International Journal of GEOMATE, May, 2020, Vol.18, Issue 69, pp. 254 - 261
ISSN: 2186-2982 (P), 2186-2990 (O), Japan, DOI: https://doi.org/10.21660/2020.69.71522
Geotechnique, Construction Materials and Environment

DETERMINATION OF LAND COVER AS LANDSLIDE FACTOR BASED ON MULTITEMPORAL RASTER DATA IN MALANG REGENCY

*Abdul Wahid Hasyim[1], Hyang Iman Kinasih Gusti[1] , Gunawan Prayitno[1]

[1]Urban and Regional Planning, Brawijaya University, Indonesia

*Corresponding Author, Received: 25 Oct. 2019, Revised: 28 Nov. 2019, Accepted: 06 Feb. 2020

ABSTRACT: Malang Regency is one of the regency administration areas in East Java Province. The complex physical condition of Malang Regency, especially its land reliefs accompanied by high rainfall, causes Malang Regency obtain floods and landslides frequently. Based on the BPBD data in 2017, it is stated that around 80% of Malang Regency is disaster-prone area of floods and landslides, especially in the southern part of Malang Regency. This is caused by several natural factors, one of which is slope, and human factors called changes in land cover. This study aims to examine the land cover factors that influence the extent of landslides that occur in the Southern Malang Regency. The independent variable used is builtup area, dense tree vegetation, vegetation of rare trees, shrubs, grass, open space, slope, and distance. Based on the results of multiple linear regression analysis, it can be concluded that the builtup area cover with coefficient value 0.062 and open space with coefficient value 0.020 are variables that are directly proportional to the area of the landslide that has a higher percentage of the area of land cover being built and open, the area of landslides will increase, while the variable cover of vegetated land has properties inversely proportional to the extent of landslides which means that it can reduce the extent of landslides if the percentage of vegetated land cover increases.

Keywords: Landslide Deliniation, Landslide Factors, Remote Sensing, Multiple Linear Regression

1. INTRODUCTION

Malang Regency is an administrative area that has a very diverse physical condition compared to other district administrative regions in East Java. The complex physical condition of Malang Regency, especially its land relief, causes Malang Regency to often experience catastrophic events such as floods and landslides [1]. Based on the BPBD data in 2017 [2], it is stated that more than 80% of Malang Regency is a disaster-prone area, often landslides, especially in the southern part of Malang Regency which are the most frequently affected by floods and landslides. The factors that cause landslides are natural factors and human factors. Natural factors can be in the form of soil type, contour conditions, rainfall intensity, and human factors, namely, especially the development of land use changes which causes the built up land cover to increase and vegetation land cover decreases [3].

The high rate of population growth and improvement of infrastructure from year to year has caused the rate of land use growth to grow rapidly [4] and indirectly will reduce some of the variables inhibiting landslide disasters such as vegetation areas. If these variables are reduced, the water will easily seep in the soil and will affect the soil structure more easily and cause landslide disasters on land that has a certain slope [5].

In this study aims to examine the land cover factors that most influence the vulnerability of landslides in Malang Regency by using remote sensing method, where data acquisition is done by processing satellite images which then produce the data needed in the study.

2. MATERIAL AND METHOD

2.1 Delineation

Delineation of the location and extent of landslide disasters is based on information supporting data such as landslide events and the results of multi temporal comparative analysis of raster data that are corrected radiometrically and geometrically using difference multilayer of raster method or what is called land cover change analysis with multi temporal raster analysis.

The raster data used is sentinel 2A raster with the acquisition date of 09/18/2017 for data before the landslide and sentinel raster 2A with acquisition date 31/05/2018 as data after landslides.

2.2 Establishing Data Sampling Area Grid

The grid used is a square field that has the same side size using a standard size reference that is 1 sq. Km in accordance with the Regulation of the Director

General of Conservation of Natural Resources and Ecosystem Number: P. 11 / Ksdae / Set / Ksa.0 / 09/2016 [6]. Grid creation is done using ArcGIS software with Create Fishnet feature which will be carried out by the grid selection process.

