The Triggering Factor of Landslide Phenomenon in Karangkobar, Banjarnegara, Indonesia

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Abstract
Banjarnegara district is dominated by hills which have the potential for landslide disaster. Landslide phenomenon occured many times in the Jemblung village, Karangkobar District, Banjarnegara which took many casualties such as loss of sizeable human lives and facilities. Landslide analysis was conducted to examine the factors which caused landslides by checking the supporting data such as topographic maps, geological maps, and rainfall data in Banjarnegara regency. The study was literature review back analysis about landslides in Karangkobar by using analysis Regulation of the Indonesia Minister of Public Works No. 22 / PRT / M / 2007 as disaster mitigation analyses. The level of hazard in the Jemblung village area, Sampang, Banjarnegara was revealed in this paper. This study showed that the main factor causing landslides in Karangkobar especially the village of Sampang was the topography of Sampang village which is located on the steep slopes and rock types which are easily weathered, and high daily rainfall before the landslide. The analyses of the level of hazard revealed the same results that Jemblung was categorized as high landslide hazard level area. Mitigation effort which could be conducted was by giving socialization to the community on appropriate land management, preventing any additional slope load as well as an effort to flatten the existing cracks.
Keywords: landslide, topography, rainfall, geologic of soil

Introduction

Landslides are one of the disasters which often occur in Indonesia. The Indonesian Deaprtement of Disaster Mitigation (BNPB) recorded that during the four years (2010-2014), 1500 landslides occurred in Indonesia. Therefore, this case requires further investigation to minimize the impacts. Landslides can cause various problems (type, affecting factors, time and the scene) both before, during and after the landslides [1], [6], [8]. Natural factors which become the cause of the mass movement are the high rainfall, soil conditions, rocks, vegetation and seismic factors, as well as, humans' activities that could trigger landslides. Banjarnegara was one of the districts which experienced quite serious landslides in 2014. The damages were 88 casualties, severely damaged / buried 40 units of house, 1 unit mosque, 1 Km land – covered river, 8 Ha damaged rice field, garden crops 5 ha, 5 cows, 30 goats, 500 chickens and ducks [2]. Landslides could have been prevented if the surrounding community were more responsive to disasters and stop destroying the environment. One of the ways to mitigate landslides was by knowing the location of the land in which landslide frequently occur and its hazard level [3]. Banjarnegara is a regency which has the potential of medium to high mass movement. As a consequence, this study of mass movement is necessary. This study was carried out by reviewing literature on landslides which occurred in Banjarnegara. The analysis of landslides by using Permen PU (Regulation of Indonesian of Public Work Ministry) was conducted to examine the factors which caused landslides by checking the supporting data such as topographic maps, geological maps, and rainfall data in Banjarnegara regency. The results of this study provided advice on mitigation efforts which can be conducted to avoid the landslide and to minimize its losses. The location of the study was in District Karangkobar, Banjarnegara regency, Central Java. Location of the study were at coordinates 109 ° 43 '15.3912 "East and 7 ° 16' 52.5828" South. According to the vulnerability of mass movement zone map 2014 published by the Center for Volcanology and Disaster Mitigation Geology (CVDMG), the location of the study is on the red zone (Fig. 1). Therefore, the potential of mass movement in this region is high.

