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LANDSLIDE HAZARD MAPPING USING THE SCORE AND WEIGHT METHOD IN BANJARNEGARA

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Abstract

Banjarnegara has a category of high or very vulnerable landslide susceptibility, according to data from the National Disaster Management Agency from 2006 to 2021, there has always been at least 1 landslide disaster in Banjarnegara. As a step in disaster reduction in Banjarnegara, a landslide hazard analysis was carried out. The methodology used is scoring and weighting using 4 indicators of rainfall, geology, land use, and slope. Landslide susceptibility is measured by calculating the total score which is then categorized based on the total score. The landslide susceptibility category is divided into 4 categories, namely Very Low, Low, Medium, and High. Areas with high vulnerability category have a proportion of 0.06% with an area of 682,073 m2, Medium has a proportion of 55.51% with an area of 625,539,155 m2, and Low has a proportion of 44.43% with an area of 500,730,369 m2. The results of the landslide hazard map can then be used as a reference for the Regional Disaster Management Agency to reduce the risk of landslide vulnerability.

Keywords: *Banjarnegara, Landslide, Map, Score and Weighting.*

1. INTRODUCTION

Banjarnegara is a district located in Central Java, based on a physiographic zone consisting of the North Serayu Mountain Zone, the CentralDepression Zone, and the Central Serayu Mountains Zone, with an altitude of 100-500 meters above sea level[1]. The physiographic location of Banjarnegara consists of several valleys and steep slopes[1]. According to the soil type, Banjarnegara consists of 6.25% latosol, 11.72% grumsol, 14.5% andosol, and 7.53% other soil types[1]. Physiographic conditions and soil types in Banjarnegara are contributing factors to the vulnerability to landslides. Among several factors that influence the occurrence of landslides, the slope factor is the factor that is considered to have the most impact[2], [3]. Andosol soil type is one type of soil that has a landslide risk[4]–[7].

Banjarnegara has a high vulnerability to landslides or is very vulnerable[8], [9]. According to BNPB data from 2006 to 2021, there has always been at least one landslide disaster in Banjarnegara[10]. The most landslides occurred in 2017 when 51 landslides were recorded[10]. Meanwhile, based on the most fatalities in 2014, where 100 people died due to landslides[10]. Based on statistics on the incidence of all-natural disasters in Banjarnegara, an average of 56.86% of natural disasters are landslides annually[10].

To reduce disaster risk, especially for landslides in Banjarnegara, mapping of landslide-prone areas is carried out, which can be used as a medium of information to the public[11], [12]. The landslide hazard map in Banjarnegara itself is currently available, but the map only has a 5-year lifespan which, after five years, must be updated, and the expiration date will end in 2023. The landslide hazard map itself needs updating to replace the current map. It exists and ends in 2023, so in 2022 a landslide susceptibility analysis is required, which can then produce a landslide susceptibility map.

2. RESEARCH METHOD

This research has several paths, including 1) Data Collection, 2) Data Categorization, 3) Vector Data Conversion and Creation, 4) Overlay, Scoring, and Weighting, 5) Total Score Category, 6) Landslide Prone Map Making. For a clearer flow of research can then be seen in Figure 1.

Data collection is done by retrieving data from related agencies or can retrieve data from the internet to obtain the required image data. The data that was successfully retrieved were then grouped into three types of data, namely vector data, raster data, and other data. Vector data is data that has a .shp extension format where the data describes a certain polygon. Raster data can be in the form of images with the extension .jpg, .jpeg, .png, or .tiff, where the data must be vectorized first before scoring and weighting. Other data is data in formats other than vector data and raster data, where the data can be in the form of documents or text, so vector data must be created first. After all the data is converted into vector data, then scoring and weighting are carried out.

