International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064

Applied Geomorphology for Identifying Landslide Prone Area in Brebes, Central Java, Indonesia

Nana Sulaksana[1], Pradnya Paramarta Raditya Rendra[2]

[1, 2] Laboratory of Geomorphology and Remote Sensing, Faculty of Geological Engineering, Padjadjaran University, Jalan Raya Bandung-Sumedang Km.21, Jatinangor, Indonesia

Abstract: ***Brebes regency in Central Java, Indonesia, is geographically prone to natural disaster. Almost every year landslide occurred in this area. The present research provides the preliminary information on various aspects of applied geomorphology, aiming to identify and analyze landslide evidences obtained in the field. Further, this research also aims to provide recommendation to resolve the landslide problem that occurred in research area. This research methodology relies on identification and interpretation of image or map and field observation to the research area directly. Interpretation of image or map is used to identify geomorphological aspects such as morphometry, morphography, and morphogenetic aspect. Field observation of this research focused on finding evidences of landslide occurrences. Based on applied geomorphology aspects such as morphometry, morphography, and morphogenetic aspects, the research area can be concluded as landslide prone area. Therefore, the landslide occurred many times caused the research area is not recommended to be built as residential area. There are several ways that can be done to avoid future landslide, the local residents should be concerned about their environment by seeking a good drainage system. People are also not allowed to damage the land and change land use carelessly. Further, the research area is fully recommended to be made as conservation forest area or agriculture cultivation area on small-medium scale.***

Keywords: Brebes, landslide, natural disaster, applied geomorphology

1. Introduction

Brebes regency is located in Central Java, Indonesia, along North Java Sea at the latitude 6° 44' - 7° 20' South and longitude 108° 41' - 109° 11' East. This area extends to the south and is bordered by several regencies, Tegal in eastern part, Banyumas and Cilacap in southern part, and Cirebon (West Java) in western part (Figure 1).

Figure 1: Location of research area (Brebes Regency)

Brebes is geographically prone to natural disasters. The area divided into two disaster-prone areas, the southern and northern areas. Since 2005, landslide has often occurred in the southern area of Brebes regency. Almost every year landslide occurred in this area. Factors causing landslides are many illegal logging and land use change. These factors will cause the hills are not able to absorb water when it rains [6].

Landslide in Brebes is mainly caused by the rain that fell continuously for several days. In 2006, landslides have occurred three times in Brebes during the rainy season in Paguyangan, Tonjong, and Sirampog District. Landslides that occurred were the collapse of the cliff on the roadside. Fortunately, there were no casualties in that incident. During 2008, landslide occurred in 11 districts and 71 villages in Brebes [6] (Table 1).

Table 1: Landslide Occurred in 2008

No	*Districts*	*Total of Affected Village*	*Villages*
1	Banjarharjo	4	Bandungsari, Sindangheula, Blandongan, Kertasari
2	Bantarkawung	13	Legok, Waru, Karangpari, Cinanas, Telaga, Cibentang, Tambakserang, Terlaya, Jipang, Banjarsari, Ciomas, Pangebatan, Sindangwangi
3	Salem	8	Bentarsari, Wanoja, Bentar, Gandoang Pasirpanjang, Gununglarang, Ganggawang, Gunungjaya Lama
4	Paguyangan	7	Cipetung, Pandansari, Cilibur, Pakujati, Ragatunjung, Wanatirta, Winduaji
5	Sirampog	7	Sridadi, Mlayang, Mendala, Manggis, Kaliloka, Kaligiri, Batursari
6	Bumiayu	6	Pruwatan, Kalierang, Bumiayu, Adisana, Laren, Kalinusu
7	Ketanggungan	5	Jemasih, Ciseureuh, Sindangjaya, Pamedaran, Cikeusal Kidul
8	Larangan	3	Pamulihan, Larangan, Kedungbokor
9	Tonjong	11	Galuhtimur, Kalijurang, Karang Jongkeng, Kutamendala, Linggapura, Negarayu, Pepedan, Purwodadi, Rajawetan, Tanggeran, Tonjong

10	Songgom	2	Jatirokeh, Cenang
11	Jatibarang	5	Kebonagung, Kebogadung, Buaran, Kedungtukang, Jatibarang Kidul

Geomorphology is the study of Earth's physical land-surface features, its landforms - rivers, hills, plains, beaches, sand dunes, and myriad others [4]. The present research provides the preliminary information on various aspects of applied geomorphology in research area, aiming to identify and analyze landslide evidences obtained in the field. Further, this research also aims to provide advice and recommendation to resolve the landslide problem that occurred in research area.

