

RESEARCH ARTICLE

Identification Comparison of Landslide Potential Area with Analytical Hierarchy Process and Logistic Regression Methods in Cisarua District and Surroundings, Bogor Regency, West Java

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Abstract

Landslide is one of the geological disasters that often occur in Indonesia, especially in Cisarua District and its surroundings, Bogor Regency, West Java, so mitigation activities need to be carried out, one of which is by making a map of potential areas of landslide in the research area. This study aims to analyze the spatial distribution of potential landslides in Cisarua District, Bogor Regency, using the Analytical Hierarchy Process (AHP) and Logistic Regression (LR) methods, and to determine the more effective method for landslide prediction in the study area. The results showed that the AHP method obtained the distribution of potential areas of landslide in the low category with an area of 39.592 km² with a percentage of 38.99%, the moderate category with an area of 39.690 km² with a percentage of 39.09% and the high category with an area of 22.253 km² with a percentage of 21.92%. In the LR method, the potential for landslide was obtained in the low category with an area of 39.158 km² with a percentage of 38.15%, the moderate category with an area of 39.485 km² with a percentage of 38.86%, and the high category with an area of 22.967 km² with a percentage of 23% and the best method in determining the potential area of landslide was the LR method with an overall accuracy level of 86.41% compared to the Analytical Hierarchy Process (AHP) method with an overall accuracy of 78.64%.

Keywords: Landslide, Analytical Hierarchy Process (AHP), Logistic Regression (LR), Confusion Matrix

1. Introduction

Many researchers studied landslide susceptibility using some methods such as Logistic Regression (LR), Analytical Hierarchy Process (AHP) (Bourenane et al., 2016; Do et al., 2020; Kavzoglu et al., 2014; Park et al., 2013; Pourghasemi et al., 2013). In this paper, we study landslide in Cisarua District and surroundings which is administratively part of Bogor Regency, West Java Province, Indonesia. Cisarua District and surroundings are one of the target tourist destinations in Bogor Regency. Cisarua District and surroundings are one of the tourism targets in the Bogor Regency area. According to BPS data in 2019, tourists who visited this area were around 2,346,771 tourists, especially to the Puncak Bogor area (BPS, 2019). Based on that data, it can be said that Cisarua District and surroundings are among the tourist destinations frequently visited by travelers.

Bogor Regency is one of the areas that is prone to landslide events, one of which is Cisarua District and surroundings. According to BPBD data in 2023, this area was affected by disasters around 34 cases of landslides (BPBD, 2023). Based on the data, the Cisarua district and surroundings are included in a zone that has the potential for landslide.

This study uses the Analytical Hierarchy Process (AHP) and Logistic Regression (LR) methods. The Analytical Hierarchy Process (AHP) method is used in determining decisions in a multi-criteria manner in which the score of

the level of importance of each parameter is determined (Liu et al., 2024). However, this method has shortcomings in determining the score and weight based on the consideration of expert opinions and is not a statistical approach. In the Logistic Regression (LR) method, a statistical approach is carried out in determining the potential for landslide using the occurrence of landslide (Zhen et al., 2020).

Based on the very high landslide potential and the shortcomings of the Analytical Hierarchy Process (AHP) and Logistic Regression (LR) methods, the purpose of this study is to determine the extent of potential landslide using Analytical Hierarchy Process (AHP) and Logistic Regression (LR) methods. Judgement in AHP is expert-dependent, often reused across different areas. In addition, Consistency Ratio (CR) in AHP also often be uncertainty in weights. The utilization of combining AHP and LR aims to obtain more reliable models in identifying extent of landslides. Moreover, the purpose is also to address the most suitable method in determining the potential for landslide in Cisarua District and its surroundings.

2. Literature Review

2.1 Geomorphology

Based on Van Bemmelen (1949), the research area is in the Bogor Zone. The Bogor Zone itself is located in the south part of the Jakarta Plain. This zone has the appearance of hilly morphology that extends west-east from Bogor City

which turns south to form an arch called anticlinorium (Van Bemmelen, 1949).

Based on the map of Poedjoprajinto (2011), the type of geomorphology in the research area is the Shape of Volcanic origin (V), which follows the classification of Van Zuidam (1979). The geomorphology of the study area is the shape of the volcanic origin (V) with the type of young volcanic cones (V1), parasitic young volcanic cones (V6), lava fans/parasitic volcanic pyroclastic flows (V7), ancient volcanic lava fans (V9), ancient volcanic cones (V12), and lava plugs (V13) in Figure 1.

2.2 Stratigraphy

The stratigraphy of the research area (Figure 2) based on the Bogor sheet geological map made by A.C. Efendi Kusnana and Hermanto (1986) is divided into 3 units, namely the breccia and lava of Gunung Kencana and Gunung Limo (Qvk), basalt lava flow of Gunung Gegerbentang (Qvba) and older deposits, lahar and lava, andesite basalt (Qvpo). This unit is the controlling factor of stratigraphy in the research area.

2.3 Geological Structure

Geological structure in the research area generally has 3 structural patterns that develop. According to Pulunggono and Martodjo (1994), there are 3 structural patterns, namely the Sunda pattern in the northwest-southeast direction, the dominant Java pattern in the west-east direction and the meratus pattern in the southwest-northeast direction.

The Citarik Fault (Figure 3) is one of the active faults in the research area. According to Sidarto (2008), the Citarik

Fault passes through several areas, one of which is Bogor Regency. This fault is a horizontal fault that is oriented to the Sunda pattern in the northwest-southeast direction.

3. Data and Methodology

This study uses secondary data (Table 1). The data used is the Digital Elevation Model (DEM) to produce slope maps, the Indonesian Terrain (RBI) to obtain roads, rivers and land use. Then rainfall, soil type, lithology, regional administration and Landsat 8-Oli & TIRS satellite imagery to create EVI (Enhanced Vegetation Index) and NDMI (Normalized Difference Moisture Index) maps. As well as the occurrence points landslide event were obtained through Regional Disaster Management Agency (BPBD), National Agency for Disaster Management (BNPD) and Center for Volcanology and Geological Hazard Mitigation (PVMBG) recapitulation data and observation by satellite images with a value of 1 as many as 142 occurrence points that have been recorded the occurrence of landslide with 60% of the occurrence points while the negative point is a random distribution point which illustrates that the point has never occurred ground movement with a value of 0 as many as 198 points. Then the validation used 103 validation points with an accumulation of 40% of the occurrence of landslide.

These parameters were obtained for rainfall, slope, lithology, land use, soil type, proximity to rivers, NDMI, EVI and road cutting the slope and specifically processing LR data using point landslide. Data processing parameters can be seen in Figure 4.

