J E M T
Journal of Earth and Marine Technology
homepage URL: ejurnal.itats.ac.id/jemt

Use of Spatial Data in Mapping Landslide Prone Areas in Luhurjaya and Surrounding Areas, Lebak Regency, Banten Province

M. Dimas Al Abiyyu *[1], Harnani [2]
[1 2]Sriwijaya University
*email: dimasalabiyyu@gmail,com

Article info
Received:
Nop 14, 2023
Revised:
Feb 05, 2024
Accepted:
Jun 05, 2024
Published:
Mar 31, 2024

Keywords:
Landslides,
parameters,
Luhurjaya

Abstract
Landslides are a natural process that occurs in a natural landscape on earth which can cause various environmental damage and can cause loss of life. An increase in the risk of landslides can be caused by uncontrolled land conversion due to the increasing population so that land development is necessary. The research was conducted in Luhurjaya and surrounding areas, Cipanas District, Lebak Regency, Banten with an area of 9 x 9 km. The spatial integration method was used to map landslide-prone zones using a scoring and weighting method, using five parameters, namely slope, rainfall, lineament density, rock type, and NDVI. Those five parameters are then overlaid to form a landslide susceptibility map. As a result of analyzing the research area based on these five parameters, it was found that this area has five slope classes, one rainfall class, five lineament density classes, three rock type classes, and four NDVI classes. After all the datas are scored and weighed, it was found that this research area can be classified to three zones, namely low landslide susceptibility zone, medium landslide susceptibility zone, and high landslide susceptibility zone. From the results of this analysis, disaster mitigation should be needed that can affect the community in the Lebak Regency area, Banten Province, namely in the form of providing provisions in the form of knowledge to the community regarding disaster management which is useful for minimizing the risk of the consequences of landslides.

1. Introduction

Natural disasters are a phenomenon that can pose a threat to society which can cause environmental damage, property loss, psychological impacts, and can cause loss of life[1]. One effort to mitigate landslides is to create a map of landslide prone zones which is created by referring to several parameters which are then analyzed through a Geographic Information System-based application.

Administratively, the research area is located in Luhurjaya and surrounding areas, Cipanas District, Lebak Regency, Banten Province with a research area of 81 km2 and to reach the research location from the author's location takes 8 hours 21 minutes by car with a distance of 743 km[2]. In this research, the author analyzes the vulnerability of landslides in the Luhurjaya and surrounding areas, Lebak Regency based on data taken in 2022.

Physiographically, the research area is included in the Bayah Mountains Zone[3], where this zone is divided into three morphologies, namely lowlands, hills and mountains. The island of Java has three main structural directions, namely the northeast-southwest direction or Meratus Pattern, the north-south direction or Sunda Pattern, and the east-west direction or Javanese Pattern. In the research area, the geological structural pattern formed has an east-west direction so it is included in the Javanese Pattern[4].

