IDENTIFICATION OF LAND MOVEMENTS BASED ON GEOGRAPHIC INFORMATION SYSTEMS AND DIPOLE-DIPOLE CONFIGURATION RESISTIVITY METHOD FOR LANDSLIDE DISASTER MITIGATION IN THE SELOHARJO, PUNDONG, BANTUL, YOGYAKARTA SPECIAL REGIONS

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ABSTRACT.

Seloharjo Village, Pundong, Bantul is an area that has geographical conditions in the form of mountains and hills, making the area prone to landslides. Landslides are geological disasters where masses of soil and rock move down slopes which are influenced by landslide parameters in the form of rainfall, slope, vegetation, seismicity and geology. A slip plane is a rock layer that has relatively lower permeability compared to the layer above it so that it can become a plane for the movement of soil and rock masses above it. Identification of the landslide slip plane was carried out using the dipole-dipole configuration geoelectric method with a path length of 260 m on track 1 and 220 m on track 2. The results of geoelectrical measurements show high subsurface resistivity values with a value range of 158 - 280 Ωm which is thought to be limestone material as a land sliding area and low resistivity values with a value range of 5 - 150 Ωm which is a layer of alluvial sediment as landslide material. Alluvial deposits in the research area become landslide material with the sliding surface being a layer of limestone, because the permeability value of limestone is smaller than that of alluvial deposits. Based on a review of the geographic information system in the form of a landslide susceptibility map obtained from the parameters of landslide events, it shows that the research area has a high rainfall value of 2,629 mm/year, a slope slope of 25 - 45%, vegetation with strong roots and dense leaves, level high earthquake susceptibility, and geological conditions in the form of a slip plane in the direction of the slope, from these parameters the research area has a high level of landslide susceptibility. On track 1, the slope direction of the slip plane is found to be in the same direction as the slope of the slope with high landslide potential. Meanwhile, on route 2, the direction of the slope of the slip surface is opposite to the direction of the slope of the slope with low landslide potential. The results of the integration of geophysical data with GIS show that route 1 has a high landslide potential in terms of the analysis of the slip plane in the direction of the slope as well as the geographic information system which shows that the research area has a high level of landslide proneness so that mitigation is needed in the form of creating an evacuation route.

Key words: Geophysics, Geoelectricity, Landslides, Mitigation, GIS

I. INTRODUCTION

Landslides are a type of mass movement of soil or rock, or a mixture of both, down or off a slope as a result of disrupting the stability of the soil or rock that makes up the slope. Landslides occur because there is a disturbance in the stability of the soil/rock that makes up the slope (Taufik, et al, 2016). Landslide occurrence is influenced by several factors, namely rainfall, slope slope, rock type, soil type, and land use on a land. Indonesia is an archipelagic country with a high potential for landslides. BNPB stated that throughout 2020 there were 573 landslides. Indonesia's geographical conditions are a tropical country and are dominated by geomorphological conditions in the form of hills, resulting in a high potential for landslides. One area that has a high potential for landslides is Pundong District, Bantul.

Pundong District is one of the sub-districts in Bantul Regency, Yogyakarta Special Region which has a high potential for landslide disasters. According to the Bantul Regency BPBD, throughout 2015 - 2019, there were 39 landslide disasters in Pundong District. Morphologically, the Pundong area has a morphological form in the form of hills with gentle to steep slopes with soil types in the form of regosol and cambisol. The Pundong area consists of land in the form of forests, bush areas, rice fields, and residential areas. The geological conditions that develop in Pundong District are the Nglanggeran Formation and the Wonosari Formation. This condition is a parameter or factor that causes the Pundong District area to be one of the areas that has a high level of potential for landslides, so it is necessary to carry out landslide mitigation efforts in the form of identifying land movements based on geographic information systems and resistivity methods.

The research carried out is one of the efforts to mitigate landslides which is carried out by combining data processing from geoelectrical resistivity measurements of dipole-dipole configurations with landslide susceptibility maps obtained using a geographic information system with landslide parameters in the form of rainfall, slope, soil type, rocks, and land use are carried out by a scoring and weighting process. The results obtained from the analysis and interpretation process are in the form of the geometry of the land slip plane which shows the direction of potential material slides and the level of landslide vulnerability at the research location in the Seloharjo, Pundong, Bantul areas.

