The effectiveness of community-based early warning system of Kelud volcano eruption 2014

by Eko Teguh Paripurno

Submission date: 24-May-2023 10:33AM (UTC+0700)
Submission ID: 2100547954
File name: 51._020085_1_online.pdf (2.14M)
Word count: 2296
Character count: 12062

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AIP Conference Proceedings 1987, 020085 (2018)
https://doi.org/10.1063/1.5047370

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Landslide Hazard Potency Using DEM-SRTM, Landsat 8, and Aerial Photo, Case Study at Ngawen Regency, Gunungkidul District, Yogyakarta

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Abstract. Landslide is a common natural disaster often happened in Indonesia. Those natural disaster has caused many victims. It can occur because Indonesia has tropic climate, so that the weathering procces does rapidly, and may rain water enters the rock or soil's pores increasing mass of the rock or soil. Lithology and structural geology condition also influence the landslide. The most of area in Indonesia has landslide potential. The research area is located at Ngawen Regency, Gunungkidul District, Yogyakarta. That place consist of ancient volcanic rock such as laharic breccia, andesite lava, tuffaceous sandstone and lapilli. Radial pattern of the fault growth in Ngawen because the procces of ancient volcanic activity. The research methods using remote sensing methods and qualitative methods. Remote sensing methods are interpretation using DEM-SRTM, Landsat 8 and Aerial Photo, while qualitative methods using weighing factor, scoring, and overlay maps. The geological controls of landslide using in the interpretation are lithology, structural geology, geomorphology, slopes and the rate of rainfall. The result of the research is zonation map of landslide potential. The zonation of landslide potential divided into three there are high, medium and safe. The zonation of landslide potential map of Ngawen may help the government to make a mitigation and evacuation plan appropriately.

Keywords : Landslide, Ancient Volcanic Rock, Qualitative Methods, Zonation of Landslide Potential Map, Ngawen

INTRODUCTION

Geology is the knowledge of earth science includes the physical condition and the procces of the rocks. Each area has different geological condition based on the proccesses influenced the area. The knowledge of rocks can be used for mitigation to know about the potential of hazard and disaster mitigation. The research area is located at Ngawen Regency, Gunung Kidul District, Yogakarta. As in a literature study, the research area consist of ancient volcanic rock from the Semilir Formation influenced by vulcanic inflation structure and the limestone of Oyo and Wonosari Formation [1]. Structural control and rock resistance are very influential, in areas with dominant structural control and low rock resistance will result in vulnerable soil susceptible zones that potentially produce landslide [2].

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RESEARCH METHODOLOGY

In this research, the methodogy is divided into four steps, there are literature study, remote sensing and GIS interpretation, and then field check. Literature study used to know the stratigraphic condition of the research area. The stratigraphic condition is the one of the parameter to make a zonation map. The second step is make an interpretation using aerial photo using google earth to know the recent condition and the lineanments of the valley, slope and hills. Those lineanments is important to make a score for the parameter when making a landslide zonation map. The third step is GIS interpretation using the rainfall, slope and landuse data to be comined with the stratigrapic condition and lineanment. After that, each parameter being created based on the main landslide control of the research area. After getting the score, the calculation is used to make a landslide zonation map. The last step is field check that is used to prove the zonation landslide map.

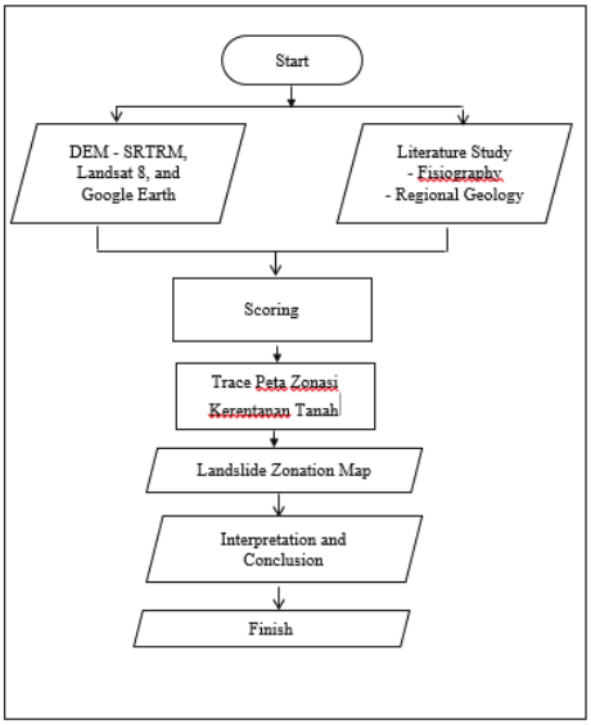

FIGURE 1. Research Methodology's Flow Chart

RESULT AND DISCUSSION

Slope

Slope is one of the factors that cause the potential of landslide. The slope affects the weathering process that develops, because on the slopes with a high slope will allow rain water to flow, the rocks passed water will be more susceptible to weathering process and can reduce the level of rock resistance so that the area has the potential for mass movement. The slope classification that is used is the modification of Van Zuidam (1983) [5].

