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Risk level of landslide disaster in Wonosobo

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Abstract. Entering the rainy season can certainly cause various disasters, such as landslides. National Agency for Disaster Management (BNPB) noted since early 2017 to December 4, 2017 recorded as many as 577 incidents of landslides throughout Indonesia. Wonosobo is of the regency in Central Java that has occurred of Landslide. Based on Indonesia Disaster Information Data (DIBI) within 2017 until now in Wonosobo regency there are 9 landslide. By SMORPH modelling, found that the area of landslide potential with the highest grade in Wonosobo district of 17% area, and for sub-district and the sub-district with the highest potential landslide is Wadaslintang with the percentage of 13.85% area. Therefore, it is necessary to conduct research on risk level of landslide to reduce fatalities and material loss. To know how risk level, indicator used is landside potential area, vulnerability, and capacity. The output is risk level area of landside in Wonosobo, and for final results indicate that areas experiencing low risk levels are 7688,144 km² or 8%, moderate 10111,89 km² or 11%, and high 78123,15 km² or 81%. Landslide risk distribution with high class are dominates in north, south, and west.

1. Introduction

Wonosobo is a district in Central Java Province. The capital is Wonosobo. It is adjacent to Temanggung and Magelang regencies in the east, Purworejo regency in the south, Kebumen regency and Banjarnegara regency in the west, and Batang regency and Kendal regency in the north. Wonosobo district consists of 15 sub-districts. The central government is located in Wonosobo sub-district in Wonosobo district: Garung, Kalibawang, Kalikajar, Kaliwiro, Kejajar, Kepil, Kertek, Leksono, Mojotengah, Sapuran, Selomerto, Sukoharjo, Wadaslintang, Watumalang, and Wonosobo [1]. Wonosobo district have potential area for landslide based on research and paper that not yet published by Muhammad Chaidir Harist et.al. at International Conference on Disaster Management (ICDM) [2].

Landslide is one type of mass motion of soil or rock, or mixing both, down or out of the slope due to disturbance of soil stability or slope constellation rocks [3]. Landslide is a disaster that can arise as a result of various factors like human and natural factor. From this factor we can know and produced potential area map [2], Vulnerability map, and Capacity map for risk level of landslides in Wonosobo. Disaster risk is a possible assessment of the expected impact if the danger becomes a disaster.

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The potential map of the area is obtained from gradient and shape slope data that is processed using SMORPH method. Factors for Vulnerability Map are four data covering economic including number of economic means, number of working population, productive land. Socio-cultural factor including population density, the number of elderly population, the number of under-fives. Physical factor including built area, road network, and etc.. Last factor is environmental including land use. For capacity is obtained from the number of health personnel, and the number of health facilities. These three factors can be used to determine the risk level of landslides present in Wonosobo [4].

2. Method

SMORPH is a semi-empirical method developed by the Washington Department of Natural Resources to identify the steep and concave sections of the Watershed (DAS) that are vulnerable to shallow landslides that can mobilize into debris flows [5,6,7]. This method is computationally simple and suitable to be implemented in Geographic Information System (GIS). SMORPH is used to determine the hazard / potential landslide that occurs in Wonosobo district.

The SMORPH model analyzes on the basis of gradients and slope shapes, which is the field's vulnerability to the landslide process [8,9]. There are 2 input data needed, namely topographic data and geomorphic interpretation of landscapes that are susceptible to erosion by landslides in the observed area. For this reason, digital elevation data (DEM) is used, DEM is used because they are the most commonly used topographic data sources available in GIS systems, although these models can evenly accommodate other types of digitally formatted data. Modified version of the GRID tool, "curvature", in ArcInfo is used to analyze slope morphology and potential failure. the slope matrix is formed from a combination of slope gradient and slope shape. This slope matrix is based on certain geomorphic units, on determining the field of typical hill configurations where natural avalanches occur. Geomorphic units are areas where the earth's surface processes and sedimentation regimes are relatively uniform. The morphological slope criteria were determined from the analysis of landslide behavior in a number of representative locations in geomorphic units and then extrapolated to similar units in geological provinces, or regional regions with different tectonic histories [10]. The model output consists of a map where pixels or cells representing 900m² on the ground (DEM data resolution) are distinguished based on potential failure rates.