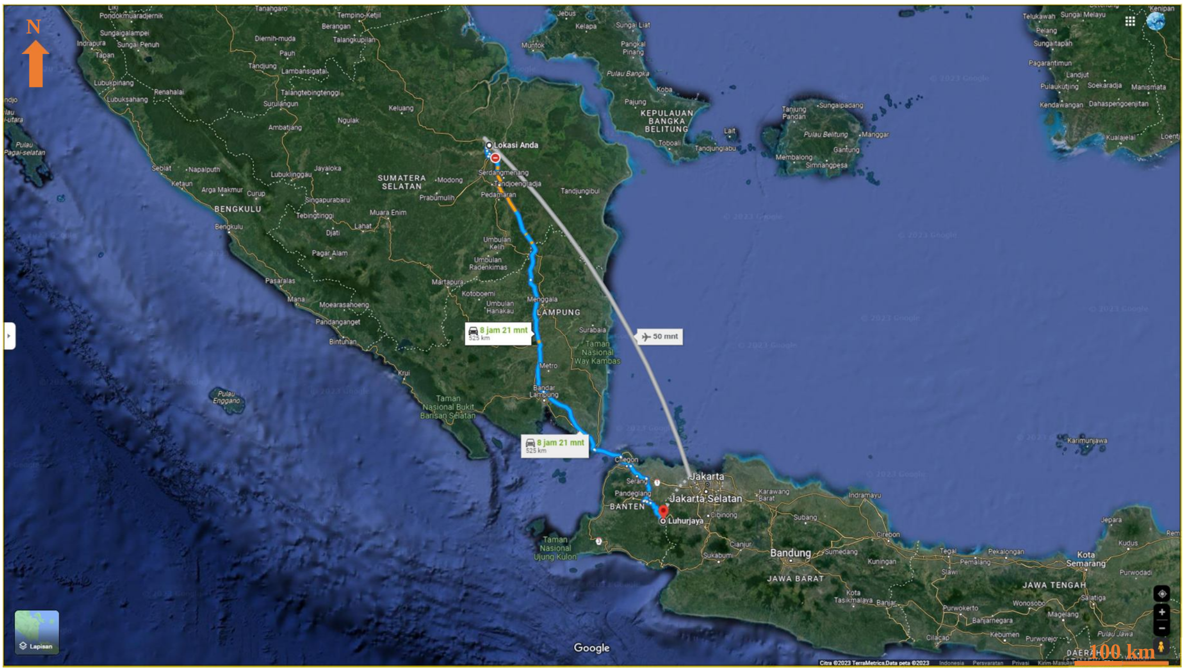

Figure 1. Reachability of the research location

According to the BPDB (Regional Disaster Management Agency) of Lebak Regency in 2022, as many as 24 sub-districts in Lebak Regency are included in areas that are prone to landslides. An example of a case that occurred can be seen in October 2022 when a landslide and flood occurred which damaged 124 residents houses in the area[5].

As an area that has quite high vulnerability to landslides, it is necessary to mitigate disasters that can affect the community in the Lebak Regency area, Banten Province, namely in the form of providing provisions in the form of knowledge to the community regarding disaster management which is useful for minimizing the risk resulting from landslide, one of which is the availability of landslide susceptibility maps.

Landslides or mass movements are related to the scientific process of erosion that occurs in a natural landscape on earth. Landslides can be accompanied by ground movement, causing the movement of soil and rock material with considerable force. The speed of movement and speed of movement of materials is caused by the type of soil and rock at the location. Landslides can also be caused by high rainfall intensity[6]. A landslide is a natural event in the form of a mass slipping against another mass due to the lack of strong adhesive force (resisting force) between layers of soil to resist changes in the mass[7]. An increase in the risk of landslides can be caused by uncontrolled land conversion due to the increasing population, making it necessary to develop land for residential, economic and infrastructure activities[8]. One effort to mitigate landslides is to create a map of landslide prone zones which is created by referring to several parameters which are then analyzed through a Geographic Information System-based application. Remote sensing methods are used with the aim of obtaining parameters based on processing from Landsat images[9]. GIS can also be used to mitigate disasters by providing accurate geospatial data information and spatial analysis systems[10].

2. Methodology

This research is divided into three stages, namely the preliminary stage, data collection stage, and data analysis stage, which is visualized in the flow diagram in Figure 2 below.

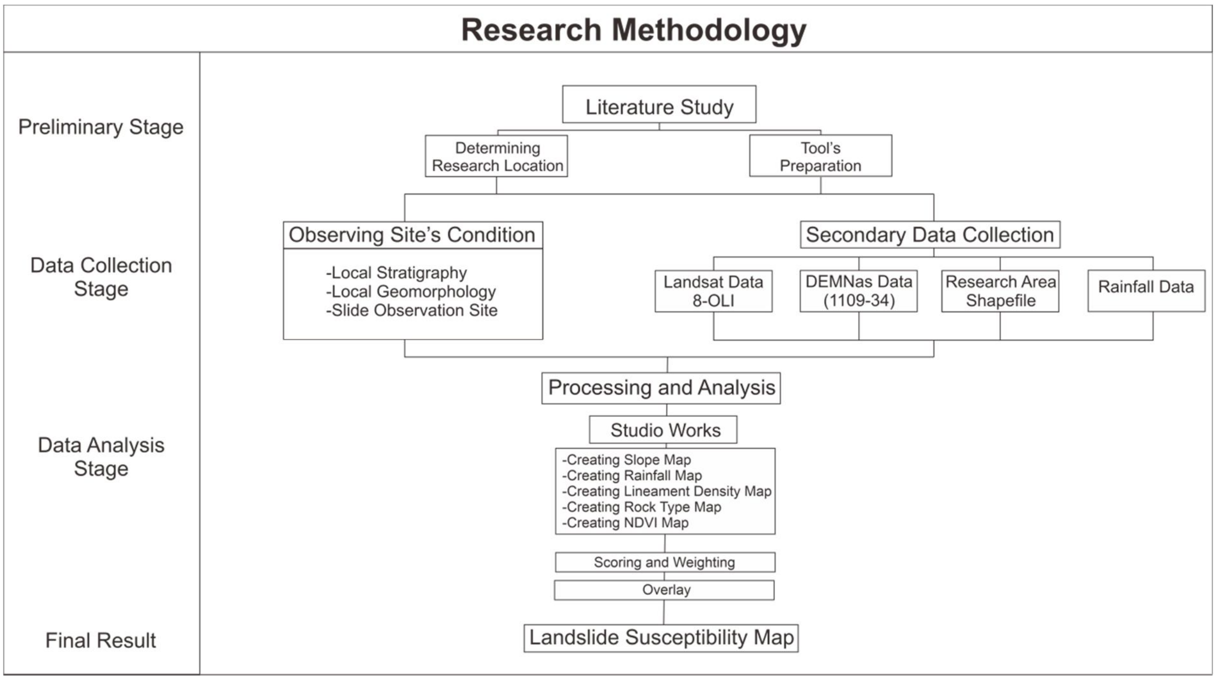

Figure 2. Research methodology flow chart

2.1. Prelimanary Stage

The preliminary stage consists of studying previous literature, determining the research location, and preparing the necessary tools for mapping landslide-prone zones. The research was conducted in Luhurjaya and surrounding areas, Lebak Regency, Banten Province with a research area of 9 x 9 km.

