Spatial analysis and mapping of landslide prone areas in Kemuning lor village, sub-district Arjasa, district of Jember

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Abstract. Kemuning Lor is one of the villages in district of Jember that is prone to landslides, especially when the intensity of rainfall is high. Previous research on the classification of landslide vulnerability level which was analysed based on socio-cultural, economic, physical and environmental parameters, showed that the level of vulnerability in the PTPN XII Kebun Renteng Afdeling Rayap which includes Kemuning Lor village in medium class. This condition contradicts the actual facts which show that Kemuning Lor village has a high level of vulnerability based on data on the number of landslide disasters during the last 10 years. The purpose of this study was to conduct spatial analysis and mapping of landslide-prone areas in Kemuning Lor Village. The method used to determine the location of landslide-prone areas is the Storie Index, which will be used in the Geographical Information System program. Before the overlay process is carried out, several parameter maps (slope and rainfall maps) will be made and scores will be given on each criterion from the parameter map. After doing the store index and getting the values in the form of numbers, the next step is to convert this range value into several levels as needed.

1. Introduction

The geographical location of Kemuning Lor Village, which has a steep hilly topography to mountains with an altitude of 450-900 masl, causes many steep cliffs along the road and irrigation canals. Thus, when heavy rain falls, it will cause landslides to occur frequently in the area. And if a landslide occurs, it will hit the roads and irrigation canals.

Based on the classification analysis of landslide vulnerability level [1] which is analyzed based on socio-cultural, economic, physical and environmental parameters, it shows that the level of vulnerability in the PT. Perkebunan Nusantara XII Kebun Renteng Afdeling Rayap which includes Kemuning Lor village is in medium class. This shows that the consequences that arise when a landslide disaster occur can have a moderate impact on the area. This condition contradicts the actual facts. BNPB data shows that landslides are also a disaster that ranks third out of 42 disasters with 9 occurrences during 2018 in the district of Jember.

Geographical Information System (GIS) in 1960 aims to solve geographic problems. Forty years later, GIS developed not only aimed at solving geographic problems, but has penetrated into various fields, such as epidemic disease analysis (dengue fever) and crime analysis (riots), including tourism analysis. The basic capability of GIS is to integrate various database operations such as querying, analyzing it

and displaying it in a map based on geographic location. This is what differentiates GIS from other information systems [4].

According to the Ministry of Energy and Mineral Resources [5], in principle, landslides occur when the driving force on the slope is greater than the holding force. The holding force is generally influenced by the strength of the rock and the density of the soil. While the driving force is influenced by the magnitude of the angle of the slope, water, load and density of rock soil. According to Nandi [6], the common symptom of landslides is marked by the appearance of cracks in the slope parallel to the cliff direction, usually after rain, new springs appear suddenly and brittle cliffs and gravel begin to fall. There are several factors that cause landslides, namely as follows: rain, steep slopes, soil that is less dense and thick, rocks that are not strong enough, types of land use, vibration, shrinkage of lake water levels or dams, additional loads, binding / erosion, presence of material embankment on cliffs, old landslides, discontinuity fields (discontinuous fields), and deforestation.

BNPB data also shows that the landslides is a disaster that almost always occurs every year and always ranks in the top 3 in the trend of disaster events for the last 10 years [2]. The 2011 Indonesian Disaster Hazard Index (IRBI) data also shows that The District of Jember ranks 11th out of 142 cities as a flood and landslide prone area in Indonesia with a score of 53 which means it is in the high category / class [3]. Based on the data above, this research will re-map the landslide prone area in Kemuning Lor Village, Sub-District of Arjasa, District of Jember.

2. Material and methods

The determination of landslide-prone areas was carried out using the Storie Index method. The Storie Index is a semi-quantitative method for soil assessment that was originally used to classify soil for agricultural land use based on crop productivity [7,8]. However, in its development, the Storie index can also be used to analyze soil movement vulnerability [9,10] by modifying the parameters on the Storie Index as follows:

$$L = A \times B/10 \times C/10 \times D/10$$

A: land use
B: the slope of the slope
C: soil type
D: rainfall
L: Land movement vulnerability

In this study, the range value of each of these parameters will be converted into a score. The score for each parameter can be seen in Table 1 below.