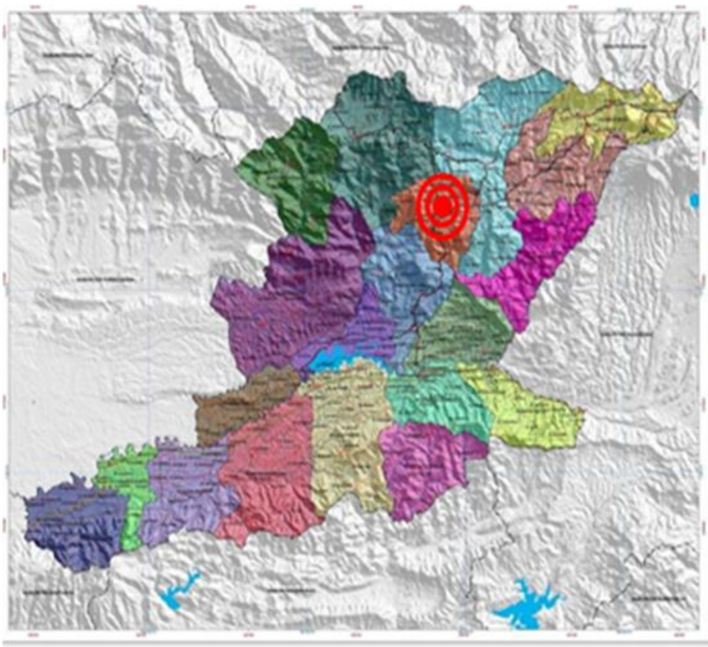
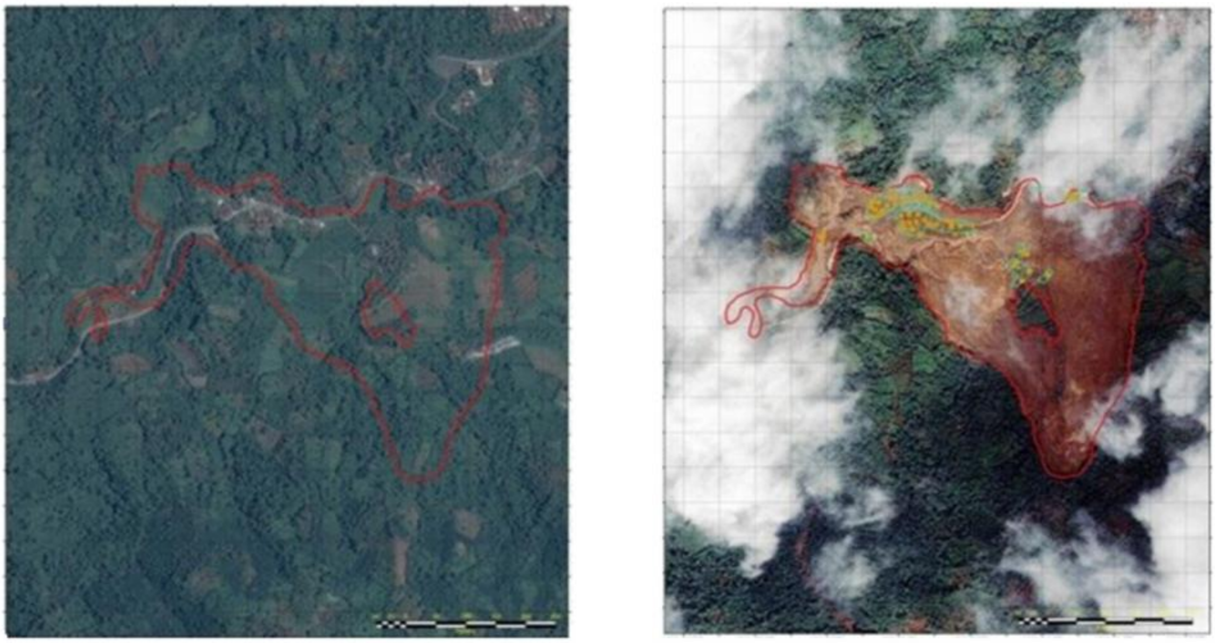


Fig 1. The Map of Study Site

History of Landslide

The landslide caused the loss of life. Out of 308 people living in Jemblung village, 200 people survived. However, 108 people were buried by landslide. Area of landslide was estimated that approximately 17 Ha was buried by landslide. The location of the landslide was in Bukit Tegalele that had an extreme slope. Bukit Telaga Lele (Tlogolele) was about 400 meters high, the landslide hit the residential area in the Jemblung village. The distance of the village with early landslide point was about 1 kilometer. The direction of the landslide was heading northwest, then hit a river wall and turned to the southwest hitting the crowded residential area in the Jemblung village (Fig. 2).