2.2. Data Collection Stage

Next, at the data collection stage, primary data was used in the form of landslide conditions in the research area, as well as secondary data, where researchers collected raw data in the form of DEMNas data (Code 1109-34) and SHP for Lebak Regency and Bogor Regency which were accessed via the website www.tanahairindonesia.go.id or https://www.indonesia-geospasial.com/p/sitemap.html and Landsat 8- OLI/TIRS imagery which is accessed via the website https://earthexplorer.usgs.gov, and rainfall data which is accessed via https://www.chc.ucsb.edu/data/chirps, and then these data are processed into several map parameters in the form of slope map, rainfall map, lineament density map, rock type map, and NDVI maps. To create an NDVI map, a formula is used in the form

$$NDVI = \frac{\text{float}(\text{band5} - \text{band4})}{float(band5 + band4)}$$

2.3. Data Analysis Stage

At this stage, the map parameters are then overlaid using the intersect tool in ArcMap 10.8 for weighting and scoring in creating a map of the landslide zone area. Data processing in this research was carried out using several software in the form of Global Mapper and ArcGIS 10.8. The results of the weighting and scoring are overlaid with the input of several map parameters, and then a landslide-prone zone map is produced. The weighting and scoring process refers to the PU Ministerial Regulation. No. 22/PRT/M/2007, where the weights are based on the influence of map parameters on landslide disasters[11]. Each parameter is given a weight based on the nature of the parameter itself, namely dynamic factors are given a higher weight due to landslides due to changes in force as a result of changes in dynamic factors. To create a landslide susceptibility map, all the weights of the parameters that have been created are multiplied, then the total weights are added up by considering the location and its suitability and relationship to the geographical location of the research area. (Table 1-5)

Table 1. Slope classification[12]

Classification	Score
>45%	5
30-45	4
15-30	3
8-15	2

<8	1

Table 2. Rainfall classification[13]

Classification	**Score**
>3.000 mm/year	4
2.000-3.000 mm/year	3
<2.000 mm/year	2

Table 3. Lineament density classification[14]

Classification	**Score**
Very Dense	5
Dense	4
Medium	3
Loose	2
Very Loose	1

Table 4. Rock type classification[12]

Classification	**Score**
Volcanic	3
Sediment	2
Alluvium	1

Table 5. NDVI (Normalized Difference Vegetation Index) classification[14]

Classification	**Score**
Non Vegetation	5
Low Density	4
Medium Density	3
High Density	2
Very High Density	1

From the parameters that have been obtained, scoring is then carried out for each classification, then each parameter is overlaid using ArcMap 10.8 software with the intersect method, then the weights of the parameters to obtain the total score are added up using the parameters of previous research[13] with slight modifications to the land use data to become normalized difference vegetation index (NDVI) and distance to fault data to become lineament density data. (Table 6)

Table 6. Percentage weight of each parameter ([13] with modification)

Parameters	**Percentage**
Slope	25%
Rainfall	20%
Lineament Density	15%
Rock Type	25%
NDVI	15%

3. Results and discussions

In the research area, there are several landslides which are the result of passive morphostructures with earth flow and translational slide types[15]. The landslides in pictures (A) that happened in Curug village and (B) that happened in Lebaksangka village are earth flow type landslides, namely longitudinal movement of material containing clay minerals and in water-saturated conditions, forming a bowl or a depression at the top. Furthermore, in pictures (C) and (D) that happened in Wirajaya village, also (E) that happened in Pasirmadang village are landslides with the translational landslide type, namely landslides caused by the movement of masses of soil and rock on a flat or gently wavy sliding surface. (Figure 3)

Figure 3. Landslide in the research area

Landslide area maps are made by weighting map parameters. From processing image data, DEMNas data and rainfall data in the research area, it was found that geological aspects in the form of slope parameters have a greater weighting compared to other parameters, which can be seen in table 6 To create a landslide susceptibility map using spatial methods, the 5 parameters are analyzed as follows:

3.1. Slope

Slope slope parameters can influence the occurrence of landslides and have quite large values and weightings so that analysis is necessary. In the study area, slopes are divided into 5 classes, namely flat (<8%) marked with dark green, gently sloping (8-15%) marked with light green, sloping (15-30%) marked with yellow, steep (30 -45%) is marked in orange, very steep (>45%) is marked in red[12]. The slope map of the research area can be seen in Figure 4.