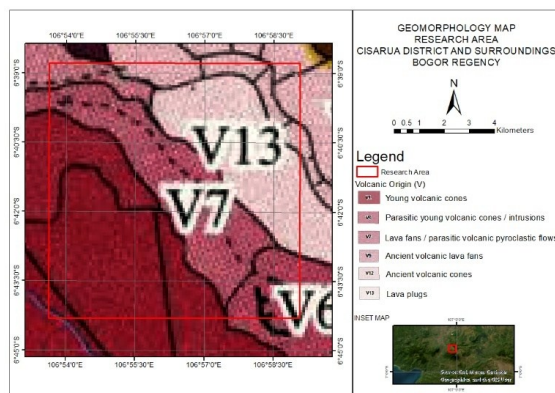


Fig 1. Geomorphological map (Modified from Poedjoprajinto, 2011)

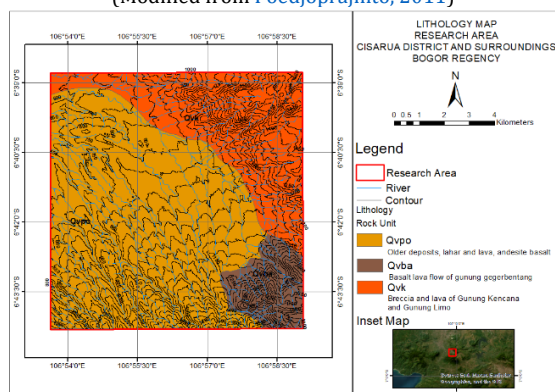


Fig 2. Stratigraphy of the research area (A.C. Efendi Kusnana and Hermanto, 1986)

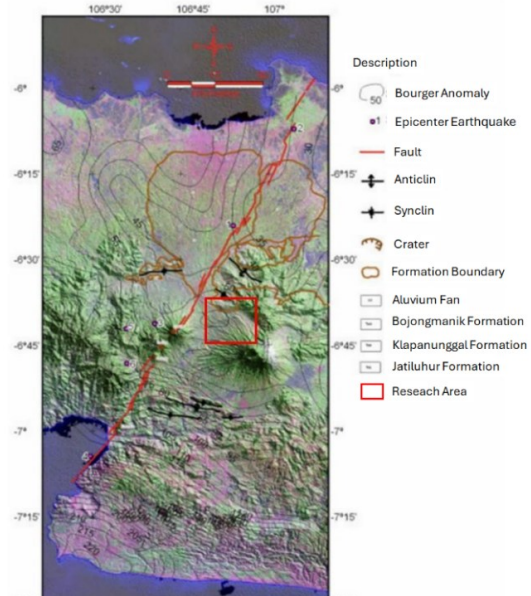


Fig 3. Citarik Fault is the result of overlaying on landslide imagery, SRTM imagery, Bourgeois anomaly data, and earthquake center (Modified from Sidarto, 2008).

Table 1. Secondary data parameters of the study

No	Data Parameters	Source	Scale/ Resolution	Data Type
1	Digital elevation model (DEM)	https://tanahair.indonesia.go.id/demnas/#/demnas	8 meters	Raster
2	Indonesia Topography (RBI)	https://tanahair.indonesia.go.id/unduh-rbi/#/	1 : 25000	ESRI Shapefile
3	Rainfall	http://www.worldclim.org/	30 meters	Raster
4	Administration	https://geoportal.bogorkab.go.id/	1 : 25000	ESRI Shapefile
5	Soil type	https://geoportal.bogorkab.go.id/	1 : 25000	ESRI Shapefile
6	Land use	Obtained from RBI	1 : 25000	ESRI Shapefile
7	Litology	https://geologi.esdm.go.id/geomap/pages/district/32.01	1 : 25000	ESRI Shapefile
8	Point landslide	https://dibi.bnpb.go.id/ https://bpbd.bogorkab.go.id/tag/tanah-longsor/ https://vsi.esdm.go.id/#	1 : 25000	ESRI Shapefile
9	Landsat 8-Oli & TIRS	https://earthexplorer.usgs.gov/	30 meters	Raster
10	Enhanced Vegetation Index (EVI)	landsat-8 data processing	30 meters	Raster
11	Normalized Difference Moisture Index (NDMI)	landsat-8 data processing	30 meters	Raster
12	Road	Obtained from RBI	1 : 25000	ESRI Shapefile
13	River	Obtained from RBI	1 : 25000	ESRI Shapefile