2. Methodology

Landslide comprises almost all varieties of mass movements on slopes, including some, such as rock falls, topples, and debris flows, that involve little or no true sliding [8]. Landslides can be classified into different types on the basis of the type of movement and the type of material involved either rock or soil [1, 2]. This research methodology relies on identification and interpretation of image or map and field observation to the research area directly. Interpretation of image or map is mainly used to identify geomorphological aspects such as morphometry, morphography, and morphogenetic aspect [3,7]. Morphometry aspect identified by topographic and morphometric map, morphography aspect identified by Digital Elevation Model (DEM) with resolution of 30 meters and drainage network map, whereas morphogenetic aspect identified by geological map.

Topographic map is used to measure percentage of slope gradient and divide research area into several morphometry units hereinafter named as morphometric map. Digital Elevation Model (DEM) and drainage network map can be used to identify clearly landform and drainage pattern of research area. In addition, DEM can be very useful to determine lineaments of geological structure that indicates active tectonic area. The Geological Map of Majenang Quadrangle [5] made public by Geological Research and Development Centre contributes very valuable information about morphogenetic aspect. The information obtained through this map is various types of rock in the research area.

Field observation of this research focused on finding evidences of landslide disaster. Further, this field observation aim to identify and analyze the type of landslide occurred and provides recommendation for landslide mitigation in the research area (Figure 2).

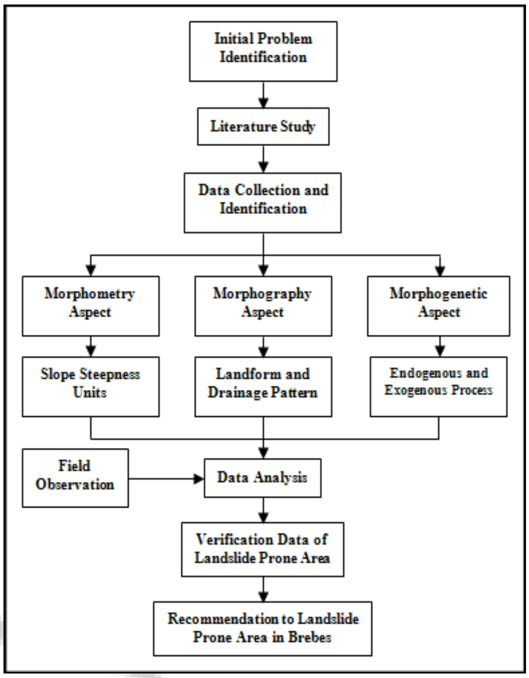

Figure 2: Research method mainframe

3. Result and Discussion

3.1 Morphometry Aspect

Research area affected by landslide has elevation ranging from 100 – 1.325 meters above sea level. This elevation value range obtained from topographic map of research area. Based on topographic map, research area can be divided into 3 morphometry units, Gently Sloping Hill, Steep Hill, and Very Steep Hill Unit. Steep Hill and Very Steep Hill Unit dominate most of the research area (Figure 3). These morphometry units indicate that research area is prone to erosion of rocks and landslide hazard. Moreover, field observation evidences suggests that research area experienced an erosion process and landslide hazard.

