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# Analysis of Landslide Factors in Argosari Village, Senduro Sub-District, Lumajang District, East Java, Indonesia

**Amanda Rakhmi Karunia,[1] Yushardi,[2] Mohamad Na'im,[3] Agus Fawait,[4] Suheri,[5]**
*[1]Master Program of Social Science Education, Faculty of Teacher Training and Education, Universitas Jember*
*[2]Lecturer of Faculty of Teacher Training and Education Universitas Jember*
*[3]Lecturer of Faculty of Teacher Training and Education Universitas Jember*
*[4]Lecturer of Educational Management STAI At-Taqwa Bondowoso*
*[5]Lecturer of Educational Management STAI At-Taqwa Bondowoso*
*amanda.rakhmi@yahoo.com - agusfawaid87@gmail.com - heryvirgo83@yahoo.com*

***Abstract***
*Argosari village is a tourist village in Lumajang regency that often occurs landslide disaster. The purpose of this study is to describe and analyze the main factors causing landslides in Argosari Village. To answer the research objectives, there are 2 approaches, namely (1) to identify the causes of landslide factors. (2) Determination of the main cause of landslide is done by main component analysis method. The main factors that have an influence in the causes of landslides are the factors of soil depth and land use. The agroforestry system is an effective cultivation system for farmers of Argosari Village to keep the soil structure in minimizing landslide disaster.*

**Keywords:** *Landslide, Major Component Analysis*

## I. INTRODUCTION

Indonesia is a country rich in natural resources. Geogfrafis and geodynamic position Indonesia has placed our homeland as one of the areas prone to natural disasters. Natural disaster is a natural phenomenon that has the potential to damage or threaten human life, loss of property, loss of livelihood, and environmental damage. Argosari village is a tourist village located in the hilly area of Mount Bromo which is located at an altitude of 2000 mdpl, where in Argosari Village there is a rising tourist attraction that peak b29 Lumajang or better known as the country above the cloud. In Argosari Village there are many steep slopes with a slope of nearly 80 ° that is transformed into agricultural land by local people. Plantation residents in the form of vegetable crops such as leek, cabbage, potatoes, carrots, and chillies that form a sloping plot adjusting the contours of hilly land is the main attraction of this region.

However, the farming pattern of Argosari Village farmers on the steep slopes is not in accordance with the rules of soil conservation. Vertical cropping pattern is applied to vegetable land in hilly hills. The cropping pattern is prone to trigger a landslide. In addition, when the rainfall is high, the contours of the soil are also unstable so it is easily eroded down and can cause landslides.

Many other factors capable of causing longter land disasters include: a). due to continuous rain (at Purworejo in 2001, Bohorok in 2003, Gowa in 2004, Banjarnegara 2006); b). due to tsunami waves in Aceh at the end of 2004; c). due to the Yogyakarta earthquake of 2006; d). due to lava flows several times by Mount Merapi, Kelud, Semeru and others. However, regardless of the mechanism and material type, the movement of landslide material among others is due to the disturbance of the stability of the slope (Surono, 2003).

The occurrence of landslide in Argosari Village, Senduro Sub-district, Lumajang District can be caused by more than one factor interacting (affecting) and characteristic (specific). By conducting a case-by-case investigation to find out the cause of landslide in Argosari Village, Senduro Sub-district, Lumajang Regency, it is hoped that a conclusion can be found to provide accurate information about the cause of landslide in Argosari Village, Senduro Sub-District, Lumajang Regency.

Identification of factors causing landslides in Argosari Village is important to do because: (1) Argosari Village is an interesting village to be studied and is a tourist destination that is currently interested wisatwan for now. To increase the tourist attraction and increase the income of the area it is necessary for disaster risk reduction efforts (especially longosr land disaster) in the tourist destination. (2) Agricultural products Argosari Village has become a vegetable producing center for Lumajang area evidenced by agricultural products able to penetrate supermarkets, modern stores,

and markets outside the city (3) Most people Argosari Village, District Senduro, Luamajang District work as farmers and farm laborers and if the farmland is damaged by landslide, it will decrease the income of farmers or even have no income at all. This study aims to analyze and describe the main factors causing landslide disaster in Argosari Village. It is expected that this research can provide the right policy for government in disaster mitigation efforts in Lumajang Regency, especially Argosari Village, additional information about the main factor causing landslide, so that the villagers argosari can anticipate and reduce the impact of disaster.

## II. RESEARCH METHODS

Various factors suspected to be the cause of the landslide were identified and analyzed. In addition to the results of the investigation, interviews with local residents were conducted to obtain information to describe the typology of landslides that occurred in the study area. Next determine the factors that cause landslides. These factors include: soil depth ($V_1$), soil color ($V_2$), erosion ($V_3$), soil texture ($V_4$), vegetation density ($V_5$), slope length ($V_6$), slope ($V_7$), ($V_8$), and conservation efforts ($V_9$).

From the total data that has been collected then determined the most influential factors and eliminate the factors that have the lowest correlation using the main component analysis method with the help of software SPSS Version 24. Selection of observed variables is based on the condition of research sites that often experience the occurrence of landslides. Determining the value (score) of each variable used in the identification and determination of factors causing landslides.