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TABLE 1. Classification of Slope (Modification of Van Zuidam, 1983)

Slope Rate	Class
> 40 %	Very Steep
25 - 40 %	Steep
15 - 25 %	Rather Steep
8 - 15 %	Sloping
2 - 8 %	Flat
0 - 2 %	-

DEM – SRTM

DEM SRTM is used to know the slope of research area with more detail, DEM SRTM usage can be processed using Global Mapper application with result as shown below.

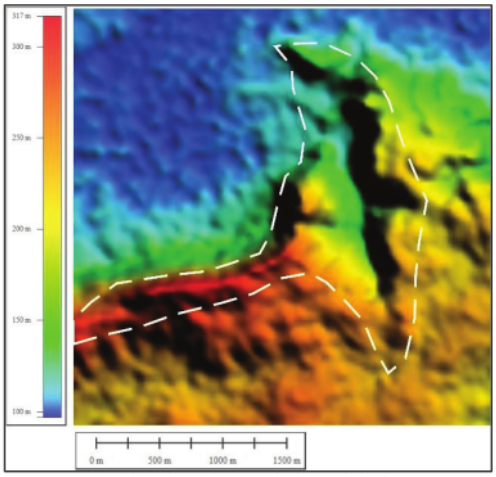

FIGURE 2. Results Processing DEM SRTM map by using the application Global Mapper with areas that have the potential of mass movement is characterized by white dashed lines

The picture above shows the results of the analysis of DEM SRTM maps obtained 5 colors that show the height of each area, with blue color has an altitude of 100 - 125 mdpl, green color shows height 125 - 175 mdpl, yellow color shows the height 175 - 225 mdpl, orange color shows height 225 - 275 mdpl and red color shows height 275 - 325 mdpl.

Zoning of the movement of the mass movement is at 1 point with the relative west-east panyebaran, following the direction of hilly grenades that exist in the research area, the controlling factor to determine this zonation is the steep slope value along with the alignment of geological and lithological structures developed in the research area.

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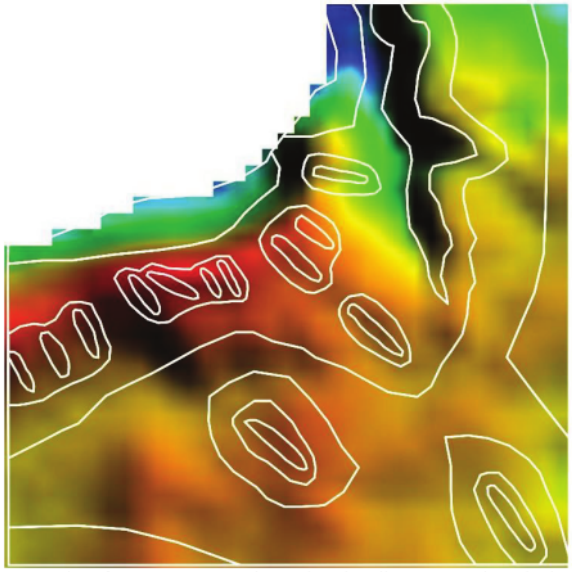

FIGURE 3. Image Processing Results of DEM SRTM to determine the alignment and to obtain the alignment map of the research area

Based on the figure no 3, it is found that the controlling factor of landslide by delineating every rock slope with a certain distance. This analysis is used to assist in the determination of scores, so as to provide more variation in the determination of potential zoning maps of landslide.

AERIAL PHOTO

FIGURE 4. Aerial photos (google earth sources) in the study area show morphological differences and landscape and land use

Based on the analysis of aerial photographs in Figure 4 shows the research area environment has a tropical climate with the presence of dense vegetation. The study area has a fault line escape morphology on the north of the map with a relatively east-west direction with the slope of the layer relative to the southeast. The drainage pattern that flourishes in this area is parallel with valley shape V and flows on the bedrock [4]. Viewed from the morphology contained in aerial photographs, shows the existence of a very steep cliff that is very potential for the occurrence of landslide. At

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the top of the hill is used by residents as agricultural land with soft vegetation so that during the rainy season the rocks are at the top of the hills are at the point of saturation of water, then the water at the top of the hills will drop down and will erode the rocks and soil from the hills and potentially leading to landslide leading to settlements to the north of the lot.

SCORING AND LANDSLIDE POTENTIAL MAP

At the stage of making landslide potential maps, the method used one of them using the scoring method, scoring is done to give certain numbers on each parameter to be entered to be able to determine whether classified as safe or vulnerable. After all parameters are given a score, then the numbers are calculated using the formula and combined. Based on data that has been processed it will get a map of landslide potential.