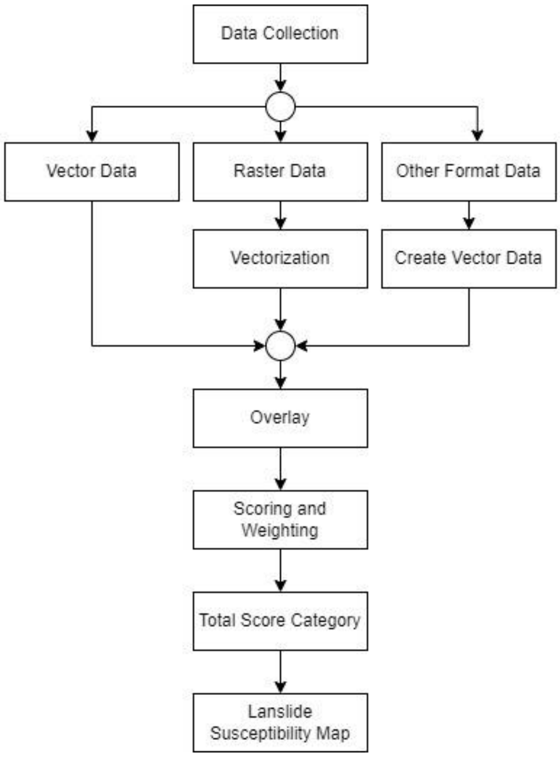

Figure 1. Research Flow

To determine an area prone to landslides, several methods are used, and the methods used in this study are weighting and scoring[13]–[16]. This method is carried out by weighting four indicators of landslide susceptibility, including rainfall (mm/year), geology, land use, and the percentage of slope. Each indicator is then given a score based on the category of each indicator.

The first indicator is rainfall, where the rainfall in the period of the year is added up and then given a score based on the amount of water discharged for one year. Rainfall affects changes in groundwater so that it can cause landslides[17]. The value of the rainfall score in the score table is divided into three values which in detail can be seen in table 1.

Table 1. Rainfall Score[13]

Rainfall (mm/year)	**Score**
<2000	1
2000 – 3000	2
>3000	3

The second indicator is geology, where the geology is the rock structure that makes up an area. The geological structure of an area can improve the analysis of landslide susceptibility[18]. With the data related to the arrangement of rocks in an area, it can improve the analysis of landslide susceptibility. The geological score value in the score table is divided into three values which in detail can be seen in table 2.

Table 2. Geological Score[13]

Geological	**Score**
Andesite, mudstone, siltstone	1
Limestone, Rock, sandstone	2
Young River aluminum, limestone, phyllite, quartzite, skis	3

The third indicator is land use, where land use is mapped based on certain categories, and then a score is determined from that category. Land use is one of the key factors that affect the vulnerability of landslides[19]. The land use score in the score table is divided into three values, which in detail, can be seen in table 3.

Table 3. Land Use Score[13]

Land Use	**Score**
Settlements, rice fields, forest	1
Garden, moor	2
Shrubs, bare/barren land, sand	3

The fourth indicator is the slope, where the slope data is measured using Digital Elevation Model data. The slope data used is in the form of a percentage. Terrain topology data is very useful in mapping landslide susceptibility[20], and one of them is the slope map of the land. The value of the slope in the score table is divided into four values which in detail can be seen in table 4.

Table 4. Slope Score[13]

Slope	**Score**
<8%	1
8 – 25%	2
25 – 40%	3
>40%	4

After scoring, the score will be multiplied by the weight of each indicator to calculate and get the category of landslide susceptibility. The weighting of the four indicators can then be seen in table 5.

Table 5. The weighting of Vulnerability Indicators[13]

Indicators	**Weight**
Rainfall	2
Geological	2
Land Use	3
Slope	3

After the data has been calculated, the scores and weights have been calculated, and all the data collected is overlaid so that the geometric and attribute data become one data. The overlay is the process of combining geometry and attributes on a layer. After knowing the score and weight of each indicator and the data has been overlaid, then the score of each indicator is multiplied by the weight, and then the total score of an area is obtained. For multiplication, it can be seen in equation (1).

$$Total\ Score = (Rainfall\ Score * 2) + (Geological\ Score * 2) + (Land\ Use\ Score * 2) + (Slope\ Slope\ Score * 2) \quad (1)$$

The category of landslide susceptibility is obtained from the results of calculating the Total Score, where the category for the Total Score can then be seen in table 6.