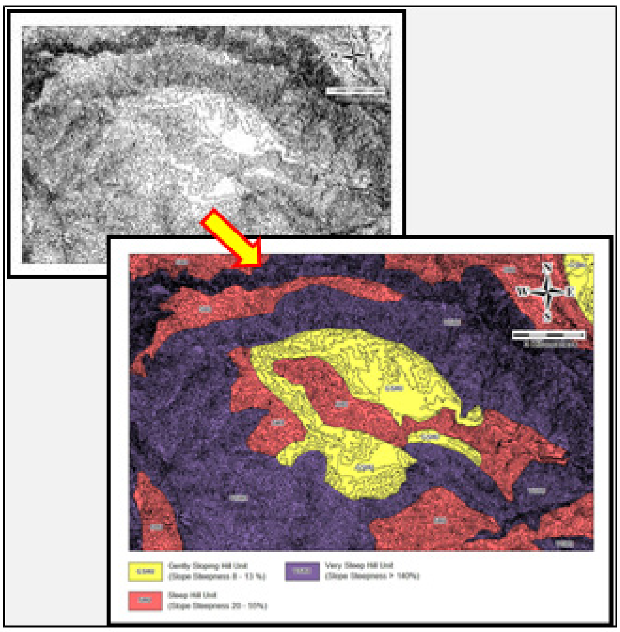

Figure 3: Topographic Map (upper left) and Morphometric Map (lower right) shows that most of the research area is dominated by very steep hill indicates landslide prone area

3.2 Morphography

Based on previously described, to identify morphography aspects, Digital Elevation Model (DEM) with resolution of 30 meters and can be used to view and analyze existing landforms whereas drainage network map can be used to analyze drainage pattern in research area.

Based on DEM, the landform of research area can be identified as a series of elongated hills and mountains which indicate active tectonic area and composed by soft rock materials in central of research area that is prone to erosion of rocks and landslide disaster (Figure 4).

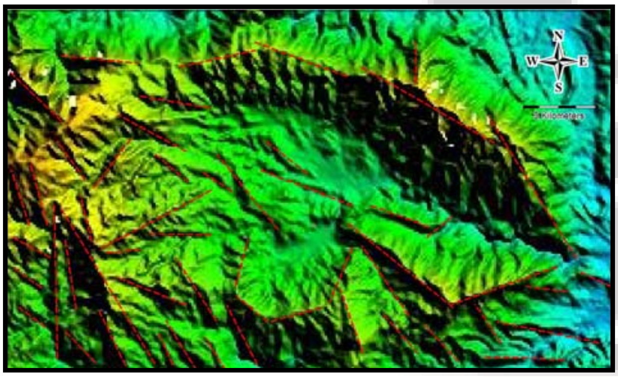

Figure 4: Lineament interpretation using Digital Elevation Model (DEM) with a resolution of 30 metres of research area indicates active tectonic area and prone to landslide disaster

Moreover, there are several drainage patterns that can be determined and analyzed specifically in research area using drainage network map (Figure 5). This drainage network consists of rivers that flow in the rainy season but dry up in the dry season. Some drainage patterns that can be determined and analyzed in research area are parallel, rectangular, and trellis pattern.

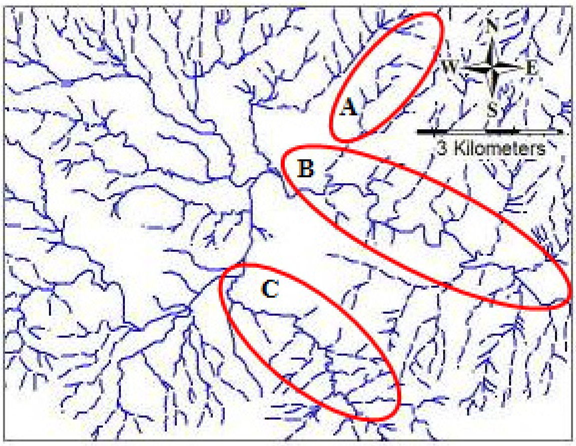

Figure 5: Drainage Network Map shows several drainage patterns that indicates active tectonic area (A: Parallel pattern; B: Rectangular pattern; C: Trellis pattern)

Parallel pattern can be identified in northeastern part of research area. This pattern characterized by its shape that relatively parallel between one tributary with others. On the other hand, this pattern indicates moderate to steep slopes and can be found in areas of parallel, elongate landforms.