Table 1. Score Value Based on Parameters Characteristics of Landslide Prone Determination

No.	Variable	Criteria	Score
1	Land Use	- No Vegetation	5
		- Grass, shrubs, paddy vegetation (rice, maize)	4
		- Mixed gardens, garden plants	3
		- Plantation (trees)	2
		- Dense forest	1
2	Slope	- Slope > 75%	6
		- Slope 46-75%	5
		- Slope 31-45%	4
		- Slope 16-30%	3
		- Slope 4-15%	2
		- Slope 0-3%	1
3	Type of soil	- Oxisol	7
		- Ultisol	6
		- Alfisol	5
		- Mollisol	4
		- Enseptisol	3
		- Entisol	2
		- Histosol	1
4	Rainfall	- Rainfall > 3700 mm/year	8
		- Rainfall 3400 - 3700 mm/year	7
		- Rainfall 3100 - 3400 mm/year	6
		- Rainfall 2800 - 3100 mm/year	5
		- Rainfall 2500 - 2800 mm/year	4
		- Rainfall 2200 - 2500 mm/year	3
		- Rainfall 1900 - 2200 mm/year	2
		- Rainfall < 1900 mm/year	1

After the data is obtained, the next step is to carry out the analysis and calculations required for the landslide analysis. The first step is to score on the map according to the parameters and criteria. Next, an overlay process is carried out, namely by overlaying the parameter map (slope map, and rainfall map). The methods applied in this research are shown in Figure 1 as follows.

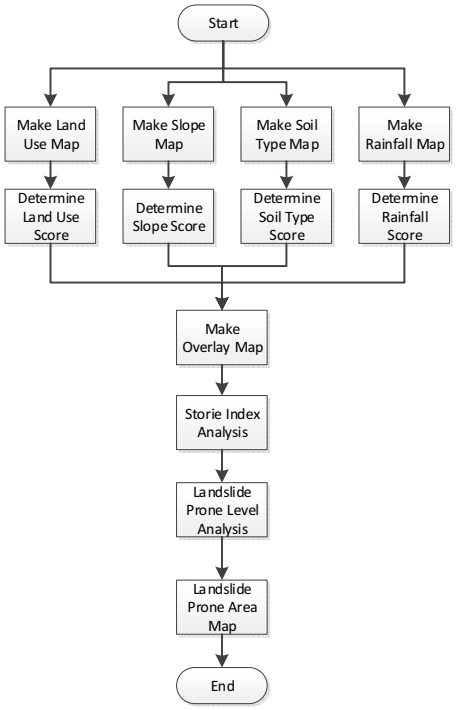

Figure 1 Research method

2.1. Landslide Prone Parameter Analysis

The parameters that cause landslides used are: climate (rainfall), topography (slope), vegetation (land use), and soil (soil type) [9,10].

a. Making Slope Topographic Map
   Scoring based on steep slopes has a large score compared to sloping or flat slopes, because one of the conditions for landslides is a steep slope, so that the volume of the soil will move / slide down.
b. Making Soil Type Map
   Scoring for this soil type is based on soil maturity. The more mature a soil type, the soil will contain higher clay and a stronger soil structure (aggregate) than the young soil type.
c. Making Land Use Map
   Scoring is based on vegetation density / rarity and level of roots. The denser the vegetation and the stronger the roots, the less likely landslides will occur.
d. Making Regional Rainfall Map
   Scoring is based on the size of the average annual rainfall. The greater the annual average rainfall, the possibility of landslides is relatively large compared to the smaller average annual rainfall.

2.2. Analysis of Determination of Landslide Prone Areas

a. Map Overlay
   This map overlay is carried out after each landslide-causing parameter has been given a score. Then the score value of each parameter will be analyzed by storie index according to the same location. In geographic information system based programs the Union process is used to unify all layers [11,12].

b. Storie Index Analysis
Scoring is used to determine the value or status of a location based on several criteria at that location. In this study, after several criteria/parameters used to analyze landslide-prone, a Geographical Information System (GIS) analysis function was carried out, namely the overlay function which was then entered into the multiplication model for each parameter. [11,12]

3. Result and discussion

3.1. Result

The web portal for spatial analysis and mapping of landslide prone areas in Kemuning Lor Village, Sub-District of Arjasa, District of Jember has been completed and is placed on a hosting site with url http://sig.kemuninglor.com. The homepage display of the web is as shown in Figure 2 as follows.