(a) (b)

Fig 2. The Conditions before (a) and after (b) the landslide Karangkobar (LAPAN, 2014)

Results and Discussion

Factors Triggering

One of triggering factor of landslide is topography which ilustrated the physical form of the slope. The case of Karangkobar landslide was caused by a number of fault lines, this region has the texture of hilly land that has a steep and upright slope. The fault lines also lead to the bond of the layers of rock and soil bearing become splitting and fragile. The effect of the fault which facilitated this landslide was multiplied with a layer of clay or marl stone under the ground. The layer of clay or marl stone easily experienced saturation when rain occurs. Based on the slope map in Banjarnegara regency, it can be seen that most of Karangkobar area has 25-40% slope that is categorized as the region with steep slopes. The classification of slopes are identified with Table 1 and slope illustartion of Banjarnegara regency could be seen in Figure 3.

Table 1: Classification of slopes

Class	Slope (%)	Claassification
I	0 – 8	Flat
II	> 8 – 15	Slightly steep
III	> 15 -25	Steep enough
IV	> 25 -45	Steep
V	> 45	Very steep

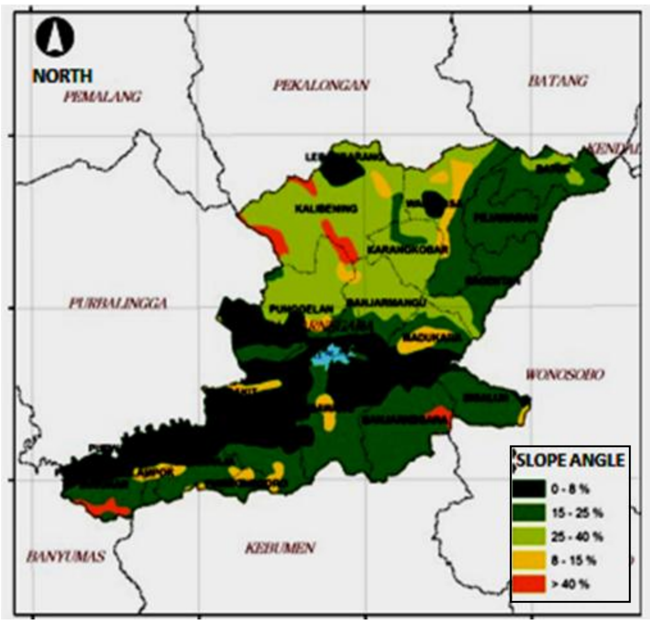


Fig 3**.** Slope angle in the Banjarnegara district (Hidayat, 2015)

Furthermore, another factor which trigger landslide is geological structures that influence the occurrence of mass movement is contact between the bedrock and weathering rocks, cracks / fractures, layers of rocks, and fault lines. Karnawati [8] depicted that Karangkobar district is the most vulnerable landslide areas in Banjarnegara regency. This area consists of brittle rocks, loose soil and steep slopes. When the rain falls, the water infiltrates the rock. Consequently, the rock becomes brittle. However, it is sufficient to hold the water in so water is flooded in. It then pushes piles of loose soil sliding and landslideoccurs. Rock cracks lead to landslide whose volume becomes greater. Along the fault lines, it does not only occur on one point. Based on regional geological map in the Karangkobar which described in Fig. 4, most of the Karangkobar area consists of renggojembangan volcanic rocks and rambatan rock formations. Those rocks are easily weathered rocks and not very solid. The type of the existing geological condition is composed of lava and alluvium sediment from volcano eruption material, lava flows and breccia, with bedrock in the form agglomerates with andesite, hornblende andesite lava and tuff.