Rectangular pattern can be identified in eastern part of research area. This pattern can be determined from joints or faults at right angles. Moreover, this drainage pattern leads to determine the condition of active tectonic area. Trellis pattern can be identified in southeastern part of research area. This pattern actually represented dipping or folded sedimentary, volcanic, or low-grade metasedimentary rocks. This pattern also transition from parallel pattern.

3.3 Morphogenetic

Research area had experienced a wide range of geomorphological process, both endogenous and exogenous process. Endogenous process is characterized by a tectonic activity such as folding and faulting that can be seen from lineaments interpretation using Digital Elevation Model with resolution of 30 meters (Figure 4) and Geological Map of research area (Figure 6). However, many landslides occurred in the central part of research area that experienced an exogenous process.

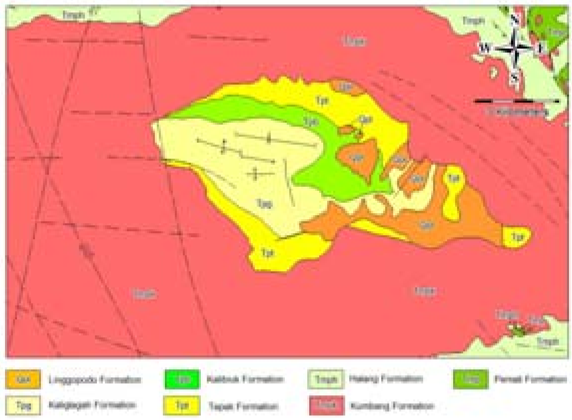

Figure 6. Geological Map of research area

Based on geomorphological process, exogenous process in research area such as weathering, erosion, and transportation of rock and soil materials has been the most dominant processes occur. Therefore, the research area can be classified into denudational landform. Exogenous process from the past to the present is the most prominent factor of the development of denudational landform and closely related to morphogenetic aspect and landslide hazard in research area.

Research area affected by landslide hazard is influenced by exogenous process such as weathering, erosion, and transportation of rocks and soil materials. In addition, the landslide hazard occurred are influenced by claystone which contain clay minerals (Figure 7). This clay mineral has specific characteristic that is swells and shrinks. This characteristic is influenced by water content of rocks. When water content of rock is increased, clay mineral will quickly swell but when the water content of rock is decreased, clay mineral will quickly shrink. These conditions resulted in soils on the slope of research area are easily expanded and shrink so the hill of research area become unstable and susceptible to landslide.

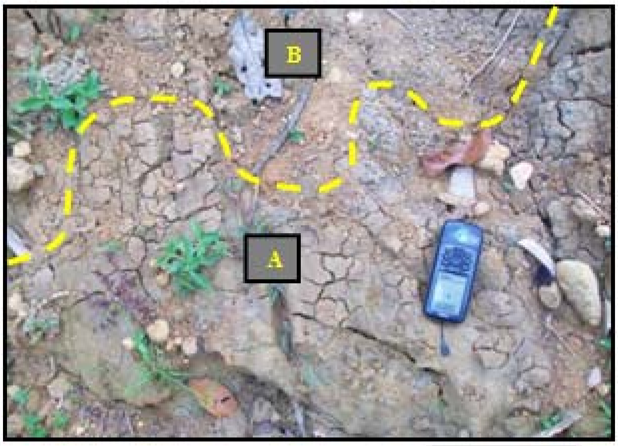

Figure 7: Claystone (A) mixed with landslide material (B) that comes from top of the slopes

3.4 Field Observation

Field observation was carried out in several areas that have been proved affected by landslide disaster. Field observation evidences suggest that landslide occurred in research area can be classified into translational landslide. The mass in a translational landslide moves down along relatively planar surface with little rotational movement (Figure 8). The landslide materials range from loose, unconsolidated soils to compacted rocks. Many plantations and agricultural area were severely damaged. In addition, this landslide can occur due to intense rainfall that fell continuously in research area.