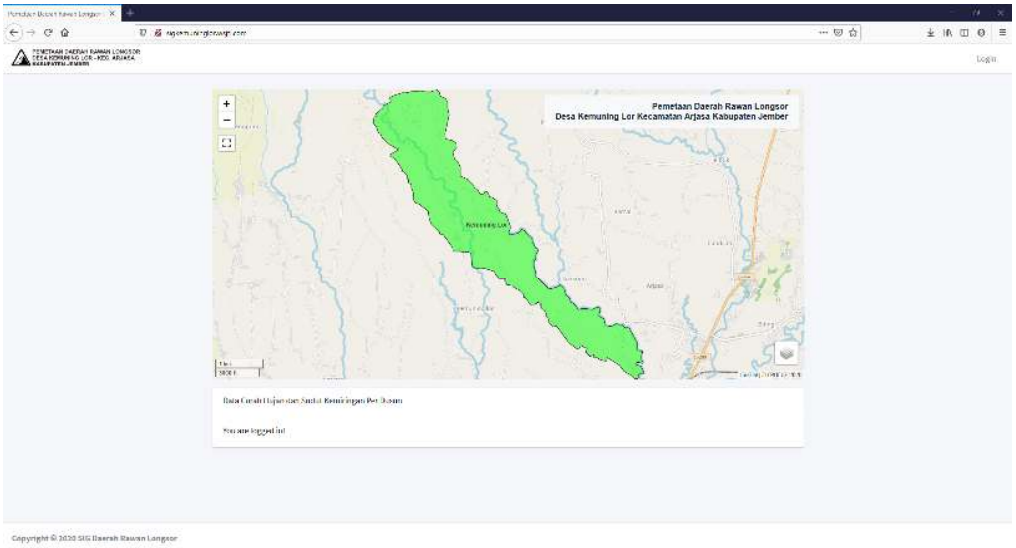

Figure 2. Homepage Display

3.2. Development Steps

The stages of making a web portal for spatial analysis and mapping of landslide-prone areas in Kemuning Lor Village, Sub-District of Arjasa, District of Jember are as follows.

a. Using Quantum GIS

The data used in this study are satellite images or aerial photographs. In this study, the data sources for satellite imagery or aerial photographs used are digital images which are obtained free of charge from Google's geodatabase using Quantum GIS as shown in Figure 3.

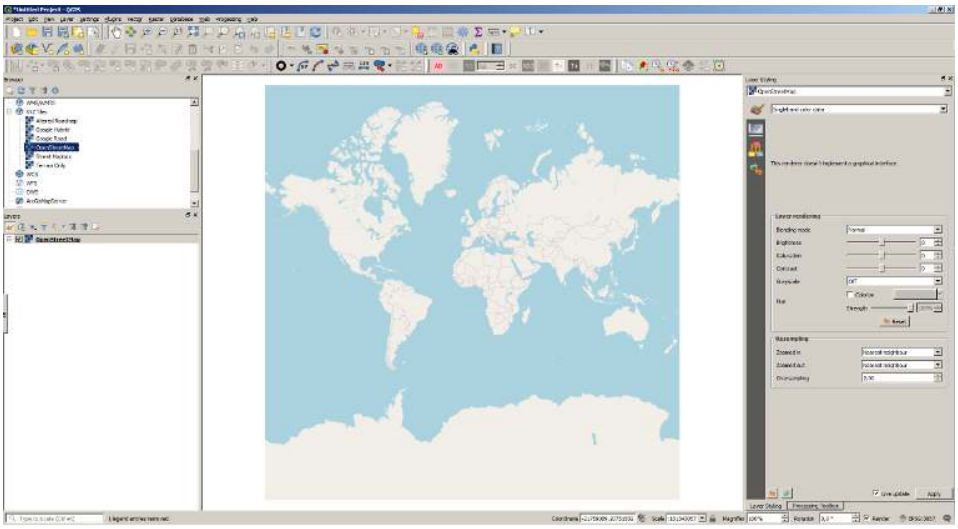

Figure 3. Quantum GIS

b. Retrieve Raster Maps from Google Maps

How to retrieve a raster map from Google Maps is as shown in Figure 4.