Table 6. Landslide Hazard Category[13]

Category	Total Score
Heigh	> 30
Medium	21 – 30
Low	11 – 20
Very Low	<= 10

3. RESULTS AND DISCUSSION

3.1. Data and Scoring

The results of this study obtained some data, which is categorized into three types of data, namely vector data, raster data, and other data with document extensions. Sources of data that have been obtained include the Geological Agency of the Ministry of Energy and Mineral Resources, Geospatial Information Agency, Bannjarnegara Geophysics Station, NASADEM Merged DEM Global 1 Satellite Imagery, and Internet sources.

3.1.1. Territorial Boundary

For the Banjarnegara Regional Boundary data itself, it is taken from the Geospatial Information Agency Data, where the data obtained is village boundaries with the extension of .shp data, but in the study, it was changed to district boundaries by doing a dissolving process. For data on the Banjarnegara Area Boundary, it can be seen in Figure 2.

Figure 2. Banjarnegara Boundary Map

3.1.2. Rainfall

Rainfall data in Banjarnegara is obtained from the Banjarnegara Geophysical Station, where the data taken is rainfall data for the last four years (2018, 2019, 2020, and 2021). The data obtained is data in .pdf format, from which the data is then searched for the average period of rain discharge for the last four years. The amount of rainfall data for the last four years from 2018-2021, respectively, is 3,029.2 mm; 3,412.3 mm, 4,588.1 mm; and 4,148.8 mm, where the average is 3,793.6 mm. The average rainfall has a score of 3 because it is more than 3,000 mm, which is marked in red on the map. The rain map itself can be seen in Figure 3.

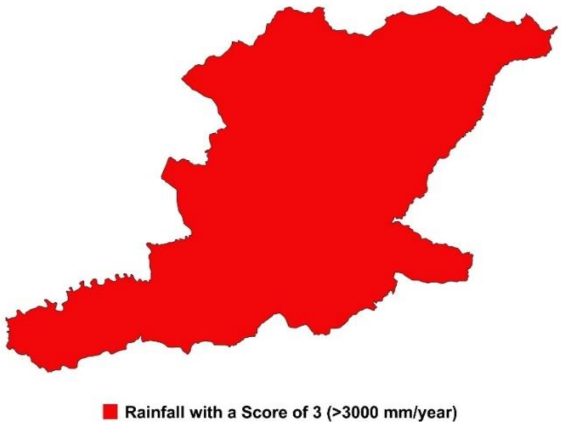

Figure 3. Rainfall Map

3.1.3. Geology

Geological data was obtained from mapping conducted by the Geological Agency of the Ministry of Energy and Mineral Resources. The data obtained is raster data with the extension .jpg, so vectorization must be carried out by creating polygons above the raster data layer. Based on the data obtained, there are several geological groups, including the Gravel Sand Group, Volcanic Breccia Group, Metamorphic Rocks, Igneous Rocks, Limestone Groups, and Claystone Groups. The scoring is given in table 6.

Table 6. Geological Scoring

Geological	Score
Volcanic Breccia Group, Metamorphic Rock, Igneous Rock, Claystone Group, Limestone Group	2
Gravel Sand Group	3

After scoring, a geological map is obtained, which can be seen in Figure 4.

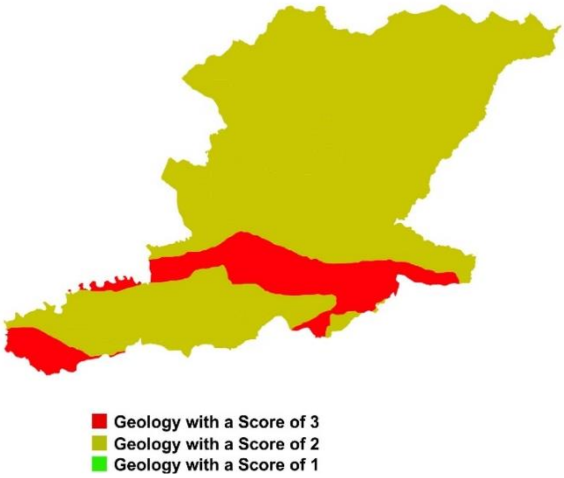

Figure 4. Geological Map

3.1.4. Land Use

Land use data in Banjarnegara is obtained from third parties who have provided land user data in .shp format. Data on land use in Banjarnegara itself is divided into fields, rice fields, gardens, buildings, weeds, forests, and shrubs. The data is then subjected to a "Disolve" process to separate the data so that they do not overlap. The discarded data is data with a lower score. From this process, a map, as shown in Figure 5, is obtained.

