface material and lithology. The four aspect of geomorphology become the keys for explain of landslide potential assessment. Geomorphology is the appropriate approach for landslide assessment in the Gede Catchment as the prone area for landslide. Otherwise, the potential of landslide will be difficult to determine if triggered by human activity or extreme rainfall.

Keyword: Geomorphology Approach, Landslide, Assessment, Gede Catchment.

1. INTRODUCTION

Landslide is the one hydrogeomorphology disaster which the most occurred in Indonesia. Landslide is the main thread disaster for people who living in the hilly or mountainous area. The potential of landslide will increase significantly when the rainy season and extreme climate. The climate condition in Indonesia is high rainfall with an average of 2000 mm year. But, the landslide could be occurred by human activities. Both of them could be landslide occur. Landslide is the most disastrous event in Indonesia during 2014. It has the highest number of occurrence and highest rate of fatality (14). It needs the landslide mitigation to decrease the occurrence. One of the ways is making landslide assessment.

Landslide event usually occurs during the peak season and in the hilly area (9). The threat of landslides is currently getting higher by the rising population whose lives are at stake as they live on the slopes in-hilly area. Geomorphology as one of triggered factor to landslide occurred (12). Commonly, landslide will be occurring in the rough geomorphology. But in the other hand, landslide and geomorphology process can accelerated by human activities (15; 23). Landslide as the natural disaster has characterization including their physiographic characteristic. It will influence to how to conserve soil as material of landslide. The characterization of landslide has significant influence of landslide i.e surface material, landuse, slope and rainfall which have significant influence each others. Landslides will increase in thick soil material and unconsolidated soil (19).

There were several landslides which had been in the Gede Catchment. Landslide was become the environmental problem in the study area. There have been several landslides in this area which have caused losses in agriculture and damage to roads and settlements. The inclination and the thick soil condition become the most influencer to landslide occurrence. In addition, the cut of slope inclination more than 15% also become the main factor. It makes unstable slope, thus it will increase the landslide potential

Mostly, the previously researcher had been done several approach and method for landslide assessment such heuristic approach (13), statistical approach (3; 7), deterministic approach (16) and probabilistic approach (5). There is weakness using heuristic approach for landslide assessment such this method is high presence subjectivity for determining the weigh and score of landslide parameters (18). Whereas, for the statistic needs several parameters that have to input to Geographic Information System (GIS).

Landslide as geomorphological approach can be separated with the geomorphology analysis including geomorphological approach (2). But, still rarely the researcher use geomorphology approach for landslide assessment. Geomorphology is the most appropriate approach for landslide assessment because landslide could not separate with geomorphology process and it also as the one geomorphology process. This paper is trying to assessment landslide potential based on geomorphological approach which considering component of geomorphology such morphology, process and material. This research expected to give the best solution for identifying of landslide potential. The result can be landslide mitigation action in this research area.

Gede catchment is the part of Bromo Volcano System. It is located in the Malang Regency, East Java Province. The wide of Gede Catchment is around 17 Km^2 (Fig.1). Its located in the middle slope of Bromo Volcano Mountain with the landscape hilly and mountainous area. Morphology in this research area is really complex such peak interfluves, upper slope, middle slope, lower slope and foot slope. The elevation in the study area until 2761 mean sea level. Whereas, for the process in this research area is landslide. The subsurface material is dominated by deposition of Bromo Volcano material.

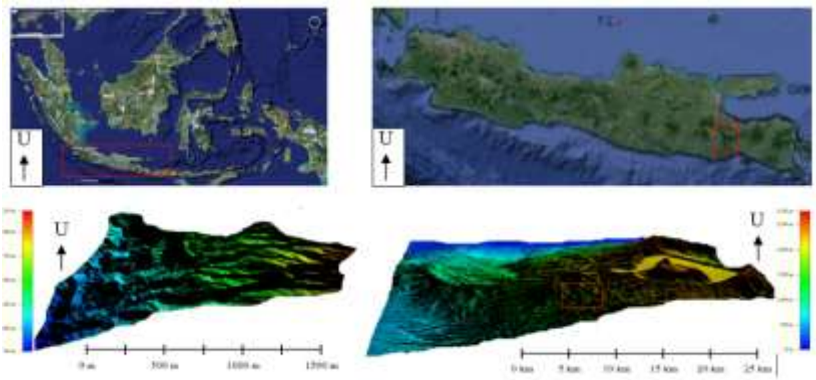

Fig 1: Study Area

2. MATERIALS AND METHODS

The method of this research is descriptive qualitative with survey technique. The data which used in this research is DEMNAS data with the resolution 30mx30m and geological map. For the identified all the component of geomorphology such morphology, process and material thorough three stages i.e preparation, analysis data using Arc GIS 10.2, and survey as accuracy check. Preparation stages consist collecting supporting literature and making tentative map. Morphology as the one component of geomorphology is produced by automated analysis using Arc GIS 10.2. Whereas, for the surface material based on the geological map. Both of them will produce tentative map of morphology and material.