2.3 Land Cover

The land cover classification of the Southern Malang Regency processed with the scope of the area affected in 41 grids of data sampling area. Image processing is carried out using supervised classification method that relies on training sample area processing as a basis for classifying land cover. Guided classification is carried out using a process of maximum likelihood classification based on statistical assumptions adopting training area samples in accordance with the observations of the researchers on the field [7].

2.4 Land Slope

In this study the slope of the slope is obtained from the results of the Sentinel 2A raster image processing process with the date of acquisition 18/09/2017 (the date before the landslide event) by using the create slope from raster feature in ArcGIS software to produce slope raster output with a level of accuracy in units level. Slope data is used as independent variable data in multiple linear regression analysis to determine the effect on the extent of landslides caused. Land slope is one of the most influential factors in landslides in Southern Malang Regency [1].

2.5 Analysis of The Effect of Land Cover Types on Landslide Areas

To find out how much influence land cover, land slope, and distance to landslide extend, it needs to be analyzed using multiple linear regression analysis. Before starting multiple linear regression analysis it is necessary to do a classic assumption test to determine whether the data to be tested has a problem or not [8]. After that, a feasibility test will also be carried out to determine whether the model is feasible or not used to predict the dependent variable.

3. RESULT AND DISCUSSION

This research area is more focused on the Southern Malang Regency Area. The South Malang Regency is 33 km from the center of Malang City. Astronomically, the study location is located between 8027‘43.40 - 8011‘32.40 LS and 112021‘26,53 BT - 112057‘36,90 BT. South Malang Regency consists of 9 sub-districts, namely the Districts of Donomulyo, Kalipare, Pagak, Gedangan, Bantur, Sumbermanjing Wetan, Dampit, Tirto Yudo and Ampel Gading. The area of this study is 1173.74 km² or 117374 ha.

3.1 Deliniation

Both of raster will be processed by difference change analysis with using some ArcGIS features. The result of this process can be seen in Fig.3. This analysis requires band 8 channel for each sentinel raster. Because band 8 contains the highest infrared waves and is very informative in order to know the character of the earth's surface [9].

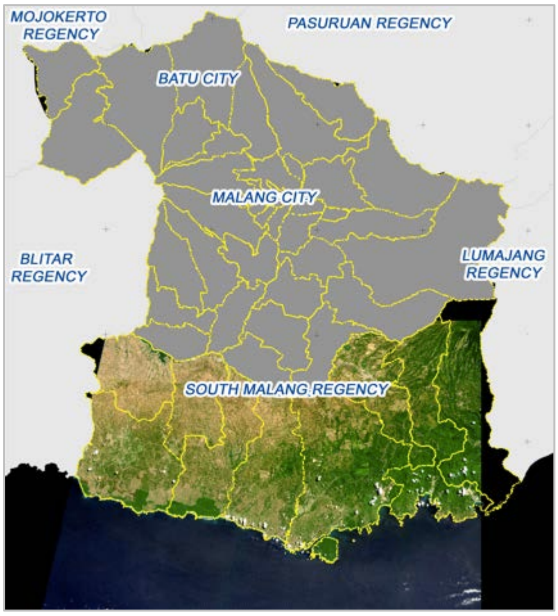

Fig. 1 Sentinel Raster 2A (09/18/2017)

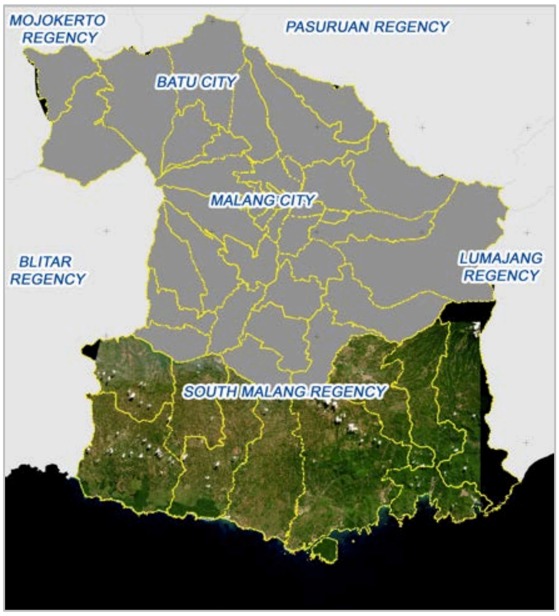

Fig.2 Sentinel Raster 2A (31/05/2018)