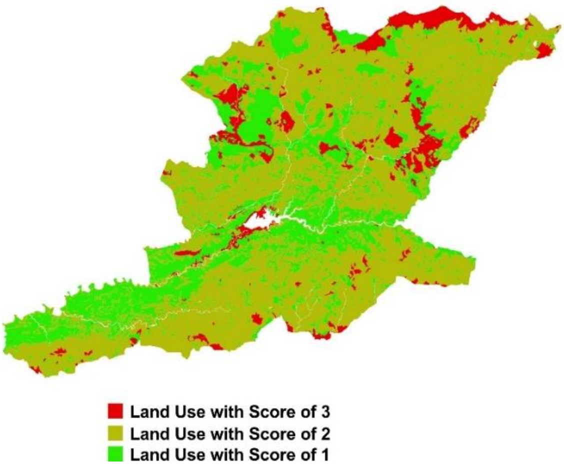

Figure 5. Land Use Map

3.1.5. Slope

The slope data is obtained from the NASADEM Merged DEM Global 1 Satellite, with the output data being Digital Elevation Model or DEM data with the .tiff extension. Data processing and data clipping using google earth engine software to be separated into four categories of slope based on the percentage of slope. The results of the slope category are then exported back into .tiff form, which is then entered into the QGIS software to be exported to .shp format. The results of the slope data then obtained the results of the slope map, as shown in Figure 6.

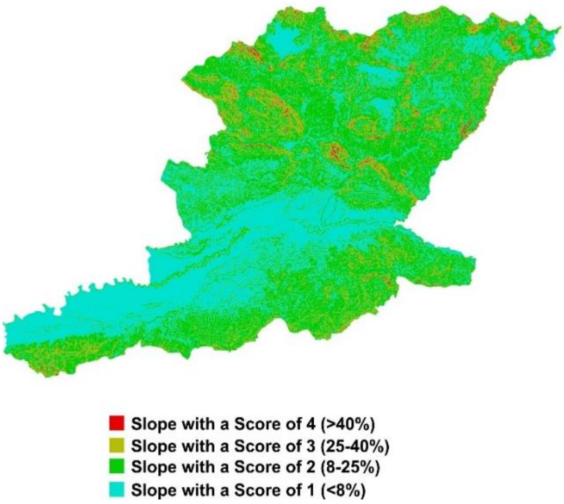

Figure 6. Slope Map

3.2. Landslide Hazard Analysis

The landslide susceptibility analysis is carried out by calculating the score that has been made previously multiplied by the weight of each indicator. However, before doing the calculations, the "intersect" process is carried out on the map data that has been made to combine the vector data maps that have been made previously. After the intersect process is carried out, the total score is calculated, where the total score is used for the landslide susceptibility category, which is divided into four categories, namely very low, low, Medium, and high. Areas with the High vulnerability category have a percentage of 0.06% with an area of 682,073 m2, Medium has a percentage of 55.51% with an area of 625,539,155 m2, and Low has a percentage of 44.43% with an area of 500,730,369 m2. There are two sub-districts that have a high landslide susceptibility, namely Banjarmangu District and Batur District. The landslide susceptibility data can clearly be seen in table 7.

Table 8. Landslide Hazard Data

Category	Area (m2)	Percentage
Heigh	682.073	0.06%
Medium	646,989.925	57.41%
Low	479,279,599	42.53%
Very Low	<= 10	

The map of landslide-prone areas is symbolized into three colors, namely green for areas with low landslide susceptibility, yellow for areas with moderate landslide susceptibility, and red for areas with high landslide susceptibility. The landslide susceptibility map can then be seen in Figure 7.