TABLE 2. Score of Lithology

Lithology	Score
Limestone (Wonosari Fm)	2
Limestone (Oyo Fm)	4
Tuffaceous Sandstone (Semilir Fm)	3

TABLE 3. Score of Rainfall

Rainfall	Score
Very High	6
High	5
Rather High	4
Rather Low	3
Low	2
Very Low	1

TABLE 4. Score of Structure Linieanment

Structure Linieanment	Score
0-100 m	6
100-200 m	5
200-300 m	4
300-400 m	3
400-1000 m	2
>1000 m	1

TABLE 5. Score of Slope

Slope Rate	Score
> 40 % (Very Steep)	6
25 - 40 % (Steep)	5
15 - 25 % (Rather Steep)	4
8 - 15 % (Slopinng)	3
2 - 8 % (Flat)	2
0 - 2 %	1

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TABLE 6. Score of Landuse

Land Use	Score
Farm	6
Field	5
Settlement	4
Rain-fed Rice Fields	3
Irrigated Rice Fields	2
Scrub	1

The datas are used to make a zonation of landslide potential with calculate in the formula:

Formula (H) = (Slope Score x 3)+(Lithology Score x 2)+ (Rainfall Score x 2)+

(Structural Geology Score x 2)+(Land Use Score x1) /10

TABLE 7. Score of Zonation

Score Zonation	Label
0 - 95	Safe
96 - 213	Medium
214 - 333	High

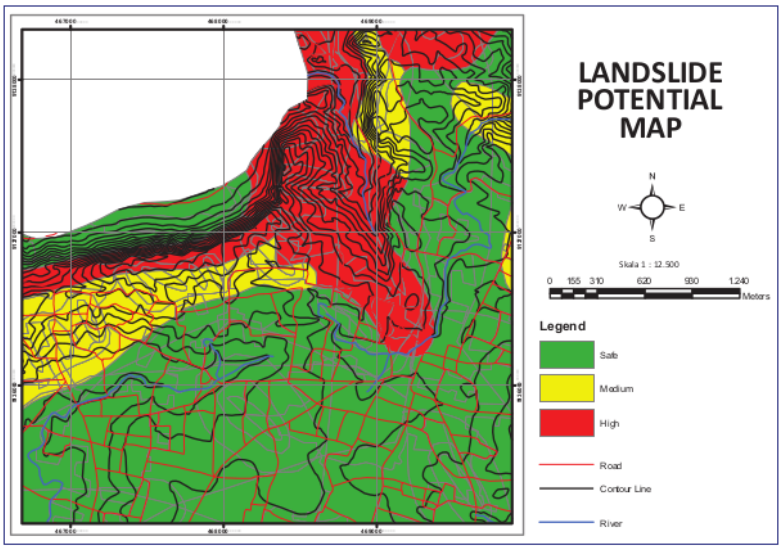

FIGURE 5. Landslide Potential Map

Based on the results of the analysis in figure 5, the results obtained in the form of landslide-prone hazard maps obtained from the incorporation of all mass motion control factors such as lithology, structural alignment, rain, slopes, and land use. Areas with potential vulnerability exist in the north of the study area located on very steep cliffs and valleys, with an area of 25% of the total area of study, the area with a moderate potential of the west-east yellow has

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a total area of 15% of the total area of research, while the area is safe against landslide spread over research area with green color has wide of 60% from total area of research area.

In determining the level of disaster landslide of the main controlling factor is the value of slopes and lithology due to the steep slopes and lithology in the rotted research area is potentially causing landslide, because the value of compaction rocks have decreased so that when it rains the rock will easily absorb water so it will increase the volume load of rocks, coupled with the steep slope value, it will increase the potential for landslide disaster.

FIELD CHECK

After making the landslide potential map, field check should be done for prove the map. The first check is the high potential zone. As showed on the figure 6, the landslide happened and it has a structural control influenced the landslide.

FIGURE 6. High Potential Landslide Zone

And then the medium potential zone, as showed on the figure 7 and 8, the landslide is not really intensive.

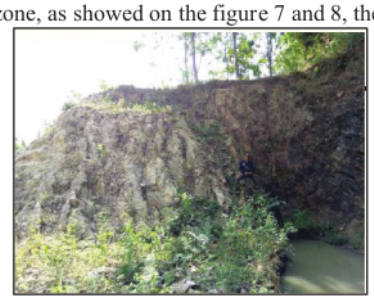

FIGURE 7. Medium Potential Landslide Zone 1

FIGURE 8. Medium Potential Landslide Zone 2

And the last is the safe potential, as showed on the figure 9, the landslide barely happened.

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FIGURE 6. Safe Potential Landslide Zone

CONCLUSIONS

1. Landslide potential in the research area influenced by many factors such as lithology, structural geology, rainfall, slope, and landuse.
2. The landslide hazard potency in the research area is divided by three, there are safe, medium and high. The result get from the scoring of each factor.
3. Traditional mining activity also increases the potential of landslide hazard in the research area.

ACKNOWLEDGMENTS

Thankyou for Mr. Dr. Ir. Eko Teguh Paripurno, M.T., as the lecturer for giving the idea to make this paper and thankyou for the family of Geological Engineering Department of UPN Veteran Yogyakarta who always support the authors to finish the paper.

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