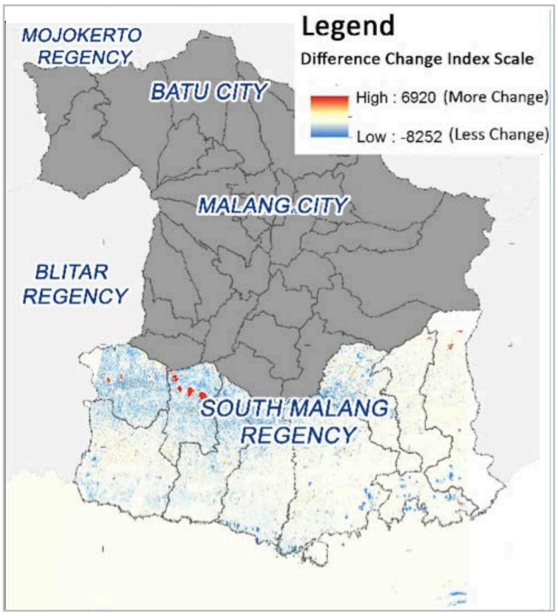

Fig. 3 Difference Change Analysis Output

Based on Fig. 3 it can be concluded that there are many pixel changes. The detection of land cover changes is spread in various locations and sub-districts which have the most extensive land cover changes marked in red. To determine the location point of the change so that it can be delineated as the location and extent of landslides [10]. An analysis is needed to compare the results of the analysis of land cover changes with information on landslide events. Two of 6 results of elimination and determination of points and locations of landslides can be seen in Fig.4 and Fig.5.

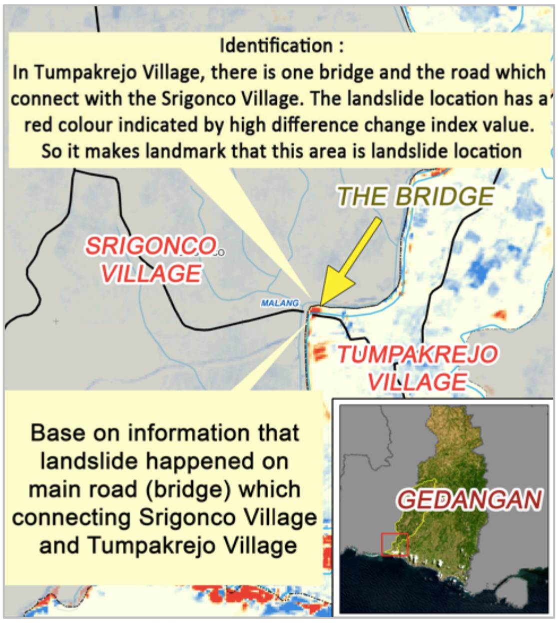

Fig.4 One of Landslide Deiniation Justification in Arround Tumpakrejo Village Bridge

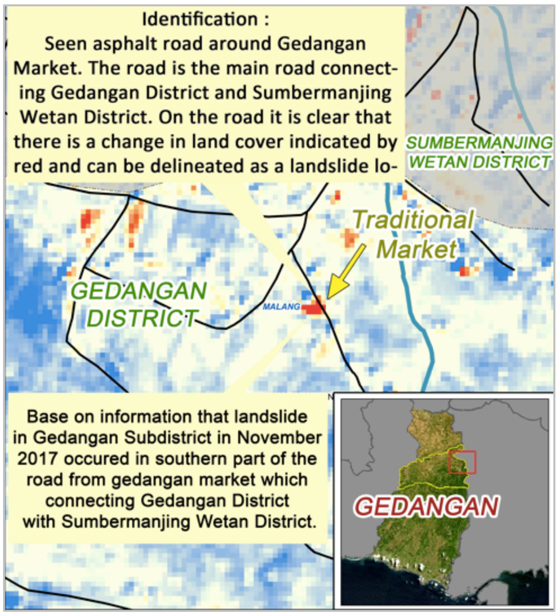

Fig.5 One of Landslide Deliniation Justification in Around Gedangan Market.