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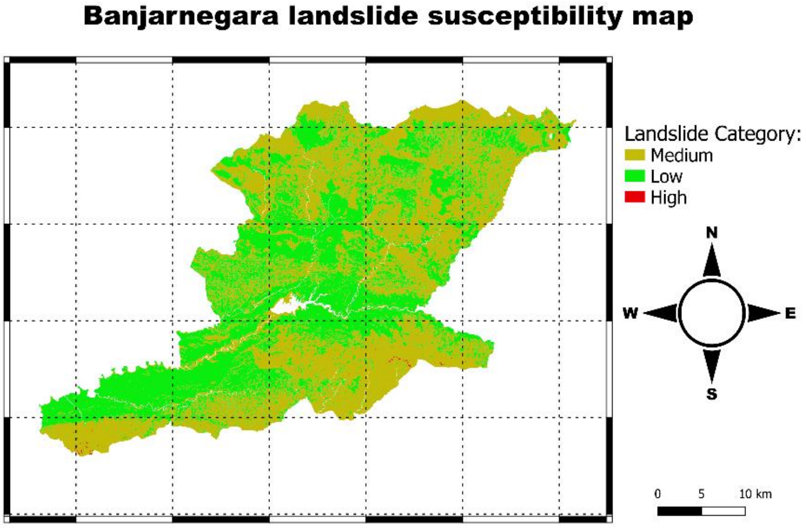

Figure 7. Banjarnegara Lanslide Susceptibility Map

4. DISCUSSION

There are several studies related to landslide susceptibility, such as the research conducted. Several studies carried out mapping of landslide hazards in Banjarnegara, such as Susanti et al. (2017)[8] research which used the weighting method from Paimin et al. (2009)[20] research. In contrast to the analysis above, the study was conducted using the weighting method of Darmawan and Theml (2008)[13].

Other research that can be used as a comparison is the research of Valdika et al. (2019)[16] and Azeriansyah et al. (2017)[15], where this study also uses the Darmawan and Theml (2008)[13] weighting method. However, it is different from the two studies that examined Ngesrep Village, Banyumanik District, Semarang Regency, and Kendal Regency. The resulting hazard maps are geographically different, so they will produce different hazard maps.

5. CONCLUSION

The research results on landslide susceptibility in Banjarnegara found that landslide susceptibility levels were high, Medium, and low. The medium category of landslide hazard in Banjarnegara has the most significant percentage, with a percentage of 57.41% with an area of 646,989,925 m2. Meanwhile, the landslide susceptibility in the low category has a percentage of 42.53% with an area of 479,279,599 m2, and the high category has a percentage of 0.06% with an area of 682,073 m2. These results indicate that the majority of Banjarngara areas have a moderate category of landslide susceptibility, so it requires various efforts to reduce the incidence and impact of landslides. Reducing the incidence and impact of landslides can be done by making various efforts such as planting trees to prevent soil movement, stopping excessive exploitation of nature, a development that pays attention to aspects of vulnerability, education related to landslides, and various other efforts.

Methodologically, the use of the scoring and weighting method used in this study still needs to be strengthened by using other methods. This is done to strengthen the accuracy of landslide susceptibility in Banjarnegara. The existence of a more accurate map will have a positive impact, especially on disaster management agencies in the area, which in this case is BPBD. An accurate landslide hazard map will provide increased accuracy in decision-making in an effort to reduce the incidence and impact of landslides.

Based on the landslide susceptibility analysis carried out, there are two sub-districts that have high landslide susceptibility, namely Banjarmangu and Batur sub-districts. Based on these data, the Regional Disaster Management Agency must take action to handle landslides in the two sub-districts. These actions can be in the form of counseling on the prevention and handling of landslides in the community. In addition, the Regional Disaster Management Agency can also install landslide detection equipment as a means of early warning of landslides in areas with high vulnerability. This map can also be a reference for local governments to provide policies that can support landslide prevention.

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