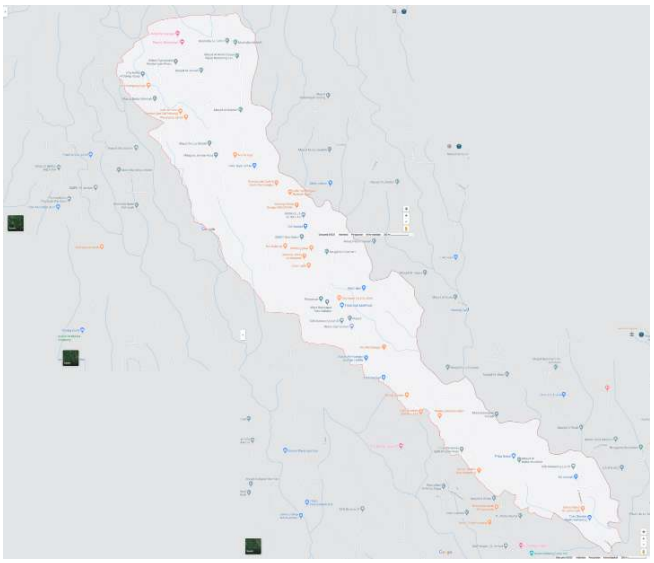

Figure 4. Google Maps Raster Maps

c. Georeference Data Raster

This step is to provide coordinates on an aerial image map that does not yet have coordinates. This is done by means of geometric correction, namely the process of georefencing the raster data into the coordinate system. Georeference is a process of transforming coordinates on raster data from scanner coordinates to real-world coordinates as shown in Figure 5.

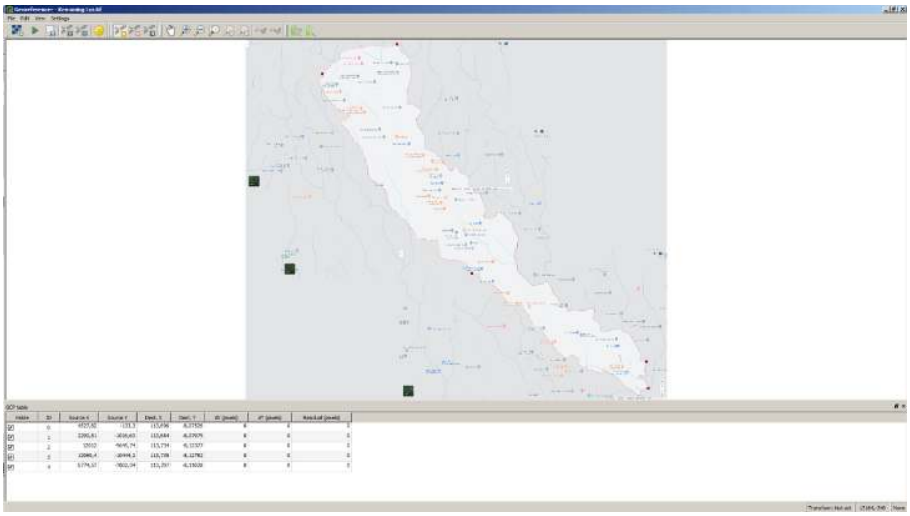

Figure 5. Georeference Data Raster

d. Digitize the Raster Map Using Add Polygons

Digitizing the Raster Map Using Add Polygon can be seen in Figure 6 as follows.