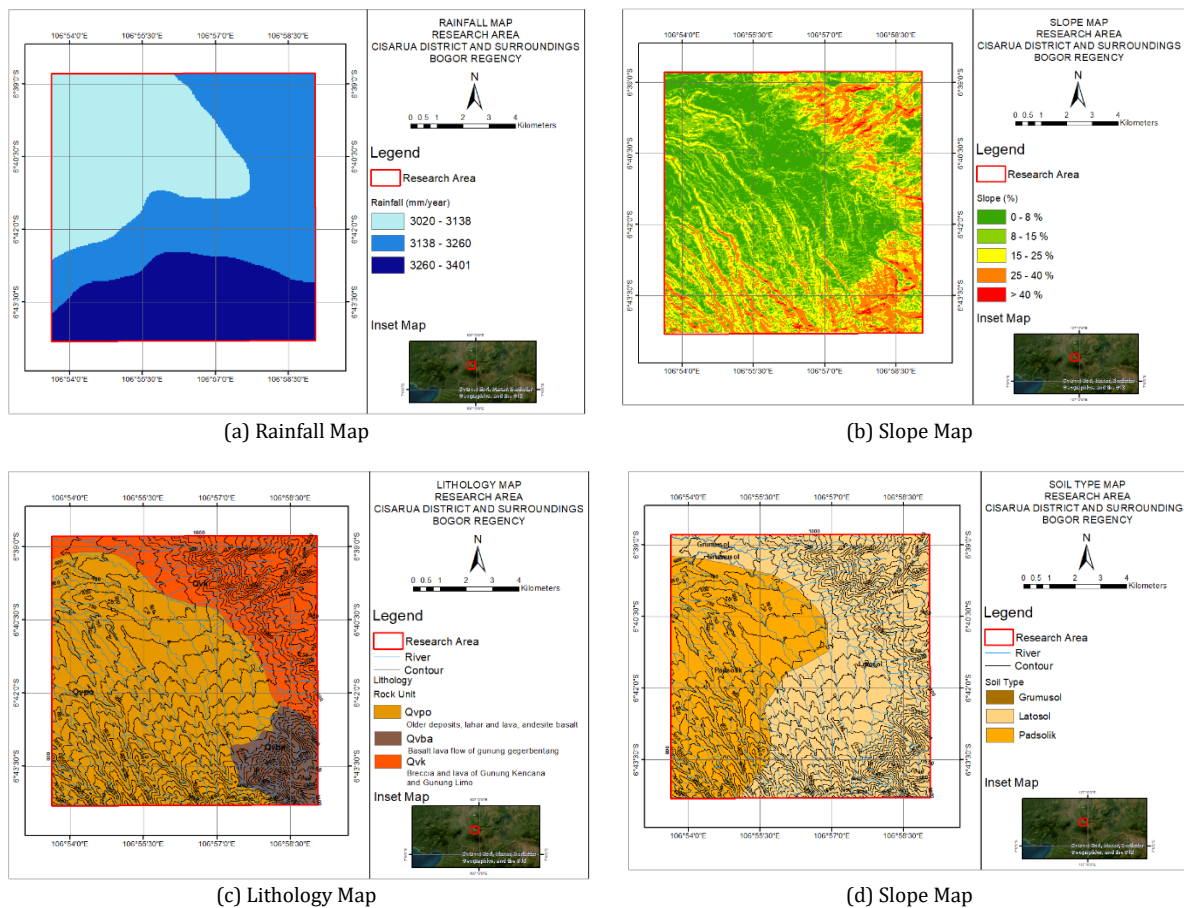


Fig 4. Landslide parameters: (a) rainfall (b) slope (c) lithology (d) soil type (e) land use (f) proximity to river (g) enhanced vegetation index EVI (h) normalized difference moisture index NDMI (i) road cutting the slope, and (j) point landslide.

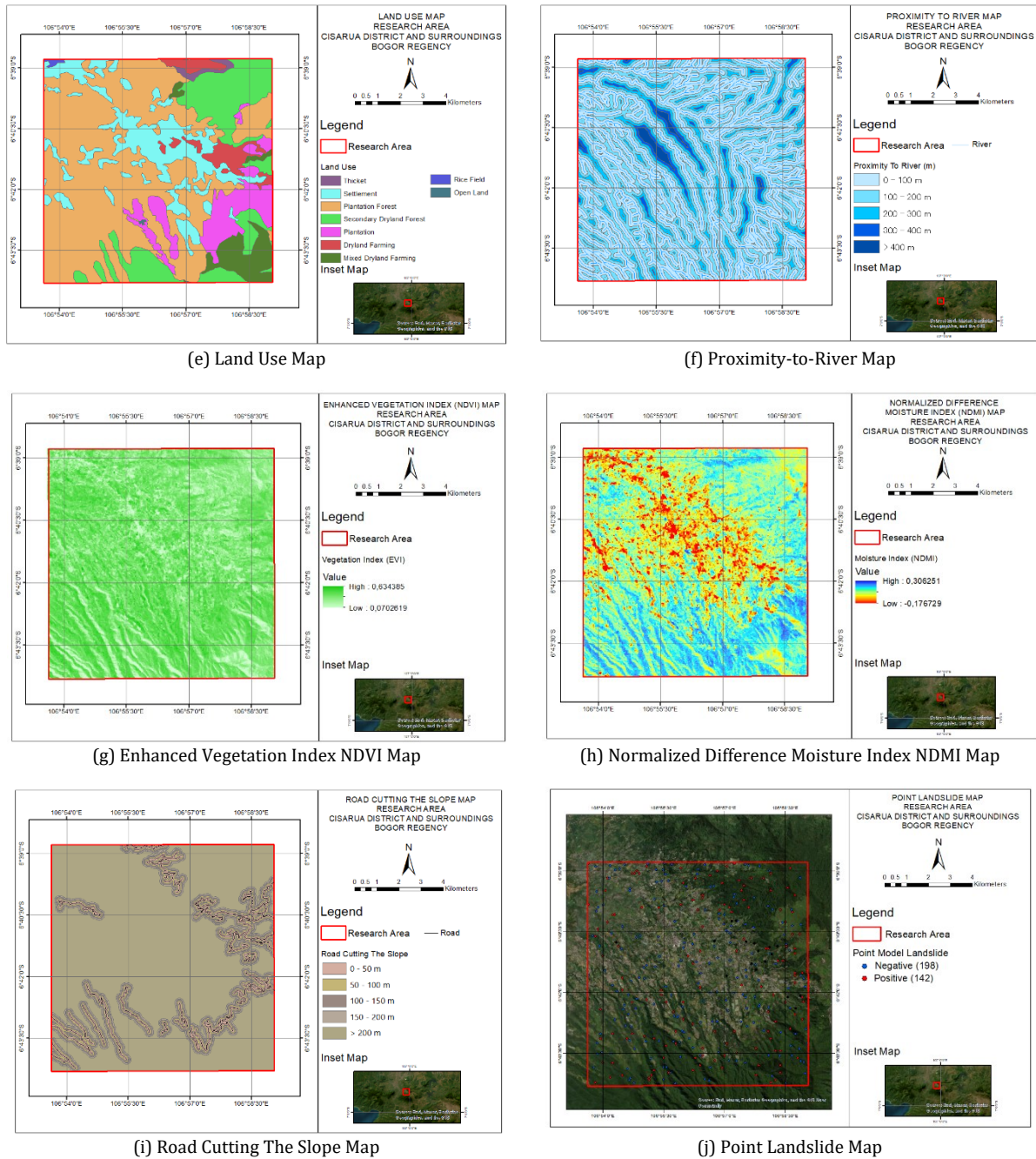


Fig 4. Landslide parameters: (a) rainfall (b) slope (c) lithology (d) soil type (e) land use (f) proximity to river (g) enhanced vegetation index EVI (h) normalized difference moisture index NDMI (i) road cutting the slope, and (j) point landslide. (Cont.)

In the processing of this research, there are 3 parts, namely the preparation stage, the data processing and analysis stage and the preparation of the report so that it can be seen in the following **Figure 5**.

3.1 Analytical Hierarchy Process (AHP) Method

The Analytical Hierarchy Process (AHP) method in landslide is a method used in predicting landslide by providing a score and priority weight for each cause of landslide (Permadi et al., 2018). The score and priority weights, as well as the scores and priority weights for landslides, can be determined through the analytical hierarchy process. In determining the scores, input is obtained from landslide experts regarding how important

each landslide parameter is in influencing other parameters, which then obtains landslide priority weights. Analytical Hierarchy Process (AHP) involves an overlay process on each landslide parameter (Misbahudin et al., 2015).