## III. RESEARCH RESULT

Based on the results of principal component analysis or Principal Component Analysis (PCA) on the 9 factors causing landslides it is known that KMO (Kaiser-Meyer-Olkin) test results were twice under 0.50 which means that data cannot be done factor analysis. Should look at the anti-image matrix to determine which variables should be removed in order to perform factor analysis.

The result of anti-correlation indicates that soil texture variable ($V_4$) is first split in the analysis because it has the smallest correlation value of 0.77 and vegetation state ($V_5$) is the second variable discarded in the analysis because it has the smallest correlation value of 0.140. Therefore, soil texture and vegetation variables are excluded from the analysis and will only perform factor analysis with soil depth variables ($V_1$), soil color ($V_2$), erosion ($V_3$), slope length ($V_6$), slope ($V_7$), land use ($V_8$) and conservation efforts ($V_9$). After removing the soil texture ($V_4$) and vegetation state variables ($V_5$), and performing PCA analysis with 7 other factors, it is known that KMO (Kaiser-Meyer-Olkin) condition is 0,555 (above 0,50).

**Table 1. KMO test results (Kaiser-Meyer-Olkin)**

| KMO and Bartlett's Test | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | ,555 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 31,498 |
| | Df | 21 |
| | Sig. | ,066 |

Source: primary data (processed)

Of the 7 variables analyzed the result of computer extraction into two factors (eigenvalue value> 1 becomes a factor). Factor 1 was able to explain 48,720% of variation while factor 2 was only able to explain 24.820% or both factors were able to explain 73.54% variation (in table 2)

**Table 2. Total Variance Explained**

| Total Variance Explained | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation Sums of Squared Loadings | | |
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 3,410 | 48,720 | 48,720 | 3,410 | 48,720 | 48,720 | 2,998 | 42,834 | 42,834 |
| 2 | 1,737 | 24,820 | 73,541 | 1,737 | 24,820 | 73,541 | 2,149 | 30,707 | 73,541 |
| 3 | ,941 | 13,437 | 86,978 | | | | | | |
| 4 | ,534 | 7,631 | 94,609 | | | | | | |
| 5 | ,170 | 2,435 | 97,044 | | | | | | |
| 6 | ,146 | 2,084 | 99,128 | | | | | | |
| 7 | ,061 | ,872 | 100,000 | | | | | | |
| Extraction Method: Principal Component Analysis. | | | | | | | | | |

By looking at table 3. component matrix and table 4. varimax rotated component matrix it is clear that grouped in factor 1 is the depth of soil ($V_1$), slope length ($V_6$), land use ($V_8$), and conservation effort ($V_9$) all with loanding factor above 0.50. While clustering on factor 2 is the depth of soil ($V_1$), erosion ($V_3$) and land use ($V_8$)

Table 3. Component Matrix

| Component Matrix[a] | | |
|---|---|---|
| | Component | |
| | 1 | 2 |
| kedalaman_tanah | ,566 | ,749 |
| warna_tanah | -,563 | ,385 |
| Erosi | ,308 | ,788 |
| panjang_lereng | ,826 | -,340 |
| kemiringan_lereng | -,919 | ,080 |
| penggunaan_lahan | ,870 | ,236 |
| usaha_konservasi | ,628 | -,478 |
| Extraction Method: Principal Component Analysis. | | |
| a. 2 components extracted. | | |

**Source: primary data (processed)**

**Table 4. Rotate Component Matrix**

| Rotated Component Matrix[a] | | |
|---|---|---|
| | Component | |
| | 1 | 2 |
| kedalaman_tanah | ,119 | ,932 |
| warna_tanah | -,680 | ,055 |
| Erosi | -,123 | ,837 |
| panjang_lereng | ,886 | ,114 |

| | | |
|---|---|---|
| kemiringan_lereng | -,838 | -,386 |
| penggunaan_lahan | ,638 | ,636 |
| usaha_konservasi | ,782 | -,103 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

**Sumber : data primer (diolah)**

## IV. DISCUSSION

Based on the description the depth of soil has a contribution in increasing the load on the slope, so that when the load on the slope exceeds its shear resistance, the soil tends to move down. In the study area looks thicker so the more landslide events are found. The highest frequency of landslides is found in the thickness of the soil between 50-100 cm. At the location of the study found 8 cases of landslides in the thickness of the soil between 50-100 cm, whereas in locations with a soil thickness of more than 120 cm occurred 4 cases. This indicates that the thickness of the soil influences the load of the slopes which makes it potentially avalanche. Theoretically, a thick layer of soil on the steep slopes (> 30 °) is very potential to become a landslide especially in the rainy season. Falling rainwater will enter the soil through infiltration and if in the underground layer there is a waterproof part (layer of parent material) then the accumulation of rain water storage will decrease the soil (cohesion) so that with the conditions continue to cause soil shear resistance will be lower than soil shear power ($\mu s < \mu k$)

Another major factor that has an influence in the phenomenon of landslides is the condition of land use, especially vegetable plantations. From the results of this observation it has been seen that landslide events at the highest-frequency research sites are found in vegetable plantations. One of the causes is the large volume of water that is accommodated by the plantation so as to increase the load of the soil, so if the force on the soil is greater than the resistance force, then the ground will move down.