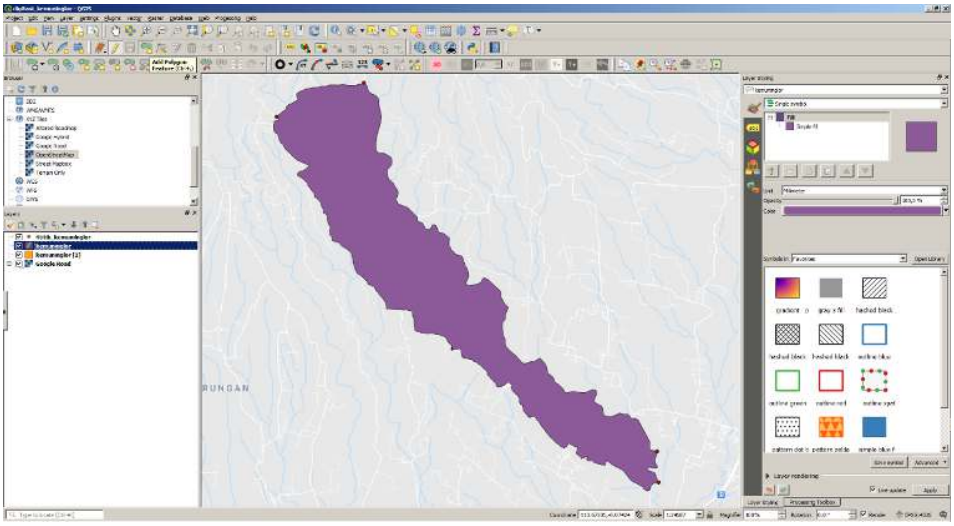

Figure 6. Digitize the Raster Map Using Add Polygons

e. Export the Polygon Shape to GEOJSON so that it can be embedded into the Web

Exporting the Polygon Shape to GEOJSON so that it can be embedded into the Web is done as shown in Figure 7 as follows.

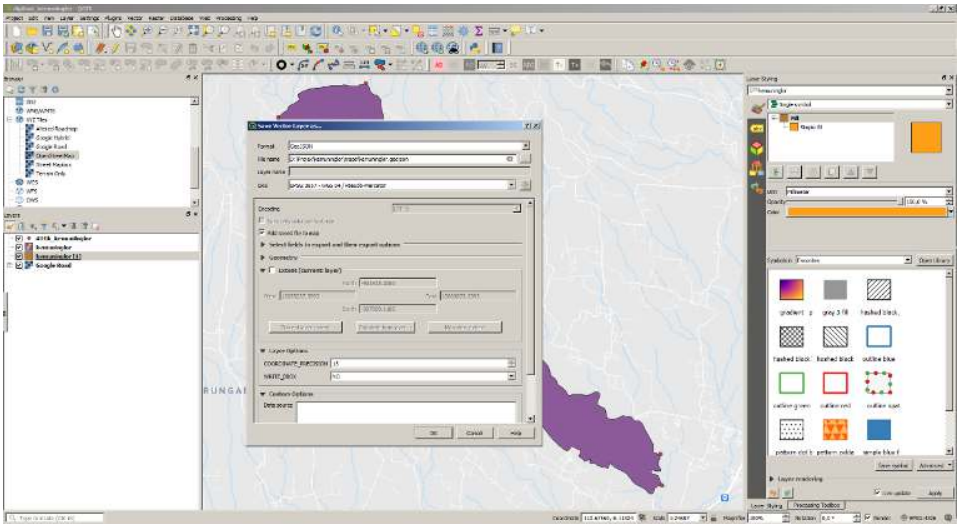

Figure 7. Export the Polygon Shape to GEOJSON

f. Generates files with the .geojson extension

The above process will generate a file with the .geojson extension as shown in Figure 8 as follows.

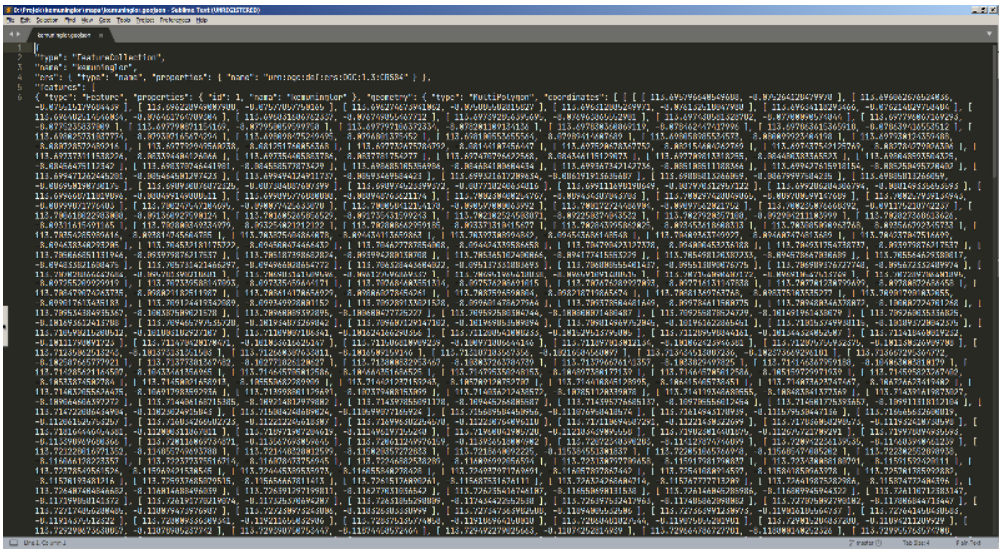

Figure 8. File Geojson

3.3. Steps to Use GIS for Spatial Analysis and Mapping of Landslide Prone Areas

Steps to Use GIS for Spatial Analysis and Mapping of Landslide Prone Areas dengan url http://sig.kemuninglor.com are as follows.

a. Login Page
The login page to enter the web sig Spatial Analysis and Mapping of Landslide Prone Areas is shown in Figure 9 as follows.