Table 1 Deliniation Of Landslide Areas

Location	Time	Area (ha)
Bridge on the southern connecting road between Tumpak Rejo Village and Srigonco Village, Bantur District	January 2018	0,316
The connecting road between Ringinsari Village RT 12 RW 10 Sidodadi Village and Gedangan Village, Gedangan District.	October 2017	0,723
Bridge on the western connecting road between Ringin Sari Village and Gedangan Village, Gedangan District.	19 October 2017	0,041
Connection access to Gedangan Subdistrict with Sumbermanjing Wetan in the southern part of Gedangan Market location.	November 2017	0,214
Connection access between Gedangan Village and Ringinsari Village,	November 2017	0,154

Location	Time	Area (ha)
Sumbermanjing Wetan Subdistrict, south. The main road connecting the Segaran Village with the Ringinsari Village Sumbermanjing Wetan District.	November 2017	0,023

3.2 Establishing Data Sampling Area Grid

From the process making of the grid with following the Regulation of the Director General of Conservation of Natural Resources and Ecosystem Number: P. 11 / Ksdae / Set / Ksa.0 / 09/2016 [5], The grid selection results are obtained as many as 41 grids where each delineation point of location and area of landslides has 9 grids. In these 9 grids, 1 grid is the grid center or center, while the other 8 grids are the first layer skin grid of the central grid, but there are several similar grids in the first layer of each landslide center grid, so the total grid is not 9 grid multiplied by 6 points of landslide which results in 54 grids, but only 41 grids. Result of determining the grid location are obtained 2 zones.

3.3 Land Cover of Grid Data Sampling Area

The land cover classification in the grid area is can be seen in Fig.6 and Fig.7. The process of classification of land cover is only carried out on the surface contained in the grid data sampling.