The aim of conducting ground movement identification research based on geographic information systems and the dipole-dipole configuration resistivity method is to determine the existence of landslide slip areas and the potential direction of landslides developing in the Seloharjo area, Pundong District, Bantul Regency, Yogyakarta Special Region and to determine the potential for landslide disasters based on parameters of slope slope, rainfall, soil type, rock type, and land use are compiled into a landslide disaster vulnerability map.

II. RESEARCH METHODS

The research method uses the integration of geographic information systems and geoelectric methods. A geographic information system is a system created to increase the effectiveness of presenting geographic data. The effectiveness of data presentation is carried out through a programming system with the ability to store, manage, process and analyze data. This system continues to develop along with the times to increase the effectiveness of data presentation. Overlay is one of the important methods in Geographic Information Systems for displaying two digital maps in one layer while still presenting the attributes of each map. GIS can be implemented in creating landslide disaster vulnerability maps based on landslide disaster event parameters using a scoring and weighting system.

The basic principle of the geoelectric method is to determine the nature of electrical flow beneath the earth's surface, either naturally or by injecting current into the earth's surface. The nature of electric flow is naturally known from the subsurface potential difference between two points using an electrode/porous pot. DC (Direct Current) current injection into the earth's surface in geoelectricity is carried out using the resistivity and induced polarization method. The method that will be described this time is the resistivity method, this method analyzes the physical properties of rocks from differences in resistivity at each depth. The basic principle of the geoelectric resistivity method is to flow current from two electrodes, then it is received by the potential electrode and the resulting potential distribution is measured. Rock resistivity measurements are influenced by several factors such as rock homogeneity, water content, porosity, permeability, and mineral content.

Mathematically, the resistivity value of a medium can be formulated:

$\rho = k.\frac{V}{I}$

which:

ρ = resistivity   V = potential
k = geometry factor   I = current

The dipole-dipole configuration is one of the configurations in the geoelectric method for determining subsurface resistivity values. In the dipole-dipole configuration, the two current electrodes and the potential electrode are separated by a distance a. Meanwhile, the current electrode and inner potential electrode are separated by a distance na, with n being an integer (Dwiharto & Purwanto, 2017). The dipole-dipole configuration has the final result in the form of a cros s section covering the horizontal and vertical planes of the research area. This configuration is commonly used for exploration of sulfide minerals and other mining materials at relatively shallow depths. The series of dipole-dipole configurations is illustrated as follows:

where :

r1 = C1 until P1
r2 = C2 until P1
r3 = C1 until P2
r4 = C2 until P2

$\Delta V = \frac{\rho I}{2\pi}\left\{\left(\frac{1}{r1}-\frac{1}{r2}\right)-\left(\frac{1}{r3}-\frac{1}{r4}\right)\right\}$

$\rho = \pi(2+n)(1+n)n.r\left(\frac{\Delta V}{I}\right)$

$k = \pi(2+n)(1+n)n.r$

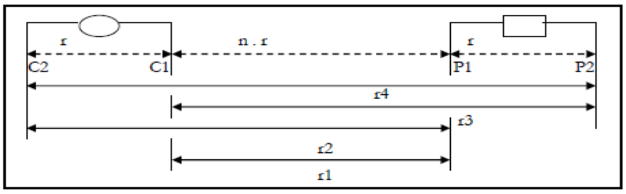

Figure 1. Dipole - dipole Configuration

Where :

I = current
ΔV = pontential
ρ = resistivity
k = geometry factor

r = electrode distance
n = cut ouff number

Geophysical data in the form of current strength and potential values were obtained from geoelectric field acquisition resistivity dipole-dipole configurations using the Syscal geoelectric instrument carried out on 2 tracks with each track length of 260 m and 220 m. Meanwhile, the parameter map data used in preparing landslide susceptibility maps are:

a. Pundong District rainfall data
b. Pundong District land use map
c. Map of soil types in Pundong District
d. Map of rock types in Pundong District
e. Slope slope map