As it is mentioned in the introduction section, AHP is expert-dependent method, and the weight score is on some degree has judgmental properties. However, this issue can be treated by Consistency Ratio (CR) when its value is within the reasonable limit. Following section will explain more about CR value. In determining the weight of each parameter, it is obtained through a matrix of comparison of each parameter that causes landslide. Then determine the consistency index (CI) test to test the consistency level of

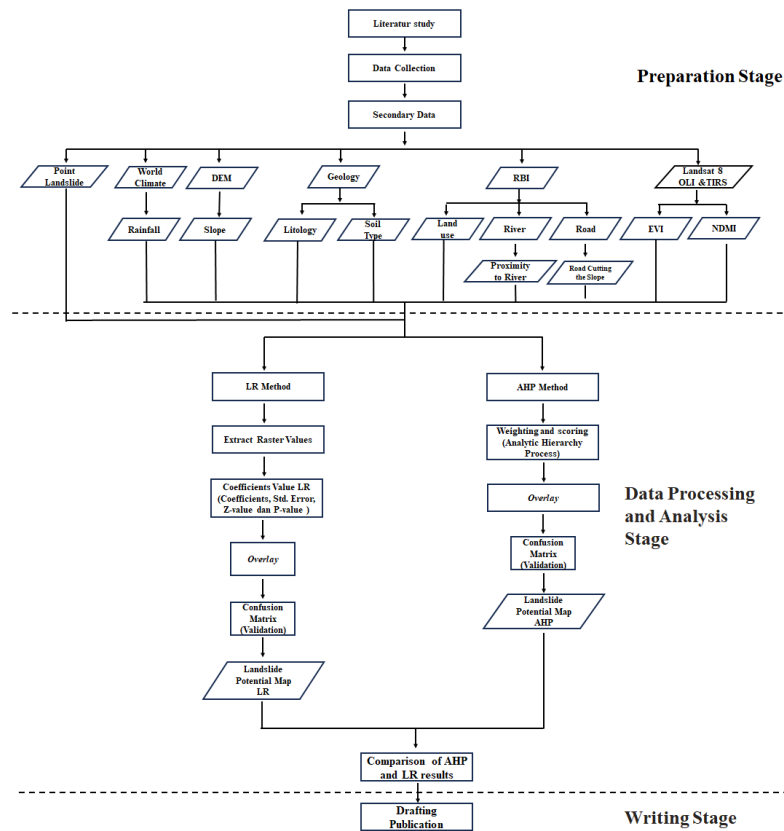


Fig 5. Research Workflow

the importance granting parameter. The consistency index (CI) is obtained through the following formula from Saaty (2002):

$$\text{Consistency Index} = \frac{(\lambda_{\max} - n)}{(n - 1)} \quad (1)$$

where λ_{\max} is the maximum Eigen principle and n is the sum of the parameters.

Consistency ratio (CR) is a value that indicates whether or not it is consistent in determining the level of importance. In determining the consistency ratio (CR), a random index (RI) value must be obtained in determining the consistency ratio (CR). The value of the random index (RI) in the following Table 2.

Table 2. Random Index (RI) for each parameter (i) matrix (Misbahudin et al., 2015)

Parameter (i)	Random Index (RI)
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

By obtaining the value of random index (RI) and consistency index (CI) so that the value of the consistency ratio (CR) can be calculated. This value is obtained by dividing the consistency index (CI) and the consistency

ratio (CR) or can be seen in the following equation from Saaty (2002):

$$\text{Consistency Ratio} = \frac{\text{Consistency Index (CI)}}{\text{Random Index (RI)}} \quad (2)$$

If the value obtained is below 10% or 0.1, the value shows consistency and has interrelated in determining the level of importance of each matrix (Saaty, 2002). In this method, the sum of the weights on each parameter is used with the following equation.

$$\text{LSI} = \sum_{i=0}^n R_i W_i \quad (3)$$

with LSI is the landslide susceptibility index (LSI) and R_i is the score of each parameter and W_i is the weight of each parameter i .

3.2 Logistic Regression (LR) Method

Logistic Regression (LR) is a statistical approach method. LR explained the relationship between response variables in the form of dichotomic data and free data variables on both categorical and international scales (Pamela et al., 2018). Logistic regression can be used in mapping the potential of landslides.

The output value of LR is 0 to 1 where the value is 0% no landslide while 1 indicates 100% of landslide which is described as the landslide susceptibility index (LSI) value (Pamela et al., 2018). The formula of the landslide susceptibility index (LSI) is as follows.

$$P = \frac{e^z}{1 + e^z} \quad (4)$$

$$Z = b_0 + b_1X_1 + b_2X_2 + \dots + b_nX_n \quad (5)$$

$$Z = \log_e \left(\frac{P}{1-P} \right) = \text{logit}(P) \quad (6)$$

The formula above explains that P is the probability of the occurrence of landslide (0-1). So that the value of Z is a combination of linear variable values that present the results of linear relationships while a is the coefficient or intercept model. Meanwhile, the values of X_n are dependent variables that can be used in multivariate analysis, namely Logistic Regression (LR) and the parameters b_n are the regression coefficients of independent variables.

4. Results

4.1 Analytical Hierarchy Process (AHP) Method

In the Analytical Hierarchy Process (AHP) method, a comparison matrix is determined in determining the priority weight of each parameter and testing the accuracy of the data by paying attention to the value of the consistency ratio (CR) that affects the research area, this is

seen in **Tables 3, Table 4, and Table 5**. It was found that the determination of the score and weight of the importance level of this study was consistent. This is because the consistency ratio (CR) value is below 0.1 or 10%. The determination of weights and priority scores is based on expert opinions from the landslide literature by comparing each parameter of the factors that cause landslides.

In making a landslide map, this method is overlaid or overwhelmed to each landslide parameter, namely rainfall, slope, lithology, land use, soil type, proximity to rivers, NDMI, EVI and road cutting the slope by ensuring each data parameter with a raster type by providing a score and weight in accordance with the weight calculation of each parameter so that a potential map of landslide of the AHP method is produced in **Figure 6**. The potential zones of landslides used are low, medium and high landslide potential.

4.2 Logistic Regression (LR) Method

In the processing of the LR method, calculations are carried out to obtain coefficients (b), standard errors, z -values and significance levels (p). The coefficients (b) represent fixed effect of each independent variable on the log-odds of landslide occurrence, while standard error

Table 3. Comparison matrix of each landslide parameter

Criteria	Slope	Lithology	Land use	Rainfall	Soil Type	NDMI	EVI	Proximity to river	Road cutting the slope	Sum
Slope	1.00	2.00	2.00	2.00	4.00	3.00	3.00	4.00	4.00	25.00
Litology	0.50	1.00	0.50	2.00	3.00	4.00	2.00	2.00	4.00	19.00
Land use	0.50	2.00	1.00	2.00	4.00	2.00	3.00	2.00	5.00	21.50
Rainfall	0.50	0.50	0.50	1.00	4.00	4.00	2.00	3.00	4.00	19.50
Soil Type	0.25	0.33	0.25	0.25	1.00	0.50	0.25	0.50	3.00	6.33
NDMI	0.33	0.25	0.50	0.25	2.00	1.00	0.50	0.33	4.00	9.17
EVI	0.33	0.50	0.33	0.50	4.00	2.00	1.00	2.00	5.00	15.67
Proximity to river	0.25	0.50	0.50	0.33	2.00	3.00	0.50	1.00	3.00	11.08
Road cutting the slope	0.25	0.25	0.20	0.25	0.33	0.25	0.20	0.33	1.00	3.07
Sum	3.92	7.33	5.78	8.58	24.33	19.75	12.45	15.17	33.00	130.32