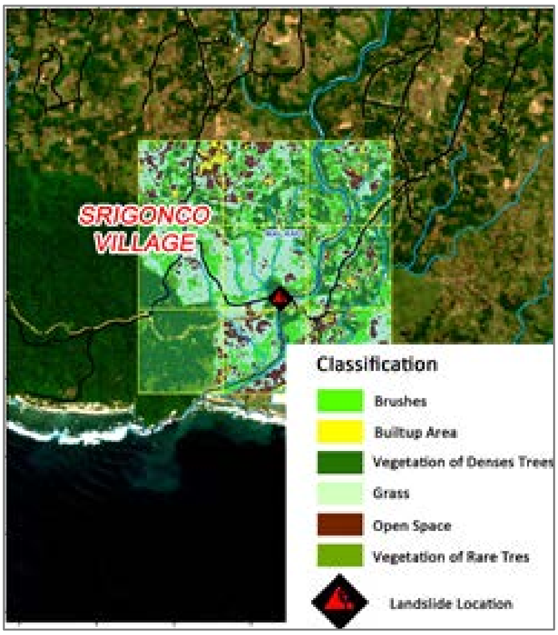

Fig.6 Land Classification Zone 1

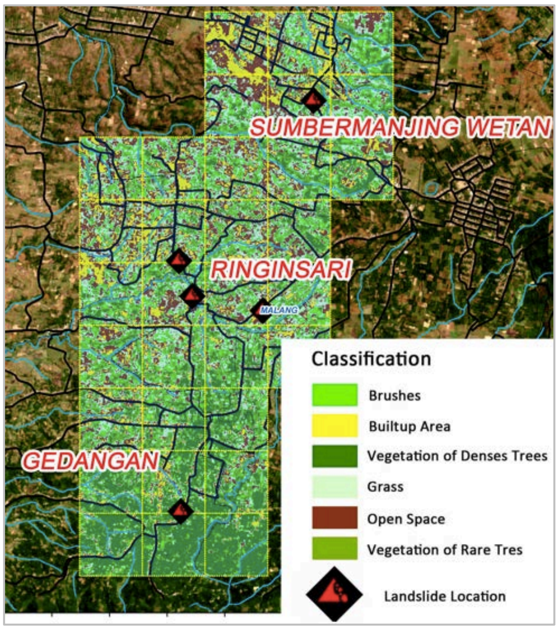

Fig.7 Land Classification Zone 2

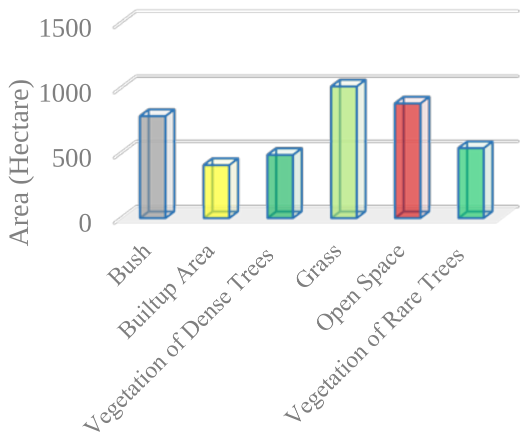

Fig. 8 Graphic of Land Cover Area (Hectare)

Based on Fig.8 it can be concluded that the most dominating land cover in the grid area is the grass land cover of 1276.1 hectares where the grass is spread around the hills and around the built area. Whereas the least extensive land cover is the builtup area cover that is 544,727 hectares which is distributed mostly on the grid which is included in the administration area of Druju Village, Sumbermanjing Wetan Subdistrict. But, the open space is one of the types of land cover which has unaccurated detection because on this land may some vegetation are exist but has lower vegetation frequency index. The difference in statistical values contained in spatial results of raster will be used to determine the value of the effect of land cover in the grid area on the landslide area inside. This is based by locations and characters of landslides are affected by the function and type of land cover around it [11].

3.4 Land Slope

The slope map can be seen in Fig. 9 and Fig.10. Both of maps have more details of land slope range.

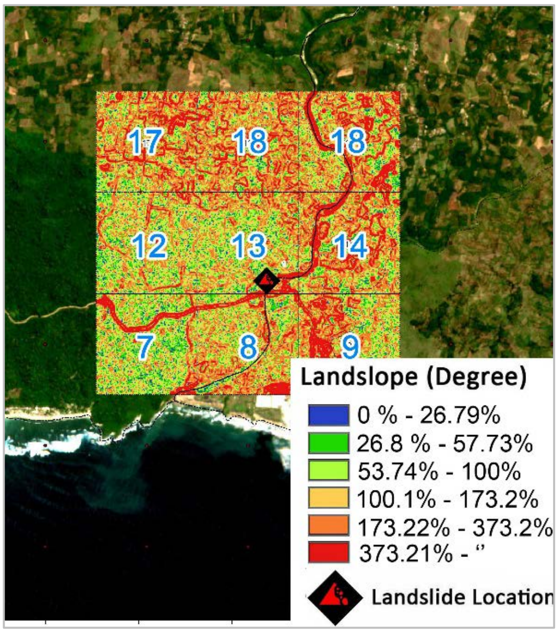

Fig.9 Land Slope Zone 1

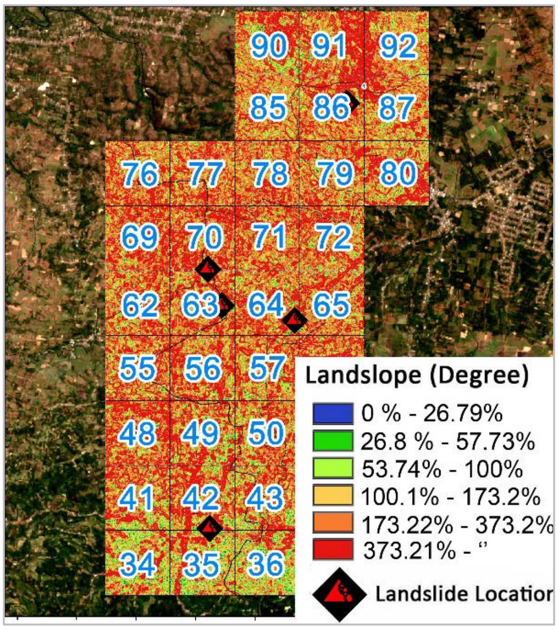

Fig.10 Land Slope Zone 2

Based on Fig.9 and Fig. 10, the data generated in the process that dominates the slope level in the grid area is a range of 373.21 % to 90 ° where the range has 126884 pixel elements scattered in various areas. Whereas the slopes range of 173.21% to 373.2 % is the second highest quantity of slope after a range of 373.2 % to 90 °. Different land slope characters also determine the condition and character of landslide events technical [12].