Table 1. Correlation between gradient and morphological slope [10]

Curvature Class	Slope Class				
	Relatively Flat	Low Steepness	Moderate Steepness	Very Steep	Extremely Steep
Concave ($CV < -0.01$)	Stable	Caution	Unstable	Unstable	Unstable
Planar ($-0.01 < CV < 0.01$)	Stable	Stable	Stable	Caution	Unstable
Convex ($CV > 0.01$)	Stable	Stable	Stable	Stable	Caution

The data used in this study is the Digital Elevation Model (DEM) obtained from Aster Global DEM [11] then the data is processed using ArcGIS application to get Slope and Curvature. Slope class distribution can be divided into 5 classifications: Relatively Flat, Low Steepness, Moderate Steepness, Very Steep and Extremely Steep. Calculation of the curvature uses an algorithm developed by Zevenbergen and Thorne (1987). If the curvature value minus (-) then indicates the concave slope, the plus (+) value indicates the convex shape of the slope, and 0 indicates the flat shape of the slope. This research uses CV limits between -0.01 to 0.01. The shape of the slope is said to be concave if the CV

value is less than -0.01 and is said to be convex if the CV value is more than 0.01. While the form of flat / planar slope has a value of them.

Vulnerability and capacity are other variables other than hazard / potential in determining risk index. Data for both variables are obtained from statistical data (BPS) from each sub-district in Wonosobo district. The data used in determining the vulnerability and capacity is quite diverse, but in this research only used population density data and health facilities, because not all sub-districts have the complete data. Weighting and scoring of each parameter is divided into three classifications: 1 (low), 2 (medium), and 3 (high). After all three have done the next scoring is to overlap, the software used is ArcGIS 10.1 software. From the overlay process is obtained low risk areas, medium risk, high risk which is then matched with the number of landslide events that exist in the area Wonosobo.

3. Result

Hazard is determined based on the relationship between the frequency of occurrence with presence or absence of warning. In this research, hazard variables include the potential for landslides obtained through the use of Geographic Information System (GIS) applications. First parameter is landslide potential area, the results show a low level of potential area dominating in green tape, in low level the morphological slope is convex with gradient of slope low/moderate steepness. Different vulnerabilities for each type of hazard calculated based on the index of population exposed in the soul, in this case related to population density.

Getting a vulnerability map requires data in the form of population density based on sub-district. It can be seen that the colour is dominated by the red colour which means the height of the vulnerability is wider than the medium or low level, The high level of vulnerability can happen because there are four sub-districts (Mojotengah, Sukoharjo, Wadaslintang, and Wonosobo) with high population density and average is >1500 population/Km². The capacity component (parameter 3) is prepared for all types of disasters based on the parameters of the preparedness system which includes the number of health facilities. Health facilities can be hospital, health centre. Health facilities are used to create capacity. The results show moderate and high levels dominate by being marked in red, moderate level in yellow, and low level in green. When the level of capacity is low it means there are many health facilities (five health facilities or more), and for moderate and high level it means health facilities are less than five.

A disaster risk assessment is conducted by assessing and determining hazard, vulnerability and capacity levels based on hazard indices. Each variable that is hazard / potential, vulnerability, and capacity are then grouped into 3 classes which are then used to calculate the disaster risk index using the following risk formula:

$$R = H \times \frac{V}{C} \quad (1)$$

Where R is Risk Level, H is Hazard, V is Vulnerability, and C is Capacity.

Table 2. Total area of landslide risk level

Num	Risk Level	Area (km ²)	Percentage
1	Low	7688.14	8.01%
2	Moderate	10111.89	10.54%
3	High	78123.15	81.44%

Source: Data processing

Risk level of landslide disaster divided into 3 class, low (green); moderate (yellow); and high (red). This based by the result of scoring method which include 3 parameters, it is landslide potential area from SMORPH method, population density and healthy facilities. The result refers to colour of the area dominated by red, it means the area of risk level of landslide largest. If landslide potential and population density are high, the output will the risk level is the highest. The high risk level should be the main focus for rescue in case of landslide. Because the impact of losses will be high if high population density resides in the area.