Geoelectrical data processing begins with calculating the R, K, Rho and Datum point values using Microsoft Excel software and continues with creating cross-sectional resistivity values using Res2dinv software. The results of geoelectric data processing are cross-sectional resistivity values used in interpreting landslide slip areas.The preparation of the soil vulnerability map was carried out based on a geographic information system obtained based on combining landslide disaster parameters. Processing begins with collecting parameter maps in the form of maps of rainfall, slope, soil type, rock type and land use based on each source. Then a scoring and weighting process was carried out, which in this research was based on a model for estimating landslide-prone areas based on the 2004 Center for Land and Agroclimate Research and Development.

Tabel 1. Scorring and weighting

No	Parameter	Magnitude	Scor	Weight
1	Slope	< 8%	1	20%
		8 - 15%	2	
		15 - 25%	3	
		25-45%	4	
		> 45%	5	
2	Rainfall Annual (mm/year)	< 1500	1	30%
		1501 - 2000	2	
		2001 - 2500	3	
		2501 - 3000	4	
		> 3000	5	
3	Soil Type	Alluvial	1	10%
		Yellowish Brown Latosol Association	2	
		Chocolate Latosol	3	
		Andosol, Podsolik	4	
		Regosol	5	
4	Geology	Alluvial Material	1	20%
		Volcanic Material	2	
		Sedimentary Material	3	
5	Land Cover	Ponds, Reservoirs, Waters	1	20%
		City/Settlement	2	
		Forests and Plantations	3	
		Shrubs	4	
		Moorland, Rice Fields	5	

Source : Pusat Penelitian dan Pengembangan Tanah dan Agroklimat in 2004

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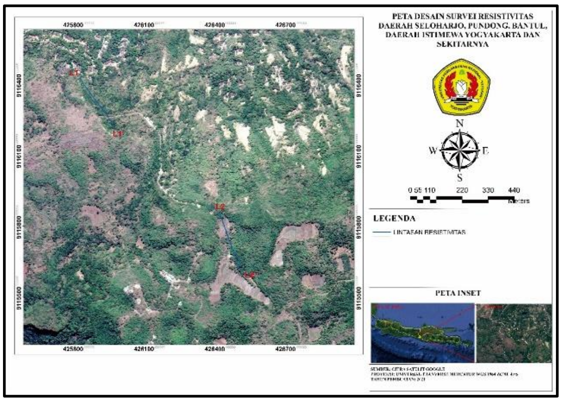

Figure 2. Research Location

The research was conducted in Seloharjo Village, Pundong District, Bantul Regency, Yogyakarta Special Region Province. The research location borders Gunungkidul Regency and is south of Yogyakarta City Center and can be reached in approximately 45 minutes by motor vehicle. The research plot has an area of 1.87 km2.

III. RESULTS AND DISCUSSION

The results of geoelectric data processing and a review of the local geology of the Seloharjo area, Pundong District, show that track 1 has 2 types of subsurface material based on resistivity or resistivity values. The first layer, which is at a depth of approximately 20 meters with a resistivity value of 50.4 to 280 ohm.m, which is depicted in dark green to dark red, is a layer of volcanic breccia. This first layer has the potential to become a landslide slip surface for the layer of material above it, where volcanic breccia has low porosity and is watertight.

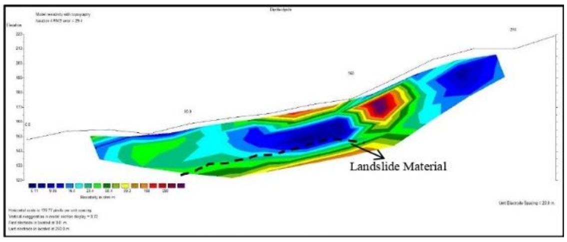

Figure 3. Traverse Resistivity Cross Section 1

The second layer, which is the surface layer with a resistivity value of 5.11 to 50.4 ohm.m, which is depicted in blue to dark green, is a layer of alluvial sediment or soil that has the potential to become landslide material to the northwest. The direction of the slope of the land sliding area on route 1 is opposite to the direction of the slope, resulting in the area on route 1 having the potential to experience landslides. So in this situation it is necessary to review the parameters of the influence of landslides.