Table 4. Priority and eigenvalue of each landslide parameter

Criteria	Slope	Lithology	Land use	Rainfall	Soil Type	NDMI	EVI	Proximity to river	Road cutting the slope	Sum	Priority	Eigen Value
Slope	0.26	0.27	0.35	0.23	0.16	0.15	0.24	0.26	0.12	2.05	0.23	0.89
Litology	0.13	0.14	0.09	0.23	0.12	0.20	0.16	0.13	0.12	1.32	0.15	1.08
Land use	0.13	0.27	0.17	0.23	0.16	0.10	0.24	0.13	0.15	1.60	0.18	1.03
Rainfall	0.13	0.07	0.09	0.12	0.16	0.20	0.16	0.20	0.12	1.25	0.14	1.19
Soil Type	0.06	0.05	0.04	0.03	0.04	0.03	0.02	0.03	0.09	0.39	0.04	1.06
NDMI	0.09	0.03	0.09	0.03	0.08	0.05	0.04	0.02	0.12	0.55	0.06	1.21
EVI	0.09	0.07	0.06	0.06	0.16	0.10	0.08	0.13	0.15	0.90	0.10	1.24
Proximity to river	0.06	0.07	0.09	0.04	0.08	0.15	0.04	0.07	0.09	0.69	0.08	1.16
Road cutting the slope	0.06	0.03	0.03	0.03	0.01	0.01	0.02	0.02	0.03	0.25	0.03	0.94
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	9.00	1.00	9.79

Table 5. Test data accuracy and data consistency

Lambda Max (λ_{max})	9.795
Consistency Index (CI)	0.099
Random Index (RI)	1.120
Consistency Ratio (CR)	0.089

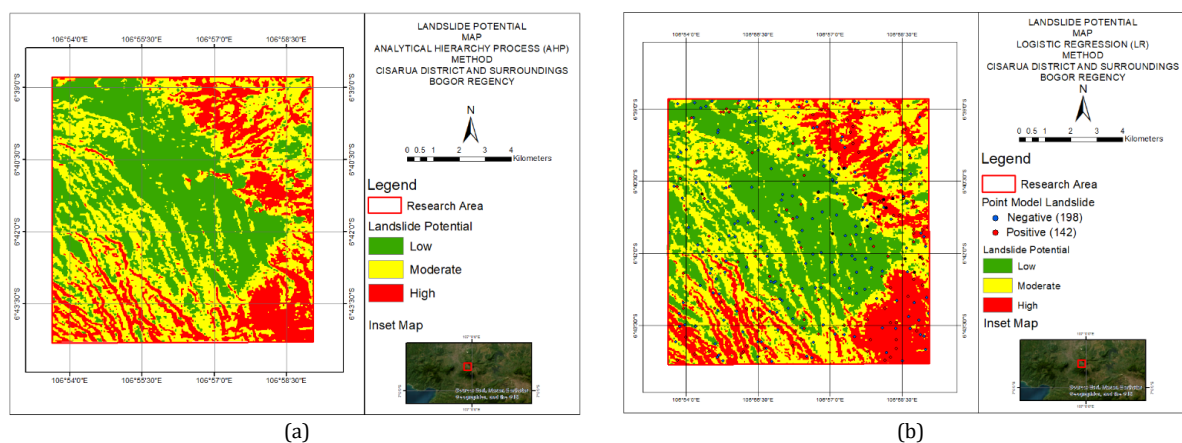


Fig 6. Map of the potential of landslide based on (a) Analytical Hierarchy Process and (b) Logistic Regression

Table 6. Result summary for LR method

Estimate	Estimate Coefficients	Std. Error	Z Value	Pr (> z)
Intercept	-1.13047	0.85382	-1.324	0.1855
Rainfall	-0.00490	0.33539	-0.015	0.9883
Litology	-0.45509	0.43760	-1.040	0.2984
Road cutting the slope	0.04587	0.34259	0.134	0.8935
Land use	-0.52543	0.47628	-1.103	0.2699
Slope	0.89336	0.50133	1.782	0.0747
Soil type	-0.20645	0.50122	1.782	0.4929
Proximity to river	0.51136	0.62418	0.819	0.4126
EVI	1.13327	0.81245	1.395	0.1631
NDMI	1.04127	0.65447	1.591	0.1116

Table 7. Comparison of confusion matrix results of landslide potential AHP and LR methods

Parameters	Analytical Hierarchy Process (AHP)			Logistic Regression (LR)		
	Landslide	No Landslide	Total	Landslide	No Landslide	Total
Landslide	33	8	41	37	4	41
No Landslide	14	48	62	10	52	62
Total	47	56	103	47	56	103
Overall Accuracy	78.64%			86.41%		
Kappa Coefficient	0.64			0.75		

Table 8. Comparison of user accuracy and producer accuracy results of AHP and LR methods

Parameters	Analytical Hierarchy Process (AHP)		Logistic Regression (LR)	
	Landslide	No Landslide	Landslide	No Landslide
User Accuracy	80.49%	77.42%	90.24%	83.87%
Producer Accuracy	70.21%	85.71%	78.72%	92.86%

measures the precision of these estimates. The z-value is calculated as the ratio of the coefficient to its standard error, and the p-value indicating the statistical significance of each parameter. These results are summarized in **Table 6**.

In making a landslide map, this method is overlaid with each landslide parameter, namely rainfall, slope, lithology, land use, soil type, proximity to rivers, NDMI, EVI and road cutting the slope by ensuring each data parameter with the type of raster by utilizing the values in **Table 6**. Thus, a map of the potential for landslides is produced in **Figure 6**. The potential zones of landslides used are low, medium and high landslide potential.

4.3 Types of Landslide Classification

The landslide-prone area is categorized into various zones based on type and characteristics. According to Regulation of the Minister of Public Works No. 22/PRT/M/2007, the landslide zones in the research area

consist of Zone A and Zone B. This classification identifies the nature of the landslide potential in the area (**Figure 7**).

4.4 Confusion Matrix

The validation of the results in this study uses the confusion matrix method. This confusion matrix to generate different accuracy metrics such as producer and user accuracy (Salleh et al., 2025). Validation uses 103 validation points which are points that have experienced landslide events (**Figure 8**). The point comes from BPBD and observations from satellite images with an accumulation of 40% of the landslide event data.

In the results of the confusion matrix comparison of the AHP and LR methods in the research area, the results were obtained.