Field survey in this research is necessary as check accuracy as prone landslide area. Field surveys are carried out to check the physical and environmental characteristics of the region that indicated landslide prone area. Field survey involves field verification to the deliniated landform unit. Each landform unit will observation regarding material and process. Geomorphological mapping could be as for landslide potential assessment

3. RESULT AND DISCUSSION

3.1 Morphology

Morphology is a part of landscape analysis which affects the landslide potential. Part of morphology which affect the landslide potential are slope, elevation, direction slope and shape of slope. Part of morphology based on research achievement mostly is emphasizing slope analysis as a part of morphology which affects landslide potential (2;11).

Slope as an important factor that initiate landslides. It gives impact to soil movement which is affected by gravity force. If the slope angel is greater, it would make greater soil material movement. Slope is related to morphology unit as both of them act as landslide initiation.

The valuation of slope and the morphology unit classification are between flat to steeper slope located in the alluvial and colluvial morphologyical unit. The slopy area with the greatest angle is situatedmostly in the middle to upper slope of hilly area or mountainous area.

In one slope system consist several unit morphology (14; 21; 4). In the Gede Catchment the unit morphology can be classified into seven parts such as peak Interfluves, upper slope, middle slope, lower slope, colluvial foot slope, and colluvial plain. Landslide is potentially affected by morphological unit. Peak interfluves is located on the flat area, so that there is no force to move soil material. The slope angle in is peak interfluves about 0%-3%.The upper slope to middle slope constituted the most slopy area of which the angle ranges between 26% to more than 45%. Geomorphological process and landslide movement usually commence in the upper slope/shoulder (14; 20; 17). Geomorphology process which develops in the upper slope/shoulder is cracking area that might initiate landslide when the soil force defence is less than soil mass load. the middle slope becomes transportation zone when landslides occur. It takes place at the slightly tilted class slope with the slope angel around 9% to15%. The lower slope, colluvial foot slope and colluvial plain are landslide material accumulation zone. The force to material movement in these area is less, so that these morphology units are more secure to landslide than the upper slope/shoulder and middles slope with the slope angle ranges between4% to to8% (Fig.2)

Based on research (11) the relationship between slope instabilities, active tectonics and drainage system at the Granada, Southern Spain showed that landslide mostly occur at the slope angel around 55%. Whereas, based on (10) which analyzed landslide using frequency ratio at the West Iran showed that mostly landslide occurs at the slope angel between 31% to 60%. Based on the both researches, we cannot exactly judge that landslide will be occurring only based on slope angel. There are other aspects to determine landslide susceptibility area according to landscape analysis Based on the unit morphology in the research area shows that unit morphology which has high potentially for landslide is upper slope, middle slope, lower slope, and foot slope

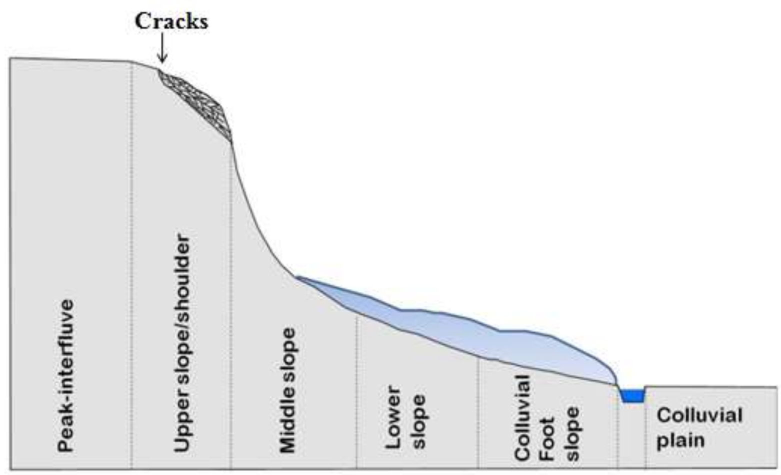

Figure 2. Landslide illustration based on Morphology (14)

3.2 Geomorphic Process

Dynamic process as geomorphological process could be separated from exogenic and endogenic geomorphic process. Exogenic process is derived by ultimate energy of the sun and the gradient of tectonic factors. The exogenic agents act from outside or above the troposphere, such as wind, water, waves and ice; these contrast with the endogenic agents which act upon the troposphere from within the earth (8). The exogenic process sometimes making disintegrated rocks by weathering process and in the certain time it will become susceptible material and potentially become material movement, material transportation and sedimentation of material. In the context of geomorphic process, landslide as soil movement is the simply as defined as the removal of weathered materials and being transported by gravity, water and inappropriate land management.

Endogenic process is process formed by energy which released from within the earth. Endogenic process can be the one process which triggering of landslide. Landslides can occur as a result of other disasters such as earthquakes. Earthquakes that occur in hilly or mountainous areas can be the initiator of a landslide. Earthquakes can occur due to endogenic processes (22). Endogenic process can form earth surface formations such as hills and mountains, both of which are forms prone to landslides. For analysis of landslide in the single slope could be separated each other of component of geomorphology such surface material and relief factors.