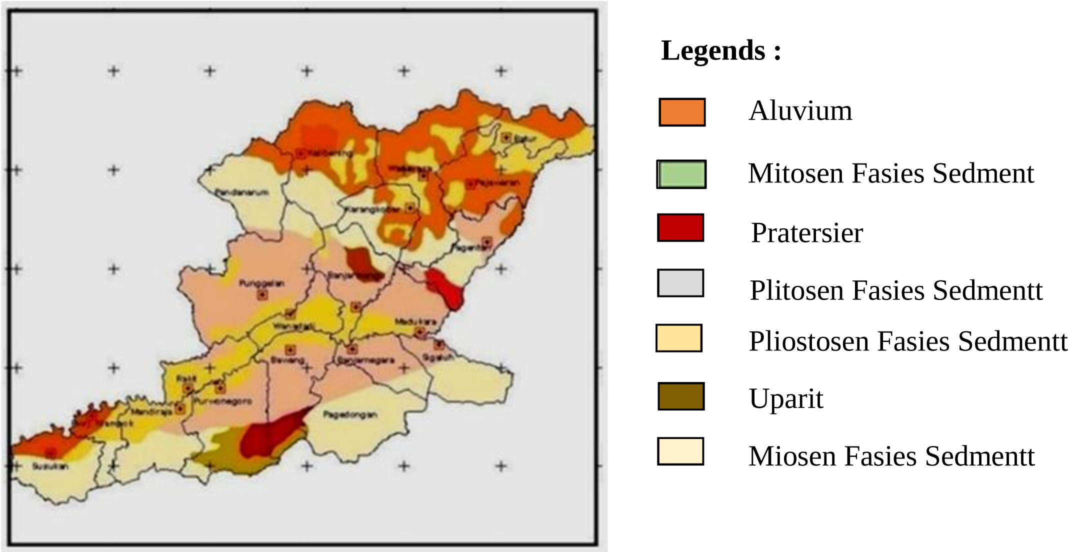


Fig 4. Regional Geologi Karangkobar area (Nandi, 2007)

The effect of rain fall on landslide phenomenon in Karangkobar indicated that it also the triggering factor. From the Fig. 5 revealed that the excessive amount of water increases the load of a slope, making the slope unstable. Rain with a high intensity, eg, 50 mm and long-lasting (more than 6 hours) potentially causes landslide, because the water saturates the soil, thereby increasing the weight of the ground [4]. According BNPB [2], long lasting heavy rainfall at the time and prior to the mass movement is one of the factors triggering landslides. Based on daily rainfall data published by BMKG, daily rainfall before the landslide in Karangkobar on December 12, 2014 was 204 mm / day.

Widagdo [11] states that, the landslide area which was the object of this study is located on North Serayu mountainous area. This slope have the declivity leading to the north-northwest (Figure 2). From Fig. 6, it described that the area of the study is located at an altitude between 900-1100 m above sea level. The peak area is on the southeast slope with an altitude of 1100 meters above sea level, which is a part from the slope of the Sampang mountainous area.

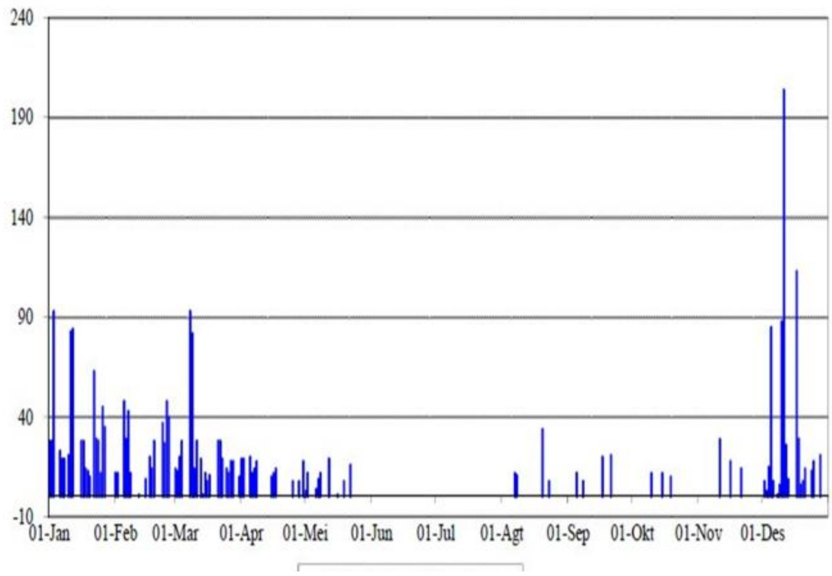


Fig 5. Daily rainfall in Karangkobar (PSDA, 2014)