In the results of the comparison of the confusion matrix calculation of the AHP and LR methods, the results were obtained for each vulnerability of landslide (**Table 7**). In the confusion matrix, the overall accuracy value of the results

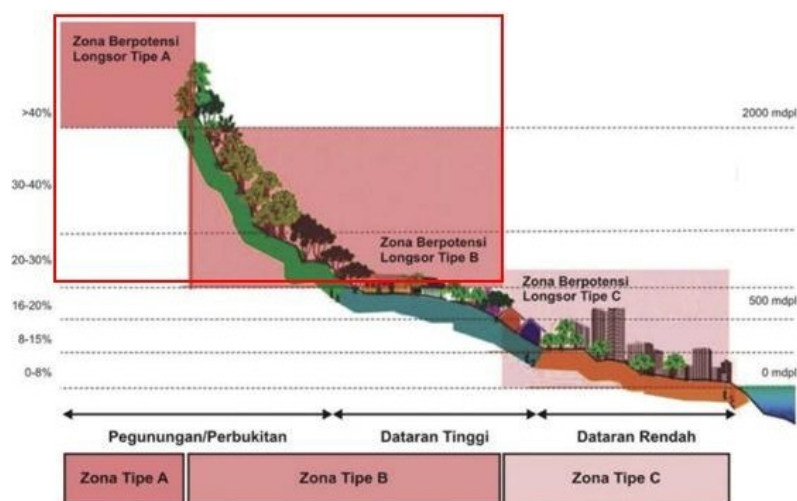


Fig 7. Typology of potential landslide zones (Regulation of the Minister of Public Works 22/PRT/M/2007)

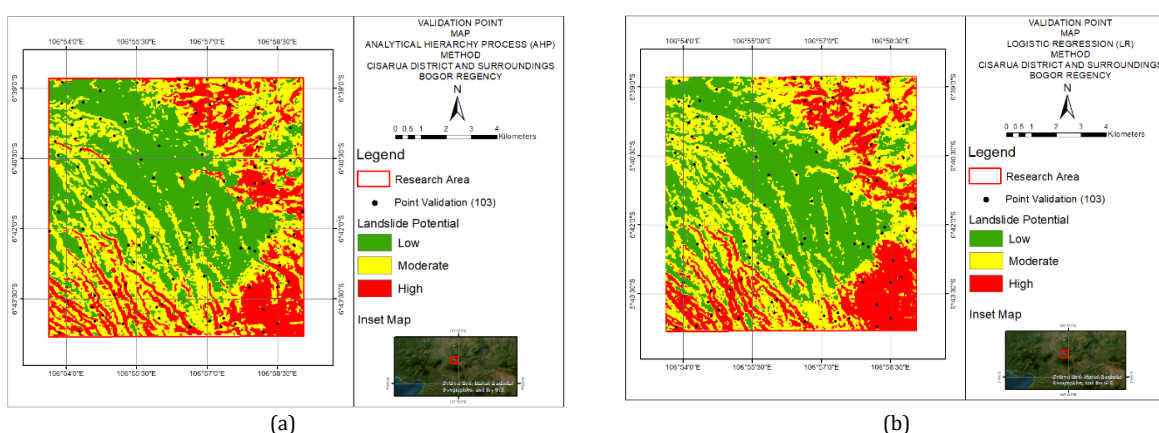


Fig 8. Confusion matrix validation point map (a) Analytical Hierarchy Process (AHP) method and (b) Logistic Regression (LR)

of the AHP method was 78.64%, while the LR method had an accuracy level of 86.41% and the Kappa Coefficient (KC) value of the AHP method was 0.64.

The KC in the AHP method is included in the good results while the LR Kappa Coefficient (KC) method is 0.75 in the good category. In the matrix confusion processing, the overall accuracy value of the results of the AHP method was 78.64%, while the LR method had an accuracy level of 86.41% and the Kappa Coefficient (KC) value was 0.64, the result was obtained that the KC value in the AHP method was included in the good results while the LR Kappa Coefficient (KC) method was 0.75 in the good category. This is based on the KC value of each method.

User accuracy and producer accuracy calculations were carried out. Based on **Table 8**, the results of user accuracy and producer accuracy in the AHP method were obtained with a user accuracy of 77.42% - 80.49% and producer accuracy of 70.21% - 85.71% so that it is included in the good category because it produces a value above 70% while the LR method obtained a user accuracy value of 83.87% - 90.24% and producer accuracy obtained a value of 78.72% - 92.86% so that it is included in the good category. However, in terms of the above value, LR is better than AHP.

In addition to the confusion matrix, additional validation is carried out by collecting data or looking at the history of the occurrence point of landslide that has been validated that landslide has occurred. This point was

obtained through previous researchers, namely [Silalahi et al. \(2019\)](#) and [Gumilang et al. \(2021\)](#) who obtained the data through historical data on the occurrence of Center for Volcanology and Geological Hazard Mitigation (PVMBG) landslide (**Figure 9**). The point was recapitulated so that it was produced that the occurrence points of landslide occurred more in areas that occurred in the potential for dominant high landslide occurred in the LR method as many as 11 events while in the AHP method only 9 events occurred.

4.5 Overlay of Land Movement Maps on Infrastructure and Regional Administration

On the map of the potential for landslides, road infrastructure is needed to facilitate mitigation and evacuation in the event of a landslide disaster. In the results of data processing in the form of the distribution of landslide potential, both using the Analytical Hierarchy Process (AHP) and Logistic Regression (LR) methods, overlapping the infrastructure is carried out (**Figure 10**).

Based on **Table 9** of the potential area of landslide based on the AHP method, the distribution of the potential area of landslide using the AHP method was obtained in the low category with an area of 39.592 km² with a percentage of 38.99%, the medium category with an area of 39.690 km² with a percentage of 39.09% and the high category with an area of 22.253 km² with a percentage of 21.92%. In the LR

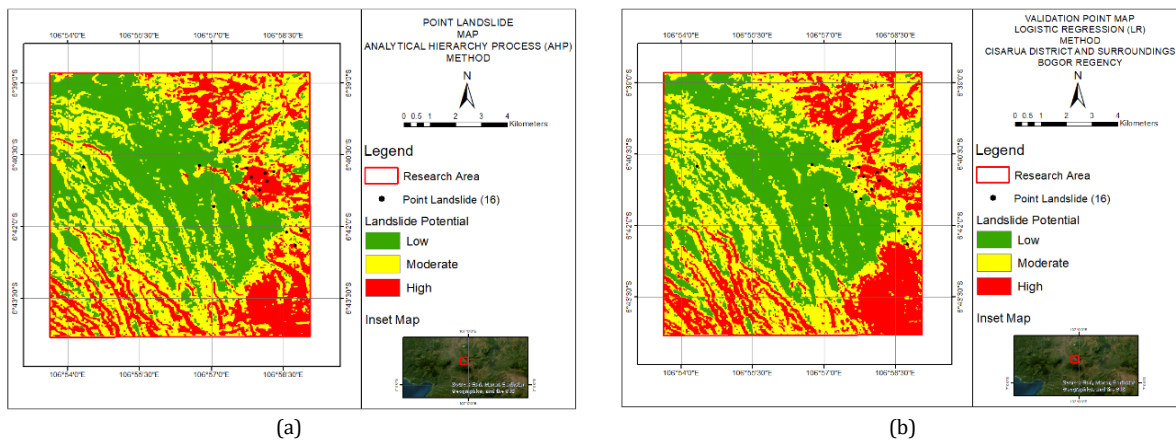


Fig 9. Map of additional validation points (a) Analytical Hierarchy Process (AHP) method and (b) Logistic Regression (LR)