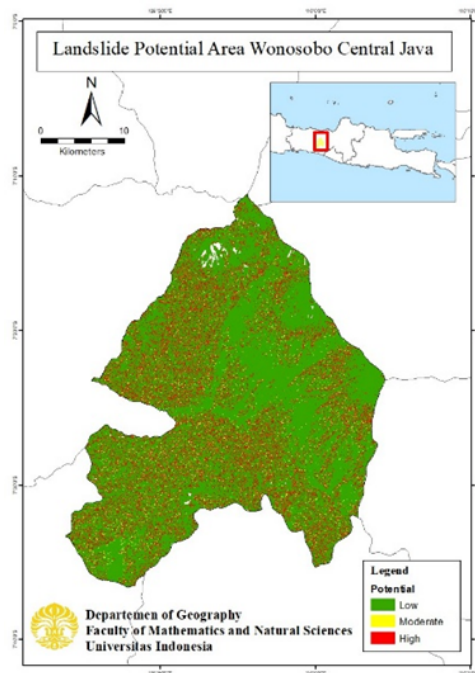


Figure 1. Map of Landslide Potential Area in Wonosobo Central Java

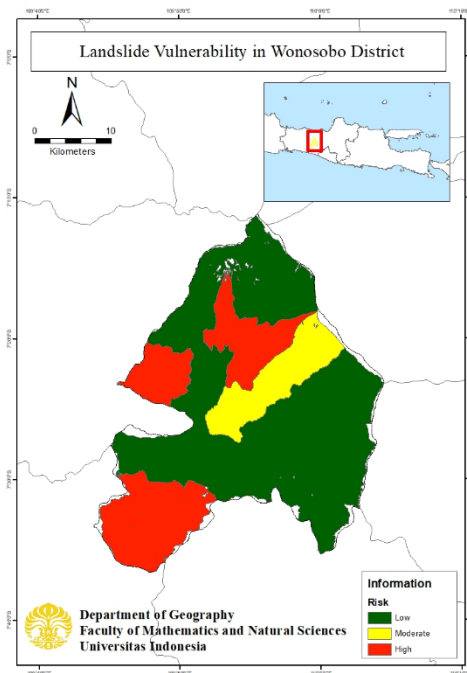


Figure 2. Map of landslide Vulnerability

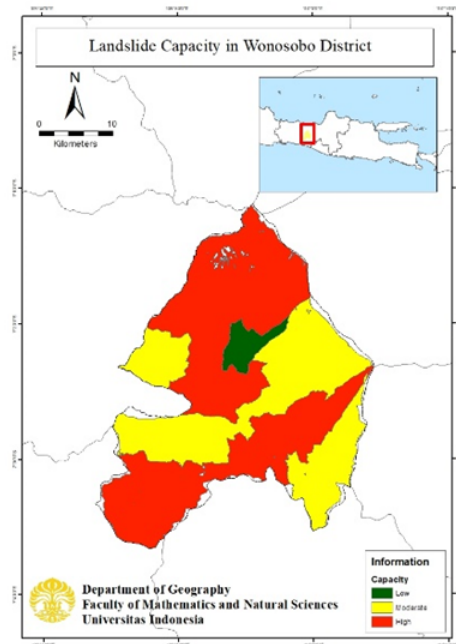


Figure 3. Map of Landslide Capacity Wonosobo Central Java

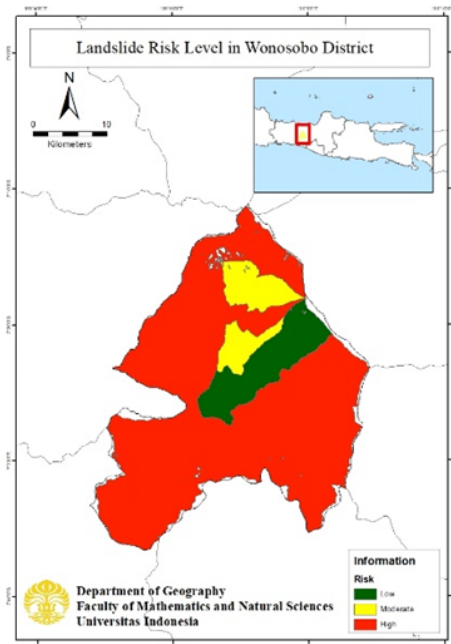


Figure 4. Map of Landslide Risk Level in Wonosobo Central Java

4. Conclusion

The result show that the largest area which the risk of landslide is 78123.15 km² or about 81.44% of total area of Wonosobo. The factors that can determine the risk level of landslide are socio-cultural, physical, and environment. Based on this level of risk can be used by various parties to conduct analysis as the basis of institutional policy, funding, and regional planning.

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