Land use in the research location is divided into several types, namely (1) Forest or Bush, (2) Settlement, (3) Rice Field, (4) Stable or Garden (5) Garden. Topographically, this plantation land is not suitable for agricultural cultivation because of the steep slopes so that the erosion rate is very high.

Settlement is adapted to the conditions of hilly terrain and steep slopes. Residents who want to build a house must cut the slope to obtain a flat plot of land. So that the position of most of the back of the house directly adjacent to the cliff or the slopes that have been cut. The residents' talun garden is usually at the top of the hill and is planted with perennials like pine trees. The type of earth-slides landslides are commonly found in intensive vegetable gardens, as is often the case in the study sites. The highest occurrence of landslide occurred in the vegetable garden as many as 6 cases, mixed gardens as many as 4 cases, landslide occurred in residential areas and infrastructure (cliff road) as much as 2 cases.

The high number of landslide cases in the vegetable garden location should be a lesson that landuse for this activity needs to pay attention to various aspects in order to prevent the occurrence of landslides. The main causes of landslides in vegetable gardens, including slope, soil structure, and high rainfall.

Regional Disaster Management Agency (BPBD) Lumajang regency confirms the planting pattern by utilizing cliffs to grow crops to be one cause of landslides in Hamlet Argosari Atas, Hamlet Gedog, and Hamlet Pasung Duwur. Landslide is due to the pattern of planting that people do too close to the edge of the road. Should plant the plant is not allowed to the edge of the road because the nature of the land on the slopes of Mount Merapi muddy and easy to carry water if exposed to heavy rain. The correct cropping pattern is to keep a distance of 1 meter from the edge of the road.

Meanwhile, a resident of Dusun Argosari Atas, Argosari Village, Senduro Sub-District, Lumajang District, said that the farmland in Argosari Atas Sub-village is very narrow, so farmers have to utilize all existing land including planting up to the edge of the road.

Based on the observation and measurement of 10 landslide points in the research location, then performed statistical analysis to determine the effect of various variables on landslide events. In this case, the response destination variable (Y) is chosen for the landslide zone condition, whereas the predictor variable consists of land use ($V_8$) and soil depth ($V_1$).
By using two predictor variables (predictors) the cause of landslide selected by using PCA analysis method that is land use ($V_8$) and soil depth ($V_1$) then obtained the model of landslide zone regression equation as follows:

$$\mathbf{Y = 3.01 - 0.0580\ V_1 + 0.352\ V_8}$$

Information :
Y: the state of the landslide zone
$V_1$: soil depth
$V_8$: land use

The model of multiple regression analysis shows the response given by the variable of destination, ie Y to various values given to the variable estimator, namely V8 and V1. The value included in this case refers to the value used in measuring a free variable as shown in Table 3.1. Furthermore, from each predictor variable value of the measurement results in the field will be obtained a value that when inserted into the model above will produce a value that will indicate the condition of landslide zones in a region. In this case the value of various predictor variables (free variables) used are also guided by the criteria that have been prepared in research methods.

Each predictor variable in the model gives a real effect on the vulnerability of the landslide zone. Land use (V8) contributes to an increased avalanche risk that may occur in the landslide zone. This increase in slope load can occur in several ways, such as by increasing the volume of water that can be stored in the rainy season. In addition, the soil itself is a burden that can cause the material above the slopes to move down. At the study site, the thickness of the soil that began vulnerable to landslides occurred in the thickness of the soil> 90 cm, where the number of landslide cases found 12 cases.

## V. CONCLUSION

Based on the results and discussion, it can be concluded several things as follows: Based on the analysis of the main factors causing landslides in Argosari Village, District of Senduro, Lumajang Regency, the factors that have influence in the cause of landslide disaster is the soil depth factor ($V_1$) , slope length ($V_6$), land use ($V_8$), conservation effort ($V_9$), and erosion ($V_3$). Those factors that have the highest contribution in the cause of landslide in Argosari Village, Senduro Sub-District, Lumajang Regency are land use ($V_8$) and soil depth ($V_1$). To anticipate the landslide disaster in Argosari Village, Senduro Sub-district, Lumajang Regency, the farmers should apply the land management pattern for the cultivation of plantation plants in accordance with the principle of environmental preservation. The planting system that the authors suggest is the agroforestry system. Agroforestry system is done by mixing planting between agricultural crops with hard crop (such as mountain spruce) is expected to produce high land productivity, so as to improve the welfare of the community. With a combination of seasonal crops and perennials it is desirable (1) Seasonal plants such as leek, cabbage, carrots, and potatoes are capable of generating periodic short-term income. (2) Cultivation of perennials such as mountain pine can provide long-term protection against soil stability, because the roots of perennials capable of gripping the soil may reduce the potential for landslide disasters

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