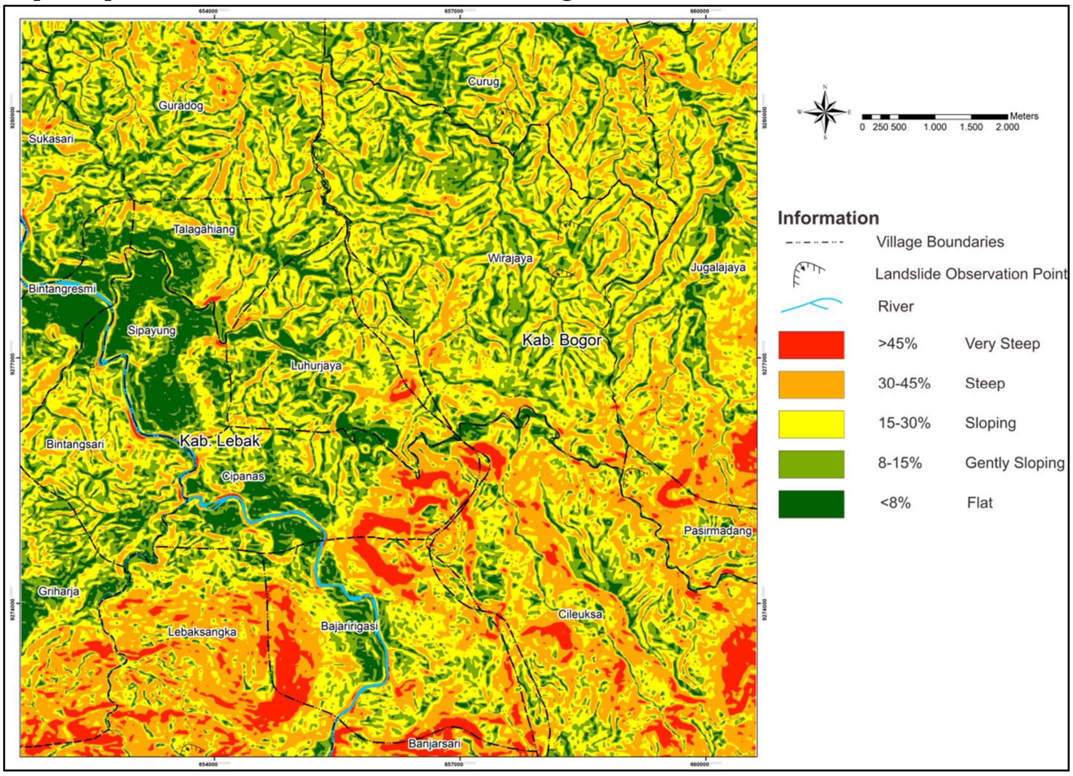

Figure 4. Slope parameter map

3.2. *Rainfall*

The rainfall parameter is used to analyze landslide susceptibility because it is one of the parameters that has the most influence on landslides. Rainfall can affect slope stability due to pore water in the slope-forming material. The data taken for this parameter is from year 2022 in CHIRPS website. The research area has high levels of rainfall, namely >3.000 mm/year. The rainfall map of the research area is shown in Figure 5.