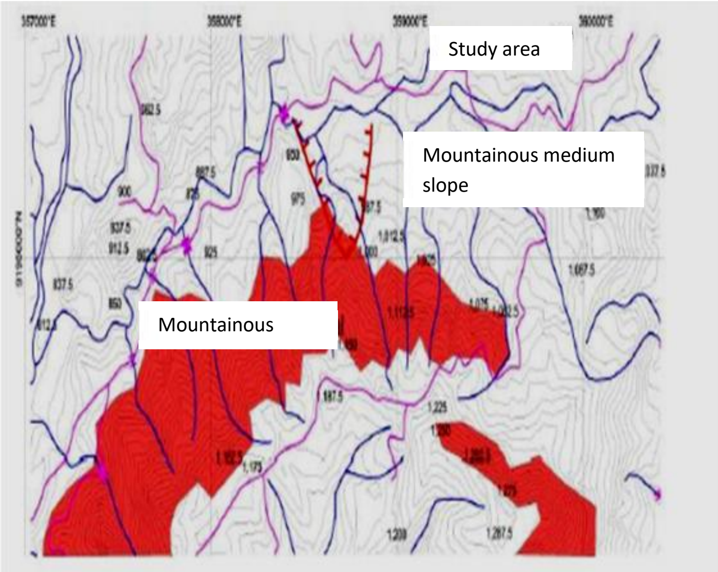


Fig 6. Geomorphological Map of the Area of the Study (Widagdo, 2015)

With the height of the area is above 500 meters, the area of the study can be categorized as mountainous area. The slope in the middle area to the north - southwest has relatively steep height between 40 to 60 degrees. The morphology of this steep slope expands from a height approximately 900 m to the top of 1100 m. Therefore, height difference of erosional escarpment / the structure of this area is 300 m[10]. Based on the classification of relief by van Zuidam (1983 in [11]), this area is included in the steep slope area. In Figure 7, the area is described as a morphological part of a mountain with steep slopes. The flow pattern that develops on steep slope is the pattern of parallel. The stadia of the river is at an early stage. The steep slope is composed of epiclastic breccia

Fig 7. The Morphology of the Landslide area in the Area of the Study (Widagdo, 2015)

According Widagdo [12], outside the landslide-prone area Sampang village, the slope increases between 20-30 degrees (Figure 7). This morphology expands from an altitude of 800-900 m in the southern part of 900-1100 m in the east. Therefore, the height difference is only 100-1n m area. This area cold be indentified as undulating hilly areas with relative rocks are Pleistocene and the environment of breccia formation is on ground loop [9].

Analysis of landslide potential

Method of analysis using Indonesia Ministry of Public Work Regulation no. 22 / PRT / M / 2007. The Guidelines of Spatial Landslide Prone Areas are arranged to complete the norms, standards, procedures, and manual in the spatial field in the form of guidelines, technical guidelines, implementation guidelines as well as technical guidelines in the spatial field. One of these guidelines are the guidelines for the preparation and a review of the provincial spatial plan, districts and urban areas contained in Decree of the Minister of Settlement and Regional Infrastructure No. 327 / KPTS / M / 2002 regarding the Determination of Six Guidelines on Spatial Planning Division. With reference to these guidelines, the possibility of the occurrence of landslides may be anticipated, prevented or minimized. In addition, losses of lives as well as wealth caused by landslide can also be minimized through spatial planning of landslides prone areas. Therefore, the consistency of implementation of space utilization with the spatial plan of the area can be maintained.