Figure 9. Login Page

b. Administrator Page
The administrator page is shown in Figure 10 as follows.

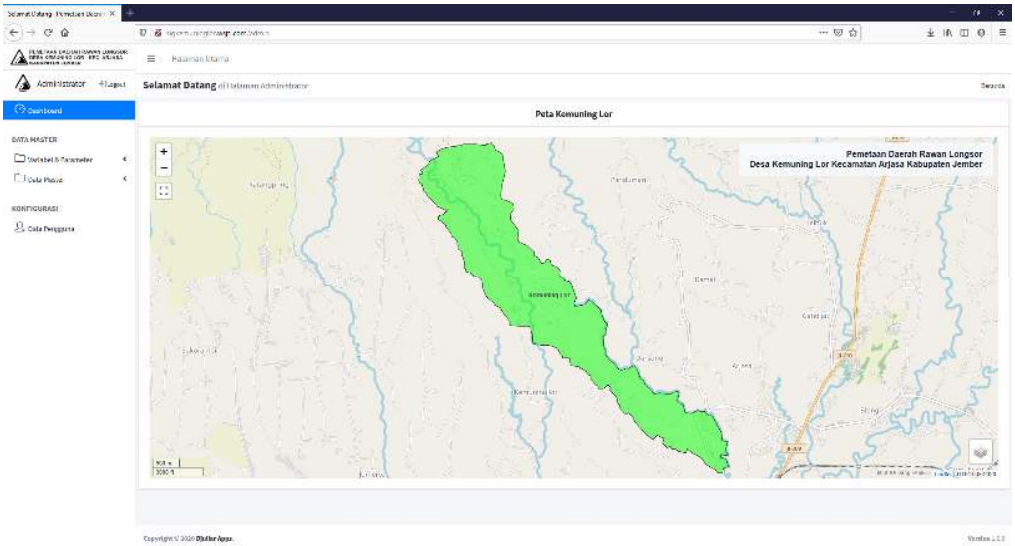

Figure 10. Administrator Page

c. Data Point Page
The data point page is shown in Figure 11 as follows.

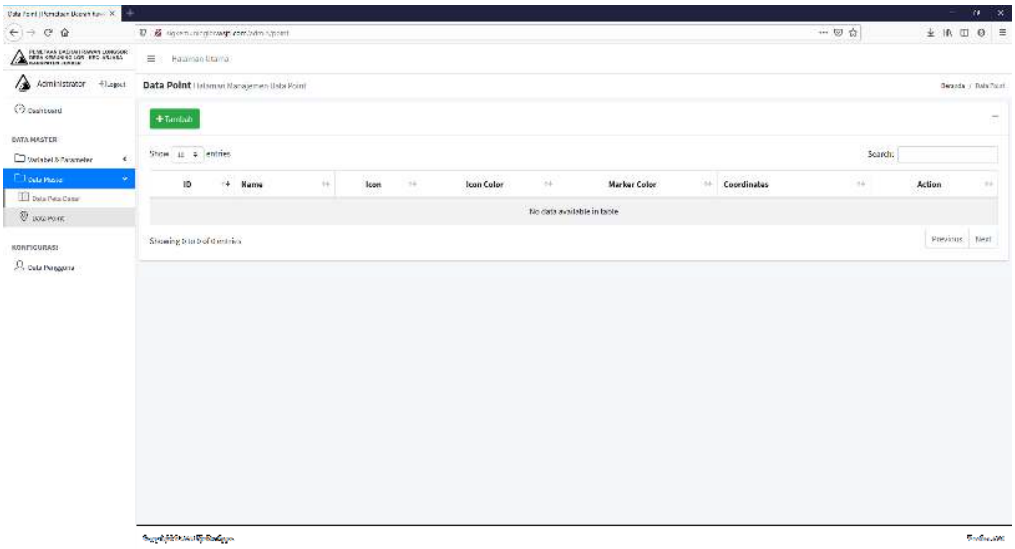

Figure 11. Data Point Page

d. Adding Data Point Page
The adding data point page is shown in Figure 12 as follows.