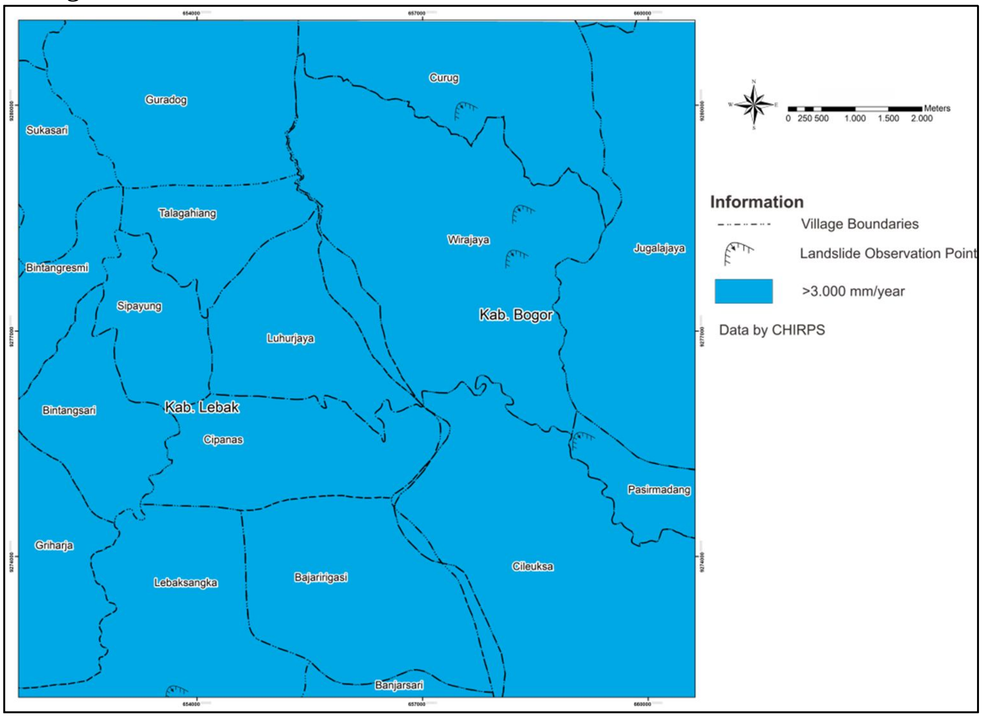

Figure 5. Rainfall parameter map

3.3. *Lineament density*

The lineament density parameter is used in this analysis to determine the level of lineament density in the research area. The higher the density, generally the higher the occurrence of landslides. The research area consists of 5 density classes, namely very loose, loose, medium, dense, very dense. The lineament density map of the research area can be seen in Figure 6.

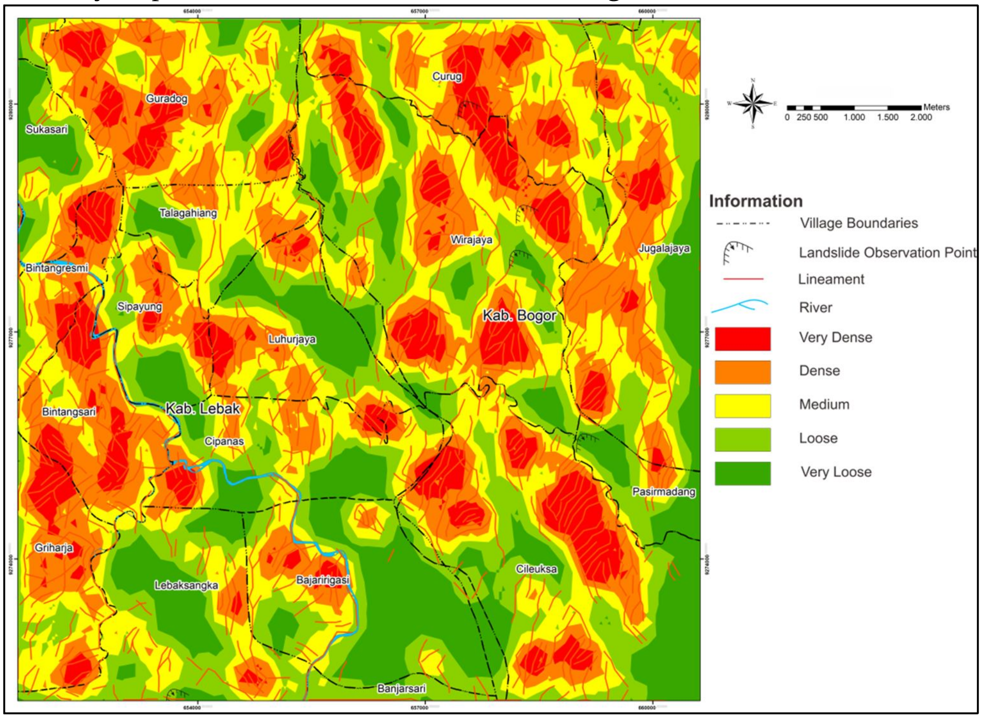

Figure 6. Lineament density parameter map

3.4. Rock type

In the research area, it is composed of lithology in the form of Volcanic rock (andesite), sedimentary rock (sandstone, mudstone and limestone), and alluvial rock (terraced deposits, gravel, mud). Lithological data in the research area was obtained by downloading Indonesia geology shapefile. The rock type map can be seen in Figure 7.