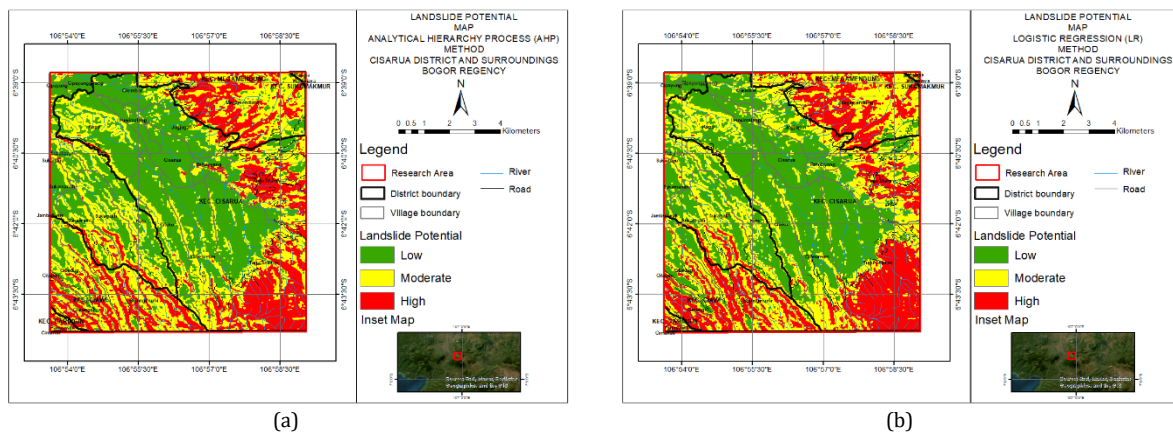


Fig 10. Overlay Map of Landslide Map on Infrastructure and Regional Administration (a) Analytical Hierarchy Process (AHP) method (b) Logistic Regression (LR).

method, the potential for landslide was obtained in the low category with an area of 39.158 km² with a percentage of 38.5%, the medium category with an area of 39.485 km² with a percentage of 38.86%, and the high category with an area of 22.967 km² with a percentage of 23%. The village with an area with a high category of vulnerability with the first Analytical Hierarchy Process (AHP) method is South Tugu Village with a potential area of landslide with a high category of 6.131 km². Then the second village is Megamendung Village with a potential area of land movement with a high category of 5.446 km² and the third is North Tugu Village with a potential for land movement with a high category of 3.011 km². Meanwhile, in the Logistic Regression (LR) method, South Tugu Village was obtained with a potential area of landslide with a high category of 7.387 km², then the second was Megamendung Village with a potential area of landslide with a high category of 5.539 km² and the third was Bojongsurni Village with a potential for landslide with a high category of 3.126 km².

5. Discussion

5.1 Analytical Hierarchy Process (AHP) Method

Based on **Figure 6**, the landslide potential map in the AHP method is produced with a landslide potential with a percentage of 38.99% of the total research area has a relatively low slope morphology of around 0% - 15% with a very dry to dry moisture level and medium to high vegetation with the dominant lithology being Older

deposits, lahar and lava, andesite basalt (Qvpo). Meanwhile, in the potential for landslide with a percentage of 39.09%, it has a relatively steep slope morphology of around 15% - 25%, dry moisture level with moderate to low vegetation levels and older deposits, lahar and lava, andesite basalt (Qvpo) and breccia and lava of Gunung Kencana and Gunung Limo (Qvk). Meanwhile, the potential for high landslide with a percentage of 21.92% has a slope morphology the slopes are relatively dominated by the very steep category of about 25% to more than 40% with humid humidity levels with very low to non-vegetated vegetation levels with lithology of basalt lava flow of Gunung Gegerbentang (Qvba) and breccia and lava of Gunung Kencana and Gunung Limo (Qvk).

5.2 Logistic Regression (LR) Method

Based on **Figure 6**, the landslide potential map with a low landslide potential category with a percentage of 38.5% has a relatively low slope morphology of around 0% - 15% with a very dry to dry humidity level and medium to high vegetation with the dominant lithology being older deposits, lahar and lava, andesite basalt (Qvpo). Meanwhile, in the category of medium landslide potential with a percentage of 38.86%, the slope morphology is relatively steep around 15% - 25% with a dry moisture level with a moderate to low vegetation level, Older deposits, lahar and lava, andesite basalt (Qvpo) and breccia and lava of Gunung Kencana and Gunung Limo (Qvk). While the potential for high landslide with a percentage of 23% has a slope

morphology that is relatively dominated by the very steep category, around 25% to more than 40% with a humid moisture level with a very low to non-vegetated vegetation level dominated by lithology of basalt lava flow of Gunung Gegerbentang (Qvba) and breccia and lava of Gunung Kencana and Gunung Limo (Qvk).

5.3 Type of Landslide Classification

Based on **Figure 7**, the relationship between the landslide potential zone and the results of the landslide method is interrelated and meets the conditions presented in the map of the potential for landslide in the AHP or LR method. In the AHP method, the potential for landslide in the type A zone is generally dominated by a slope of 30% to more than 40% at an altitude above 2000 meters above sea level and in the type B landslide zone is generally in the potential category of intermediate with a slope of 21% to more than 40% with an altitude of above 500 meters to 2000 meters. In the LR method, the relationship with the results of the potential landslide to the landslide potential zone is related to the slope of 30% to more than 40% at an altitude above 2000 meters above sea level and in the type B landslide zone is generally in the potential category of intermediate with a slope of 21% to more than 40% with an altitude of above 500 meters to 2000 meters. Types of landslides based on their occurrence points in the study area are soil types with soil creeping, reshuffle material flows, rock collapses, rotational and translational avalanches.

5.4 Confusion Matrix

The validation of the results was obtained that the validation value of the LR method was better than the method This was due to the value of the consistency ratio (CR) of the AHP method of this study was 8.9%. This causes the consistency ratio (CR) value to be close to the threshold of data consistency value (10%). This is due to the determination of the score and priority weight of the AHP method determined by the author based on the consideration of geologists in the field of landslide without paying attention to the statistical approach, which causes the AHP method in this study to have a data bias on the potential results of landslide of the AHP method. So that the results of the AHP method are not good compared to the LR method which uses the principle of statistical processing in data processing. Thus, the LR method to be better than the AHP method.

5.5 Comparison

Based on the results of data processing of the AHP method, the distribution of the potential area of landslide using the AHP method was obtained in the low category with an area of 39.592 km² with a percentage of 38.99%, the medium category with an area of 39.690 km² with a percentage of 39.09% and a high category with an area of 22.253 km² with a percentage of 21.92%. In the LR method, the potential for landslide was obtained in the low category with an area of 39.158 km² with a percentage of 38.5%, the medium category with an area of 39.485 km² with a

Table 9. Comparison of the potential landslide area (km²) based on the AHP and LR methods.