3.5 Calculation of the Center Point of the Grid to the Center of the Deliniation of Landslides

Based on the measurement results it can be seen that the value of the grid distance to the landslide center point which is the center is very diverse.

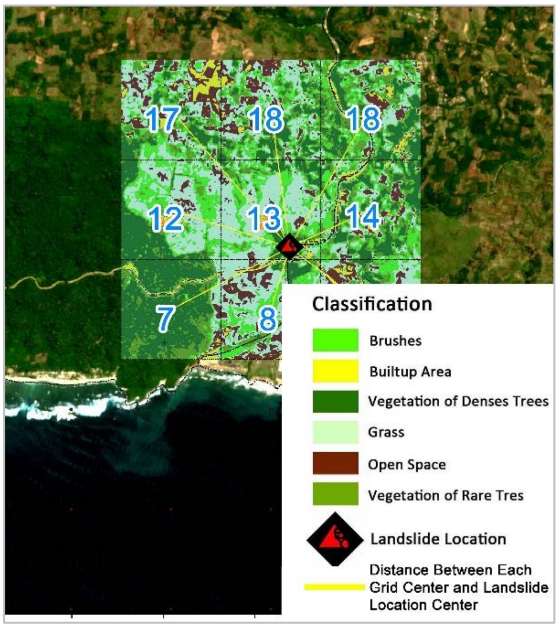

Fig.11 Distance of The Center of The Grid to The Center of The Deliniation of Landslides (Zone 1)

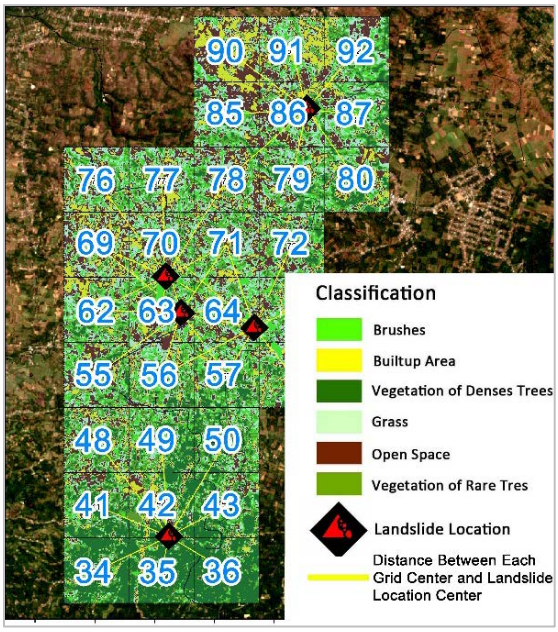

Fig.12 Distance of The Center of The Grid to The Center of The Deliniation of Landslides (Zone 2).

3.6 Analysis of the Effect of Land Cover Types on Landslide Areas

Before carrying out multiple linear regression analysis, a pre-analysis process needs to be carried out namely the classical assumption test which is a pre-analysis data test method consisting of normality test, multicollinearity test, heteroscedasticity test, and autocorrelation test. After testing the classic assumptions it is necessary to test the feasibility of the model to test the model is feasible or not to be used in predicting and the model used will be more accurate and precise.

3.6.1 Normality Test

The result of normality test in SPSS software can be seen in Table 2. This test used Kolmogrov Smirnov method.

Table 2 Normality Test Output

	Unstandardized Residual
Kolmogorov-Smirnov Z	1.349
Asymp. Sig. (2-tailed)	0.053

Based on the results of the Sminorv Kolmogrov test presented in Table 2 using SPSS, it can be known that the research data is normal distribution, this is indicated by all sig values exceeding 0.05.

3.6.2 Multicolinearity Test

The multicollinear test in this study used the VIF value in SPSS output analysis, as shown in Table 3.