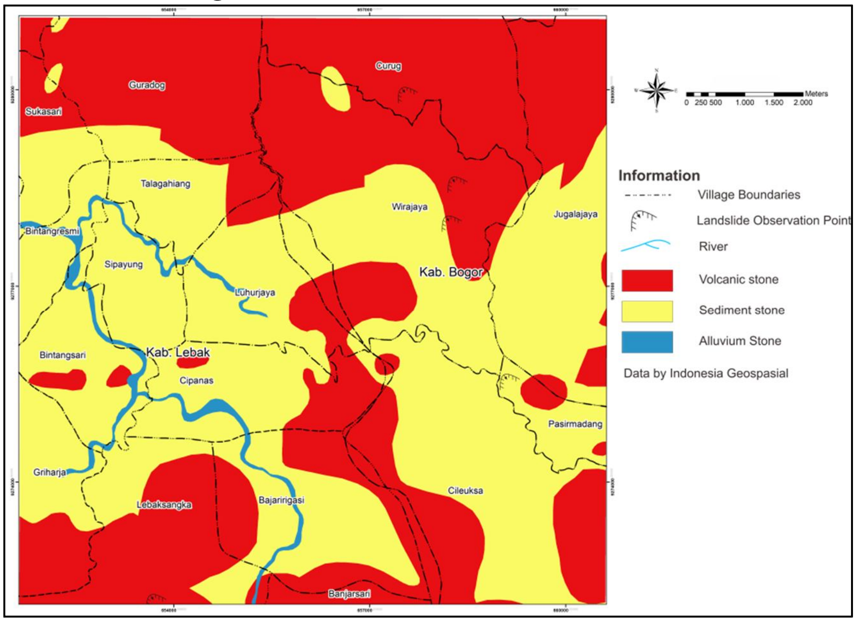

Figure 7. Rock type parameter map

3.5. NDVI

NDVI (Normalized Difference Vegetation Index) is an important parameter in analyzing landslide susceptibility, because it can be used to measure whether a slope is stable or not. If a land is filled with vegetation, the land will be more difficult to erode[16]. Making NDVI maps using Landsat 8 imagery using band 4 (red) and band 5 (near infrared) to express the vegetation index. An NDVI parameter approaching 1 indicates that the level of vegetation density is getting higher. In the research area, it is divided into five density classes, namely non-vegetation (-1 – 0.03), shown in dark red, low density (-0.03 – 0.15) shown in red, medium density shown in orange (0.15 – 0.25), high density (0.25 – 0.35), shown in yellow, and very high density (0.35 – 1) shown in green. The NDVI map is shown in Figure 8.

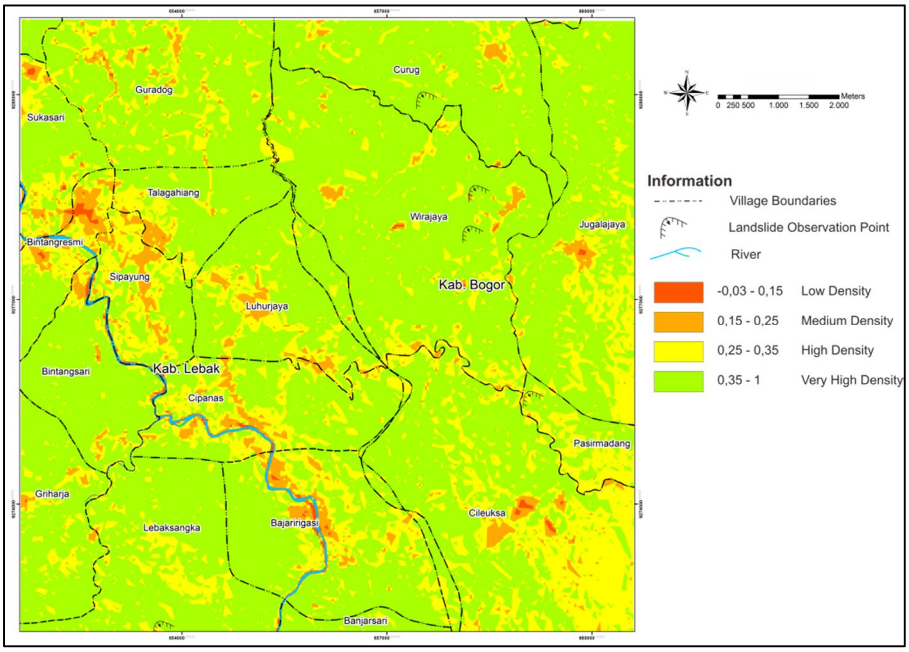

Figure 8. NDVI parameter map

3.6. Overlay

Then, by using the intersect tool in ArcMap 10.8, from the results of overlaying eight types of map parameters, To get the final score, the data obtained is then weighted using the formula:

$$Score = Parameter\ Score \times Weight\ Percentage$$

We obtained the landslide susceptibility class which was divided into three classifications, namely the low landslide susceptibility class, the moderate susceptibility class, and the high susceptibility class. The results of the landslide susceptibility map of the research area are shown in Figure 9, with the classification range shown in Table 7.