3.3 Surface Material

The structure of surface material controls various kinds of landslides in hilly and mountainous area (1). The surface material consist unconsolidated materials and consolidated materials. Both of surface material could be trigger of landslide by slip rupture of landslide. Morphology and surface material is closely interconnected each other. Sometimes, mostly for the unconsolidated material is existing in the soft morphology. Whereas, for the consolidated material is existing in the rough morphology. Identifying of surface material could be identified based on Digital Terrain Model (DTM).

The surface material in the research area is thick with unconsolidated materials. It can be identified by landslide scarp. Mostly, the surface material is dominated by depositional material form BromoVolcano. Unconsolidated material in the study area is also due to the highly intensive land management for agricultural land.For the most part, land management on sloping slopes is used for farming cassava with terrace system. Highly intensive land management without considering the physical condition of the soil can trigger landslides. For the lithology, the research area divided two classes such lithology in the upper morphology and lower morphology. It is based on geological map. In the upper morphology consist surface material such andesitic, basalt, tephra, alluvium, and material young Bromo Volcano. Whereas, for the lower morphology consist clay stone and limestone.

3.4 Landslide Assessment Based on Geomorphological Approach

Landslide assessment could be identified by geomorphological approach with considering three component of geomorphology. The component of geomorphological is interconnected each other such morphology, geomorphic process, and surface material. The morphology is the most potential component to landslide occurs because the morphology will give impact to soil movement which is affected by gravity force. The morphology as one of the geomorphological components for the assessment of landslides is closely related to the slope value. If the slope angel is greater, it would make greater soil material movement. In the research area the potential morphology for landslide assessment is unit morphology upper slope, middle slope, and lower slope (Fig. 3).

The geomorphic process is consist endogenic and exogenic process will affect to formed earth surface which can affect to landslide potential such hilly and mountainous area. Both of this form earth surface have high potential landslide than flat form earth surface. Mostly, the earth surface in the research area is hilly area. So, actually this is really potential of landslide. For the surface material components, landslides will occur more frequently in unconsolidated surface material. In this material usually has thick soil characteristics which can be identified through landslide scarp. In the research the mosquito area is dominated by unconsolidated material which is a deposional material from Bromo Volcano. Whereas, for the lithology in the research area are consist andesitic, basalt, tephra, alluvium, material young Bromo, clay stone and limestone.

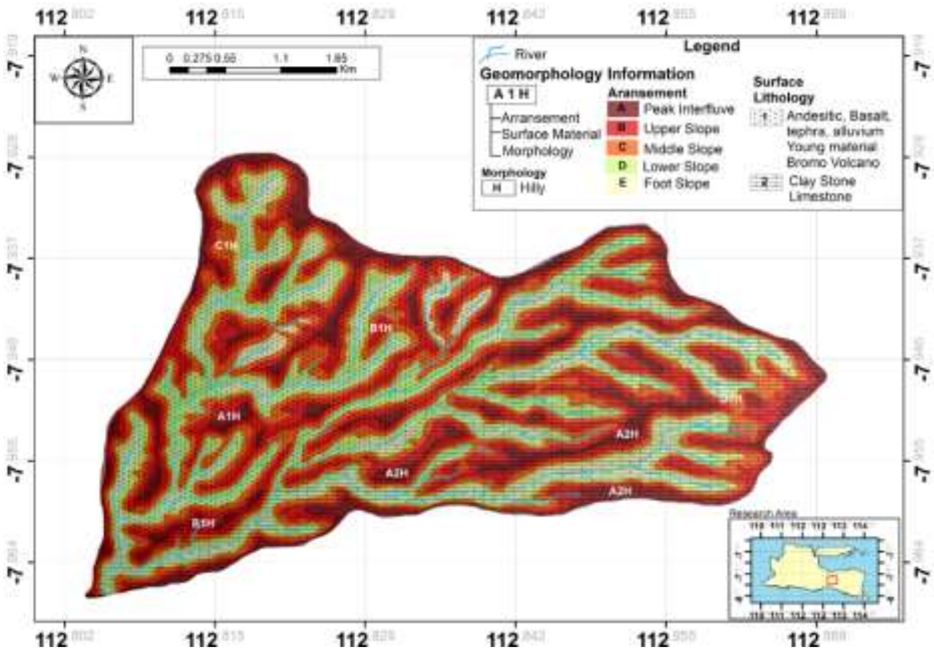

Fig 3: Geomorphology Map in the Gede Catchment

4. CONCLUSION

The geomorphological approach can be used as a landslide assessment because landslide process cannot be separated from the geomorphological process. Geomorphological components that can be used for landslide assessment are morphology, processes and surface material. Part of the morphological component that has big influence for landslide is morphology. In the Gede Catchment the morphology that has high potentially for landslide is upper slope, middle slope and lower slope.

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