No	District	Village	Analytical Hierarchy Process (AHP)			Logistic Regression (LR)		
			Low	Moderate	High	Low	Moderate	High
1	Ciawi	Bojongmurni	0.972	4.155	2.766	1.025	3.749	3.126
2	Ciawi	Cibedug	0.816	1.693	0.496	0.976	1.496	0.537
3	Ciawi	Cileungsi	0.217	1.420	1.632	0.261	1.032	1.981
4	Ciawi	Citapen	-	-	-	-	-	-
5	Ciawi	Jambuliwuk	-	-	-	-	-	-
6	Cisarua	Batulayang	0.677	0.253	0.083	0.717	0.295	0.001
7	Cisarua	Cibeureum	4.292	3.199	0.911	4.814	2.955	0.637
8	Cisarua	Cilember	2.270	0.659	0.057	1.736	1.237	0.013
9	Cisarua	Cisarua	2.449	0.163	0.024	2.362	0.273	0.000
10	Cisarua	Citeko	3.469	1.760	0.124	3.671	1.600	0.082
11	Cisarua	Jogjogan	2.602	1.147	0.228	1.789	1.991	0.198
12	Cisarua	Kopo	3.800	2.697	0.101	3.805	2.758	0.036
13	Cisarua	Leuwimalang	1.181	0.071	-	1.148	0.105	-
14	Cisarua	SouthTugu	5.465	4.092	6.131	5.724	2.607	7.387
15	Cisarua	NorthTugu	1.890	3.646	3.011	1.986	4.344	2.227
16	Megamendung	Cipayung	0.430	0.155	0.021	0.399	0.207	0.001
17	Megamendung	Cipayunggirang	0.812	0.053	0.006	0.778	0.093	-
18	Megamendung	Kuta	2.658	2.822	0.200	2.864	2.665	0.150
19	Megamendung	Megamendung	0.923	6.616	5.446	0.566	6.882	5.539
20	Megamendung	Sukagalih	1.763	1.966	0.270	1.766	1.984	0.248
21	Megamendung	Sukakarya	0.852	0.876	0.061	0.763	1.017	0.015
22	Sukamakmur	Sukamaju	0.018	0.034	-	0.012	0.042	0.000
23	Sukamakmur	Sukamanah	0.852	0.256	-	0.809	0.295	0.005
24	Sukamakmur	Sukaesmi	1.152	1.505	0.379	1.151	1.429	0.456
25	Sukamakmur	Sinajaya	0.023	0.067	0.020	0.013	0.066	0.033
26	Sukamakmur	Wargajaya	-	0.025	0.010	-	0.022	0.014
27	Caringin	Cimande	-	0.003	-	0.001	0.003	-
28	Caringin	Pancawati	0.010	0.359	0.275	0.023	0.339	0.284
	Total		39.592	39.690	22.253	39.158	39.485	22.967
	Percentage		38.99%	39.09%	21.92%	38.50%	38.86%	23.00%

percentage of 38.86%, and the high category with an area of 22.967 km² with a percentage of 23%.

The validation results in using the confusion matrix technique in these two methods. In comparing the results of the confusion matrix by comparing the results of overall accuracy and Kappa Coefficient (KC) and paying attention to user accuracy, producer accuracy and additional validation with PVMBG data as supporting validation obtained through previous research. In the AHP method, the overall accuracy was 78.64% and the Kappa Coefficient (KC) was 0.64 so that based on the overall accuracy it was included in the good category, while the LR method obtained an overall accuracy of 86.41% and a Kappa Coefficient (KC) of 0.75 so that based on the overall accuracy it was included in the very good category. In addition, additional validation was carried out with PVMBG data as a supporting validation obtained through previous research that the recapitulation of the occurrence points of landslide occurred more in areas that occurred in the potential for dominant high landslide occurred in the LR method as many as 11 events while in the AHP method only 9 events occurred. So that makes the LR method better than AHP. This is due to the value of the consistency ratio (CR) of the AHP method of this study is 8.9%. This causes the consistency ratio (CR) value to be close to the threshold of data consistency value (10%). This is due to the AHP method in this study there is a data bias on the potential results of landslide of the AHP method. So that the results of the AHP method are not good compared to the LR method.

Compared with relevant research in similar topics, our result indicate LR is more reliable than AHP. (Do et al., 2020; Park et al., 2013; Pourghasemi et al., 2013). On the other case, AHP is better than LR (Bourenane et al., 2016; Kavzoglu et al., 2014). However, in our case, LR is more reliable and this utilization of various methods for identifying landslides will be suitable differently according to certain geological and other factor situations (rainfall, slope, lithology, land use, soil type, proximity to rivers, NDMI, EVI and road cutting the slope).

6. Conclusion

The distribution of the potential area of landslide in this study by the Analytical Hierarchy Process (AHP) method produced a low category with an area of 39.592 km² with a percentage of 38.99%, a medium category with an area of 39.690 km² with a percentage of 39.09% and a high category with an area of 22.253 km² with a percentage of 21.92%. Meanwhile, in the Logistic Regression (LR) method, the potential for landslide with a low category potential with an area of 39.158 km² with a percentage of 38.5%, the medium category with an area of 39.485 km² with a percentage of 38.86%, and the high category with an area of 22.967 km² with a percentage of 23%.

The village with an area with a high category vulnerability with the Analytical Hierarchy Process (AHP) method, the first is South Tugu Village with a potential area of landslide with a high category of 6.131 km². Then the second village is Megamendung Village with a potential landslide area with a high category of 5.446 km² and the third is North Tugu Village with a potential for land movement with a high category of 3.011 km². Meanwhile, in the Logistic Regression (LR) method, South Tugu Village was obtained with a potential area of landslide with a high category of 7.387 km², then the second was Megamendung Village with a potential area of landslide with a high category of 5.539 km² and the third was Bojongmurni

Village with a potential for landslide was Bojongmurni Village with a high category of 3.126 km².

The best method in determining the potential for landslides in the research area is the LR method. This is because the LR method obtained an overall accuracy of 86.41% and a Kappa Coefficient (KC) of 0.75 so that based on the overall accuracy and Kappa Coefficient (KC) is included in the good category while the AHP method produces an overall accuracy of 78.64% and a Kappa Coefficient (KC) of 0.64 so that based on the overall accuracy it is included in the good category and carried out additional validation with Center for Volcanology and Geological Hazard Mitigation (PVMBG) data as a supporting validation was obtained through previous research, the recapitulation of the occurrence point of landslide occurred more in areas that occurred in the potential for dominant high landslide occurred in the LR method as many as 11 events while in the AHP method only 9 events occurred

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