Table 7. Landslide susceptibility classification

Classification	Score	Wide (Ha)	Percentage
High	3,25 – 4,25	3.971,98	49,04%
Moderate	2,75 – 3,25	3.171,54	39,15%
Low	1,75 – 2,75	956,48	11,81%
Total		8100	100%

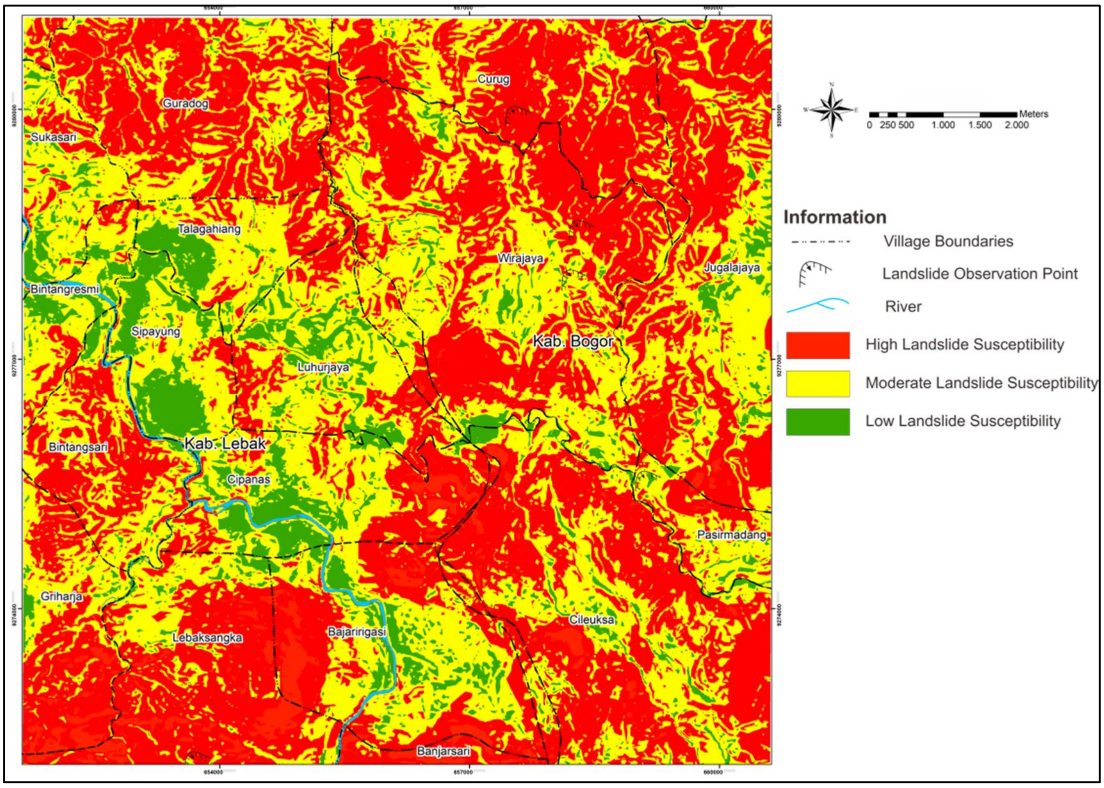

Figure 9. Landslide susceptibility map

From the landslide susceptibility map above, it is known that the research area is dominated by the high landslide susceptibility class (percentage 49.04%), where high landslide susceptibility zones usually have high slope values, straightness density values, and rock type values, with a score of 3- 5. Zones of high landslide susceptibility are in Guradog Village, Curug Village, Giriharja Village, Lebaksangka Village, Banjarsari Village, Cileuksa Village. Then moderate landslide susceptibility (percentage 39.15%) can be found in areas where the parameter values are mixed, such as low slope values with a score of 1-2 but high rock type values with a score of 2-3, or something similar. Zones of moderate landslide susceptibility are in Sukasari Village, Luhurjaya Village, Banjaririgasi Village, Jugalajaya Village, Wirijaya Village. Meanwhile, the low landslide susceptibility zone is smaller (percentage 11.81%) and has low values of slope, lineament density and rock type with a score of 1-2. Zones of low landslide susceptibility are in Bintangresmi Village, Talagahiang Village, Sipayung Village, Cipanas Village. Meanwhile, rainfall in this study area has the same value so it does not affect the zonal distinction, apart from that, the NDVI area that has a high value is in a flat village area so it has a low weight.

4. Conclusion

Based on the results of literature studies, data collection, and data processing and analysis, it is concluded that the landslide prone zoning in a research area can be estimated using spatial integration and parameters that can influence the occurrence of landslides. The parameters used were obtained using the remote sensing method. The parameters used include slope, rainfall, lineament density, rock type, and NDVI. The results of data processing by overlaying five parameters show that Luhurjaya and the surrounding areas has a landslide prone zone which is dominated by high to medium vulnerability classes caused by the large number of slope zones, lineament density and rock types, which are of high value in this research area. Even though if you look at the NDVI parameters, this zone has a low value, because the NDVI percentage in the weighting is low, this only has a slight impact. From the results of this analysis, disaster mitigation should be needed that can affect the community in the Lebak Regency area, Banten Province, namely in the form of providing provisions in the form of knowledge to the community regarding disaster management which is useful for minimizing the risk of the consequences of landslides.