Landslide prone areas are divided based on the characters and their natural physical condition. Consequently, each zone has different in the Landslide prone areas are divided based on the characters and their natural physical condition. Consequently, each zone has different in the determination of the structure of space and spatial patterns and the type and intensity of activity allowed, allowed with the requirements, or banning. Landslide prone zone is the area / region which is prone to landslide with the terrain condition and geological condition which is very sensitive to outside interference, both natural and human activities as the mass movement triggering factors. As a consequence, the landslide can potentially occur. Based on its hydrogeomorphology, an area can be categorized into three types of zone (as illustrated in Figure 8.

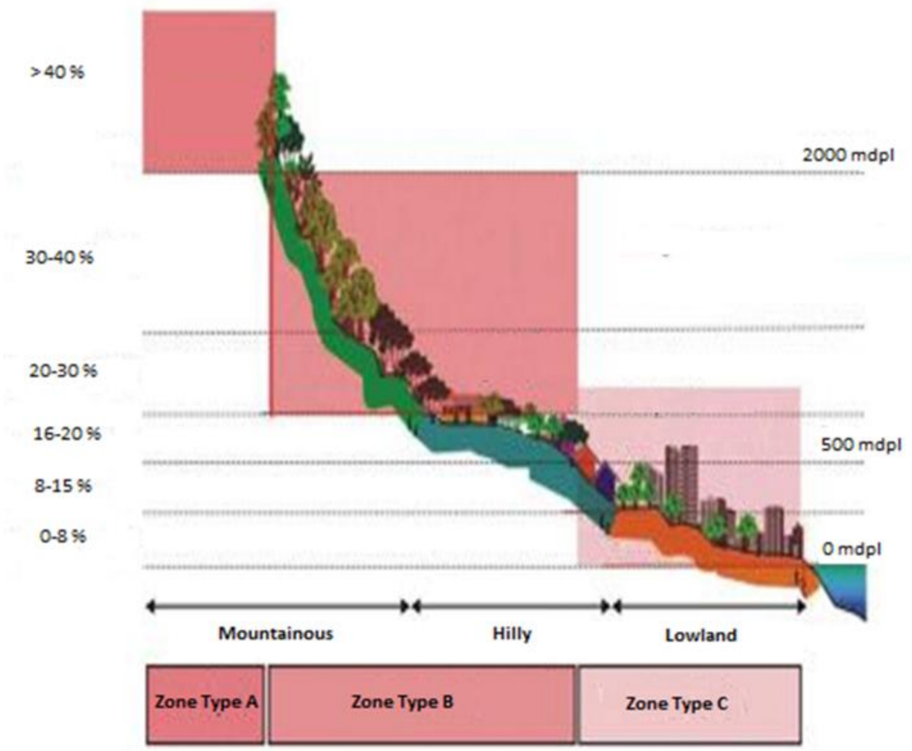


Fig 8. Typology of potential landslide zone based on the results of the hydrogeomorphology study

Table 2. The Natural Physical Aspect Criteria Kriteria Aspek Fisik Alami

No	Indicator	The Indicator Weight (%)	Vulnerability Level Sensitivity	Verifier	Research Weight	Weight Value Weighted Level of landslide vulnerability
1	Slope angle	30%	High	The slope angle is the approximately 36 – 40%	3	0.9
2	Soil condition	15%	Medium	The slope is composed of expanding clay, but there is not contrastive field with the rock beneath.	2	0.3
3	Slope composing rock	20%	Medium	The slope is composed of rocks and there is a vault structure but the rock layer is not tilted to the outside of the slope.	2	0.4
4	Rrainfall	15%	high	The rainfall reaches 70mm/hour or 100 mm/day, the yearly rainfall reaches 2500 mm	3	0.6
5	Slope waterworks	7%	medium	There is no water seepage or springs on the slopes or the contact area between impermeable rock with *permeable* soil layers	3	0.9
6	seismicity	3%	medium	The frequency of earthquakes is rare (1-2 times per year)	2	0.3
7	vegetation	10%	low	Tap rooted plants with roots spreading like hazelnut, laban, dingsem, Mindi, Venus, bungur, banyan, mahogany, renghas, teak, kosmbi, rosewood, trengguli, Tayuman, tamarind and Pilang	2	0.4
TOTAL						2.41