Figure 8: Landslide materials move down along relatively planar surface (yellow arrow represent direction of landslide)

This landslide movement was relatively slow. However, this landslide can cause heavily damage to resident houses, public buildings or facilities, and it can be life-threatening to local residents. Most of the local resident houses suffered severe damage due to landslide disaster in research area (Figure 9). A lot of local residents had to evacuate to a safer place due to landslide disaster. Local government has been trying as much as possible to resolve this problem immediately by encouraged local residents to reduce their activities in the area that had been prone to landslide disaster and always be aware during the rainy season. However the landslide disaster still occurs almost every year in this area.

Figure 9: Remnants of resident houses debris that have been affected by landslide (yellow arrow represent direction of landslide)

4. Conclusion and Recommendation

The landslide phenomenon occurred in the Brebes regency can be identified clearly through geomorphology aspects. Based on geomorphology aspects, the research area located at the intersection of various ridges lineament shows indication of active tectonic area. In addition, geomorphology aspects such as morphometry, morphography, and morphogenetic indicate that research area is prone to landslide. This conclusion is based on field observation data that this area has experienced landslide continuously almost every year.

The research area lies on the zone of regional ground movement so that manifestation of ground movement can result in intensive landslide hazard on large scale. On the other hand, manifestation of ground movement can occur gradually or suddenly depending on rainfall condition in research area. The landslide phenomenon that occurred many times caused the research area is not recommended to be built as residential area. There are several ways that can be done by local residents and government to prevent landslides. To avoid future landslide disasters, the local residents should be concerned about their environment by seeking a good drainage system so that rain water can flow properly. People are also not allowed to damage the land and change land use carelessly. Further, the research area is fully recommended to be made as conservation forest area or agriculture cultivation area on small-medium scale.

5. Acknowledgements

Authors would like to thank the researcher team of Center for Volcanology and Geological Hazard (Mr. Sumaryono, Ms. Yukni Arifianti, Mr.Twin Hosea and Mr. Iskandar) for the opportunity to carry out joint research activities in Brebes.

References

[1] British Geological Survey. 2012. UK Geohazard Note: Landslide. United Kingdom: NERC.

[2] Highland, L.M., and Bobrowsky, Peter. 2008. The Landslide Handbook - A Guide to Understanding Landslides. Virginia: USGS Circular 1325.
[3] Howard, Arthur David., 1967. Drainage Analysis in Geologic Interpretation: A Summation. The American Association Petroleum Geologist Bulletin, Vol.51, No.11, November 1967: 2246-2259.
[4] Hugget, Richard John. 2007. Fundamentals of Geomorphology, Second Edition. London: Routledge.
[5] Kastowo and Suwarna. 1996. Geological Map of The Majenang Quadrangle. Scale 1:100.000. Bandung: Geological Research and Development Centre
[6] Pemerintah Kabupaten Brebes. 2008. Status Lingkungan Hidup Daerah Kabupaten Brebes 2008. Brebes.
[7] Van Zuidam, R.A. 1985. Aerial Photo-Interpretation in Terrain Analysis and Geomorphologic Mapping, Smith Publisher, The Hague, Amsterdam.
[8] Varnes, David J. 1984. Landslide Hazard Zonation: A Review of Principles and Practice. France: UNESCO.

Author Profile

Nana Sulaksana received the Engineering degree in Geology from Padjadjaran University in 1973, Master degree in 1988 from Planology Department - Institute of Technology Bandung, and Doctor Degree in 2011 from Postgraduate Program of Geological Engineering-Padjadjaran University. Now, he is a senior lecturer in Faculty of Geological Engineering, Padjadjaran University. Interest research: geomorphology, remote sensing, volcanology, landuse planning, and mitigation of geohazard.

Pradnya Paramarta Raditya Rendra received the Bachelor of Engineering in Faculty of Geological Engineering, Padjadjaran University in 2012. Now, he is a lecturer assistant in Laboratory of Geomorphology and Remote Sensing, Faculty of Geological Engineering, Padjadjaran University. Interest research: geomorphology, remote sensing, geohazard.