Acknowledgment

The author would like to thank Allah SWT, the lecturer staff of the Geological Engineering Study Program at Sriwijaya University, colleagues who helped and supported the author in completing this paper, as well as all related parties.

References:

[1] Government of Indonesia, *UU Republik Indonesia mengenai Penanggulangan Bencana*. Jakarta, 2007.

[2] Google, "Google Maps directions to drive from Palembang City to Luhurjaya Village." Accessed: Oct. 18, 2023. [Online]. Available: https://maps.app.goo.gl/4xaeEuPzwRVhSYQN8

[3] R. V Bemmelen, *The Geology of Indonesia*, Vol. IA, G. Netherland: Printed Office, The Hague, Martinus Nijhoff, 1949.

[4] A. d Pulonggono, "Paleogene - Neogene Tectonic Change is the Most Important Event in Java," *Proc. Geol. Geotech.*, pp. 37–50, 1994.

[5] BPDB, "Landslide in Lebak." Accessed: Oct. 18, 2023. [Online]. Available: https://bpdb.lebak.co.id/

[6] N. I. Ramadhani and H. Idajati, "Identifikasi Tingkat Bahaya Bencana Longsor, Studi kasus: Kawasan Lereng Gunung Lawu, Kabupaten Karanganyar, Jawa Tengah," *J. Tek. ITS*, vol. 6, no. 1, pp. 87–90, 2017, doi: 10.12962/j23373539.v6i1.22333.

[7] N. H. Sudibyo and M. Ridho, "Pendeteksi Tanah Longsor Menggunakan Sensor Cahaya (Landslide Detection Using Light Sensor)," *J. Teknol. Inf. Magister*, vol. 1, no. 2, pp. 218–227, 2015.

[8] Priyono, "Hubungan klasifikasi longsor, klasifikasi tanah rawan longsor dan klasifikasi tanah pertanian rawan longsor," *Gema*, vol. 27, no. 49, pp. 1602–1617, 2015.

[9] A. Erlansari, B. Susilo, and F. Hernoza, "OPTIMALISASI DATA LANDSAT 8 UNTUK PEMETAAN DAERAH RAWAN BANJIR DENGAN NDVI dan NDWI (Studi Kasus : Kota Bengkulu)," *JGE (Jurnal Geofis. Eksplorasi)*, vol. 6, no. 1, pp. 57–65, Mar. 2020, doi: 10.23960/jge.v6i1.60.

[10] A. Akgun, C. Kıncal, and B. Pradhan, "Application of remote sensing data and GIS for landslide risk assessment as an environmental threat to Izmir city (west Turkey)," *Environ. Monit. Assess.*, vol. 184, no. 9, pp. 5453–5470, 2012, doi: 10.1007/s10661-011-2352-8.

[11] R. Sawitri, D. Baco, R. Ulfiyana, and T. Karo-karo, "Aplikasi Citra Landsat untuk Pemetaan Daerah Rawan Longsor di Kabupaten Bandung," *J. Geosains dan Remote Sens.*, vol. 2, no. 2, pp. 65–73, Nov. 2021, doi: 10.23960/jgrs.2021.v2i2.42.

[12] Puslittanak, "Laporan Akhir Pengkajian Potensi Bencana Kekeringan, Banjir dan Longsor di Kawasan Satuan Wilayah Sungai Citarum-Ciliwung, Jawa Barat Bagian Barat Berbasis Sistem Informasi Geografi," Bogor, 2004.

[13] T. S. Dewi, S. B. Kusumayudha, and H. S. Purwanto, "Zonasi Rawan Bencana Tanah Longsor dengan Metode Analisis GIS: Studi Kasus Daerah Semono dan Sekitarnya, Kecamatan

Bagelen, Kabupaten Purworejo, Jawa Tengah,” *J. Miner. Energi, dan Lingkung.*, 2017, doi: https://doi.org/10.31315/jmel.v1i1.1773.g1921.
[14] A. Nur Shidik, E. Cintia Purba, and P. Ayuningtyas, “KABUPATEN BREBES REMOTE SENSING TECHNIQUE FOR IDENTIFICATION LANDSLIDE PRONE AREAS IN SRIDADI VILLAGE, SUB-DISTRICT SIRAMPOG, BREBES REGENCY,” 2021. doi: http://dx.doi.org/10.30872/jtgeo.v4i2.5442.
[15] Highland, Lynn, and M. Johnson, *Landslide Type and Processes*. USGS, 2004.
[16] M. Nursa’ban, “Identifikasi Kerentanan dan Sebaran Longsor Lahan Sebagai Upaya Mitigasi Bencana di Kecamatan Bener Kabupaten Purworejo,” vol. Vol. 10 No, no. Jurnal Geografi Gea, 2010, doi: https://doi.org/10.17509/gea.v10i2.1018.g670.