Table 3. Human Activity Aspect Criteria

No.	Indicator	The Indicator Weight (%)	Sensitivity level of vulnerability	Verifier	The weight of research	Weight Value Weighted Level of landslide vulnerability
1	Planting pattern	10%	Medium	The slope is planted with appropriate cropping patterns and very intensive, for example, tap root plant (perennials tree)	0.2	0.2
2	Excavation and Cutting Slope	20%	Low	Not digging / cutting slopes, but the intensity is low, pay attention to the structure of soil and rock, and there is a calculation of slope stability analysis	0.2	0.2
3	Pool printing	10%	low	There is no pool printing	0.2	0.2
4	Drainage	10%	low	The drainage is sufficient and there are efforts to maintain the drainage system	1	0.1
5	Construction development	20%	low	The construction development has been conducted. The load is still low and has not exceeded	1	0.2

6	Population density	20%	low	the carrying capacity of the soil, or there is not construction development. The construction development has been conducted. The load is still low and has not exceeded the carrying capacity of the soil, or there is not construction development.	3	0.6
7	mitigation effort	10%	low	There is a well organized and coordinated natural disaster mitigation effort by the government or the public,	1	0.1
				Total		1.6

Table 4. Classification of zones Potential Landslide types based on the level of vulnerability Based on Table 2

No	Type of zone	The Vulnerability Level Criteria (Natural Physical Aspect)	The Risk Level Criteria (Human Aspect)	Vulnerability Level Classification
1	A The slope of the mountain / the mountain, The slope of the hill / hills, and the river bank with a slope angle of over 40%	High	High	High class
			Moderate	
			Low	
		Moderate	High	
			Moderate	Moderate class
			Low	
		Low	High	
			Moderate	
			Low	Low class
2	B The foot of the mountain / the mountain, foothills / hills and the river bank with a slope angle between 21% to 40%	high	High	High class
			Moderate	
			Low	
		Moderate	High	
			Moderate	Moderate class
			Low	
		Low	High	
			Moderate	
			Low	Low class
3	C Upland areas, lowlands, the riverbanks and the river valley with slope angle 0% to 20%	High	High	High class
			Moderate	
			Low	
		Moderate	High	
			Moderate	Moderate class
			Low	
		Low	High	
			Moderate	
			Low	Low class

The criteria for vulnerability level of potential landslide Zone Type B are based on the natural physical aspects are as follows: (1) Type B Potential Landslide Zone with high vulnerability level: the total value is 2.40 - 3.00; (2) Type B Potential Landslide Zone with medium vulnerability level: the total value is 1.70 to 2.39; (3) Type B Potential Landslide Zone with low vulnerability level: the total value is 1.00 to 1.69. The value of assessment of the vulnerability of Type B potential landslide zone based on the natural physical aspect is 2:41 which is included into Type B Potential Landslide Zone with high vulnerability level. While the value of assessment of the vulnerability of Type B potential landslide zone based on human activity is 1.6 which is included into Type B Potential Landslide Zone with high vulnerability level.

Conclusion

Based on the analysis of the factors causing the landslide in Karangkobar district, it can be concluded that the main cause of landslides Jemblung, Karangkobar, Banjarnegara is the topography which is in the steep slopes and rock types which is easily weathered and excessive rain after the 204 mm / day prior to the occurrence of landslides. The analysis of Slope landslide susceptibility using the method of Minister of Public Work Regulation No. 22 / PRT / M / 2007. The analysis revealed that Jemblung had the high landslide susceptibility. Special concern about landslide disasters has paramount importance, given landslide area is located near the residential area. Mitigation efforts become one of the things that must be conducted, such as information dissemination to the community to cultivate land properly, good management of the drainage slope, so that the level of water saturation can be reduced, no slope excavation at the foot of the slopes. If there is a crack, the public can close the cracks with landfill to make it flat.

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