Table 3 Output Of Multicollinearity Test

Variables	Collinearity Statistics	
	Tolerance	VIF
Bush	0,015	8.628
Builtup Area	0,008	1.543
Vegetation of Dense Trees	0,001	8.917
Grass	0,005	9.140
Open Space	0,003	0.770
Vegetation of Rare Trees	0,011	7.620
Distance	0,893	1.120
Slope of Grid Center	0,760	1.315
Slope of Landslide Center	0,778	1.286

Based on Table 3, it can be seen that the VIF (variance inflation factors) value for all predictor variables is less than 10, so that the independent variables used are protected from the problem of multicollinearity.

3.6.3 Heteroscedacity Test

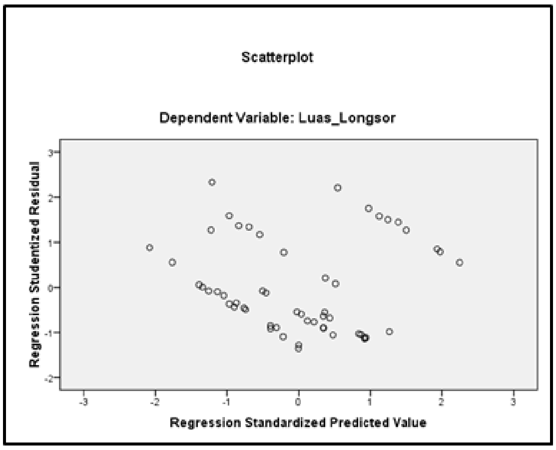

Fig. 13 Scatter Plot of Heteroscedaticity Test

Based on the results of the heteroscedasticity test using scatter plot method in Fig.7, it can be seen that the plots displayed spread irregularly in various directions and do not form a particular pattern. So that it can be said that the data does not experience heteroscedasticity problems.

3.6.4 Autocorrelation Test

Table 4 Output Of Durbin Watson Method Test

Model	R	R Square	Durbin-Watson
1	0,711	0,705	0,567

Based on Table 4 the model summary can be seen that the value of Durbin Watson is 0.576. Figure 6 is compared with the Durbin Watson table with the limits of the dL and dU values on the number of samples n = 54 and the number of variables or n = 7 included in the class there is no autocorrelation problem.

3.6.5 Model and Feasibilty Test

Based on the results of the feasibility test the model was obtained that :

1. The sig anova value is 0,000 which means it is smaller than the significance level of 5% or 0.05 so it can be concluded that the regression model is worthy of use.
2. In the results of the data t test all independent variables have a prob..t value less than the significance value of 5% or 0.05, which means that all independent variables have a significant influence with a 95% confidence level on the dependent variable

3. The R Square value of the test results is 0.705. The remaining amount of 29.5% (100% - 70.5%) is a variable that actually affects the extent of landslides but not in the model.

The model produced from multiple linear regression analysis is as follows:

$$Y = -0{,}032 + (-0{,}040)\ X1 + (0{,}062)\ X2 + (-0{,}063)\ X3 + (-0{,}024)\ X4 + (0{,}020)\ X5 + (-0{,}051)\ X6 + (-0{,}001)\ X7 + (0{,}070)\ X8 + (0{,}092)\ X9 \quad (1)$$

Information :
Y = Landslide Area (km²)
X1 = Bush (%)
X2 = Builtup Area (%)
X3 = Vegetation of Dense Trees (%)
X4 = Grass (%)
X5 = Open Space (%)
X6 = Vegetation of Rare Trees (%)
X7 = Distance (km)
X8 = Slope of Grid Center (%)
X9 = Slope of Landslide Center (%)

Based on the model Eq. 1 , it can be interpreted that the constructed land variable is the land cover variable which has the highest positive value, which is the coefficient value is 0.062. Positive direction means that if the land is built up, it will cause the landslide area to increase as well, in other words the two variables are positively proportional. While the variable vegetation of dense trees is a variable that has the highest negative value of -0.063 which means that the higher the percentage of broad vegetation of dense trees, the more widespread avalanches will result. This is certainly in accordance with the theory in general that the more or more areas that have very dense tree vegetation, the stronger the area will not be eroded by rainwater so that it will not be easily eroded. The slope variable in the model has a different coefficient value but remains in the same direction that is positive with coefficient value of slope of grid center is 0,070 and coefficient value of slope of landslide center is 0,092, which means that the greater the slope percentage, the larger the landslide area produced.