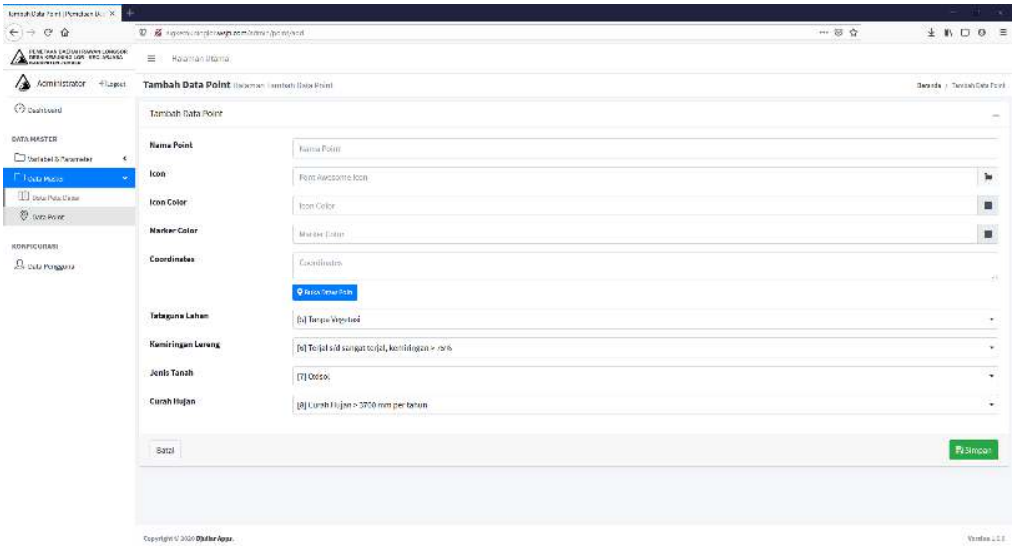

Figure 12. Adding Data Point Page

e. Spatial Analysis Result Mapping Page
The spatial analysis result mapping page is shown in Figure 13 as follows.

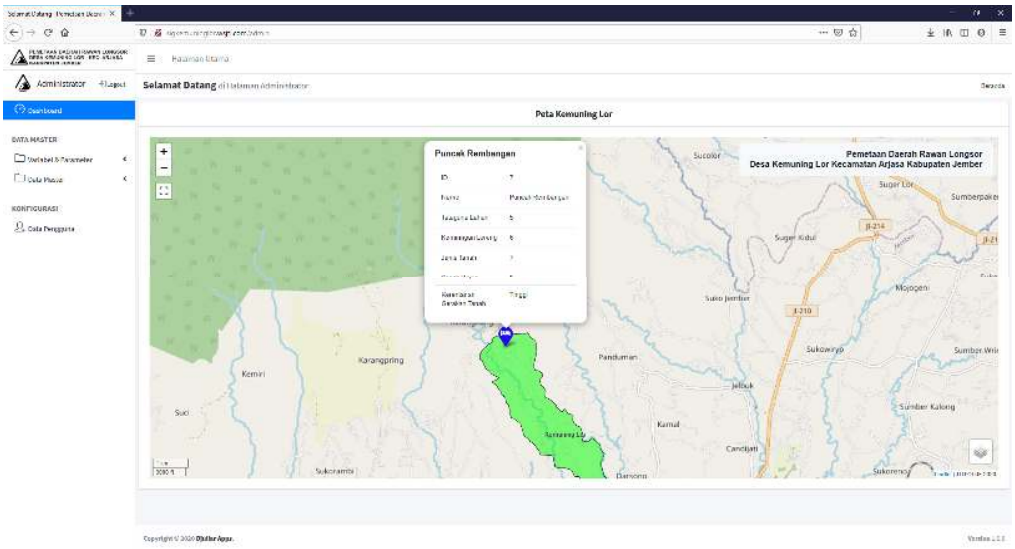

Figure 13. Spatial Analysis Result Mapping Page

4. Conclusion

From this research it can be concluded that a geographic information system has been created that can be used to carry out spatial analysis and mapping of landslide-prone areas in Kemuning Lor Village, Sub-District of Arjasa, District of Jember, namely factors of land use, slope, soil type, and rainfall.

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