4 CONCLUSION

The largest area of landslide delineation is the location of landslides on the connecting road between Ringinsari Village RT 12 RW 10 Sidodadi Hamlet and Gedangan Village, especially on the southern connecting bridge which is 0.723 hectares or 0.00723 km². While the smallest landslide area is on the bridge on the connecting road between Ringinsari Village and Gedangan Village in Gedangan Subdistrict, which is 0.041 hectares or 0.000411 km². The possibility of extensive landslides is due to the large amount of vegetation that covers the land in the form of shrubs, grasses, and trees.

Based on the results of multiple linear regression analysis, it can be concluded that the builtup area as X2 with coefficient value 0,062 and open land as X5 with coefficient value 0,020 is a variable that is directly proportional to the area of the landslide. If the value of percentage of builtup area and open space are higher, so that the area of landslides would increase, while the variable of vegetated land cover has properties are inversely proportional to the extent of landslide area which means that it can reduce the extent of landslides if the percentage of vegetated land cover increases. The highest coefficient value of vegetation land is vegetation of dense trees as X3 with the value is -0,063. Between all independent variables there are two variables which has highest coefficient value even higer than land cover coefficient value, that are slope of grid center as X8 with the value is 0,070 and slope of landslide center as X9 with the value is 0,092, so they can influence more a lot landslide extend area.

5 REFERENCES

[1] Maulana E ; Wulan T. 2015. Multi-Hazard Mapping of Southern Malang Regency Using a Landscape Approach. PUSPICS Faculty of Geography. Gajah Mada University. Yogyakarta. Page 13

[2] Disaster Management Agency of Malang Regency, 2017. Landslide Disaster Data in 2017. Malang Regency

[3] Hariklia D. Skilodimou, George D. Bathrellos, Efterpi Koskeridou, Konstantinos Soukis, and Dimitrios Rozos. 2018. Physical and Anthropogenic Factors Related to Landslide Activity in the Northern Peloponnese, Greece. Licensee MDPI, Basel, Switzerland.

[4] Snover, A.K, G.S. Mauger, L.C. Whitely Binder, M. Krosby, and I. Tohver. 2015. Climate Change Impacts and Adaptation in Washington State. State of Knowledge Report prepared for the Washington State Department of Ecology. Climate Impacts Group, University of Washington, Seattle. Section 5 Page 9

[5] Regulation of The Director General of Conservation of Natural Resources and Ecosystem Number: P. 11 / Ksdae / Set / Ksa.0 / 09/2016. 2016. Technical Instructions For Development Of Management Zone Or Block Management Plan For Natural Asylum Areas And Natural Preservation Areas. Ministry of environment and forestry. Jakarta. Page 6

[6] Dony K. 2017. Digital Classification of Remote Sensing. IPB Press. Bogor City.

[7] Janie D. N. A. 2012. Descriptive Statistics and Multiple Linear Regression with SPSS. Accounting Department, Faculty of Economics. Semarang University. Semarang, Central Java.

[8] Yingjie L; Jing C; Qingmao M; Jane L. 2018. Evaluation of Sentinel-2A Surface Reflectance Derived Using Sen2Cor in North America. Researchgate.

[9] Yuanyuan Q; Ping L; Zhongbin L. 2018. Landslide Inventory Mapping From Bitemporal 10m Sentinel 2 Images Using Change Detection BasedMarkov Random Field. The International Archives of The Photogrammetry, Remote Sensing, and Spatial Information Science, Volume XLII. Beijing, China. Page 3.

[10] Hasyim AW, Sianturi REP, Hidayat Ar. T, 2019, Spatial Pattern of Land Cover Change in The Coastal Area of Gresik Regency, Indonesia Using Land Change Modeler, October 2019, IOP ConferenceSeries Earth and Environmental Science.

[11] Priyono. 2015. Relationship between Landslide Classification, Landslide Prone Classification, and Agriculture Landslide Prone Classification. Faculty of Agriculture, Slamet Riyadi University. Surakarta. Page 3