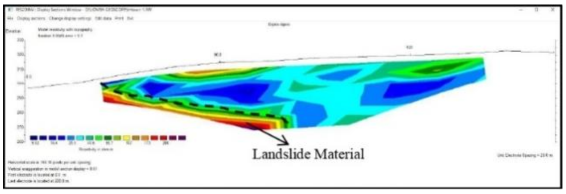

Figure 4. Traverse Resistivity Cross Section 2

The results of geoelectrical data processing and a review of the local geology of the Seloharjo area, Pundong District, show that route 2 has 2 types of subsurface material based on resistivity or resistivity values. The first layer which is at a depth of approximately 10 to 20 meters with a resistivity value of 65.7 to 280 ohm.m which is depicted in dark green to dark red is the limestone layer. This first layer has the potential to become a sliding surface for landslides against the layers of material above it, where limestone has low porosity and is water-resistant. The second layer, which is the surface layer with a resistivity value of 9.52 to 65.7 ohm.m, which is depicted in blue to dark green, is a layer of alluvial sediment or soil that has the potential to become landslide material. The direction of the slope of the land sliding area on route 2 is opposite to the direction of the slope, resulting in the area on route 2 not having the potential to experience landslides.

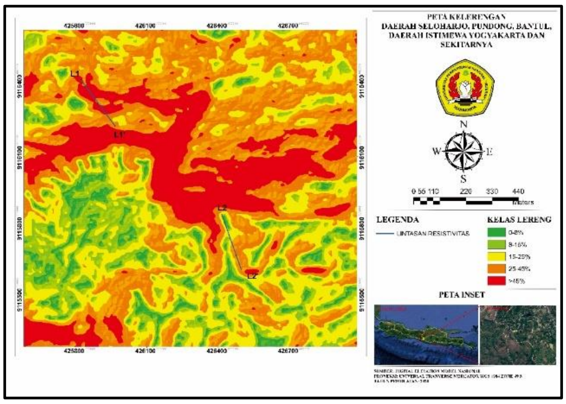

Figure 5. Slope Map

Slope is one of the parameters of landslide events with an influence of up to 20%. The level of slope in the study area is grouped into 5 classes, namely flat (0-8%), sloping (8-15%), sloping (15-25%), steep (25-45%), and steep (> 45%), where the research location is dominated by land with steep to steep slopes. The slope data was obtained from the National Digital Elevation Model. In resistivity path 1, it shows a steep slope level (>45%) which is depicted in red and in resistivity path 2 it shows a steep slope level (25-45%) which is depicted in orange.

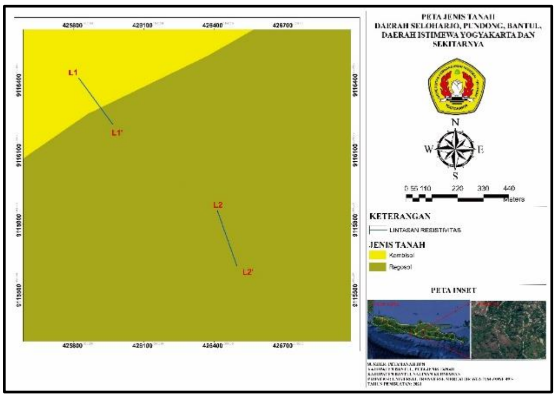

Figure 6. Soil Type

The type of soil that develops on a land can influence the occurrence of landslides with an influence percentage of 10%. The soil type map of the research location in the Seloharjo area, Pundong District, sourced from the BPN Soil Type Map of Bantul Regency, shows the existence of 2 types of soil that are developing, namely regosol soil which dominates the research area and cambisol soil. In resistivity path 1 shows the regosol and cambisol soil types, while in resistivity path 2 shows the regosol soil type.

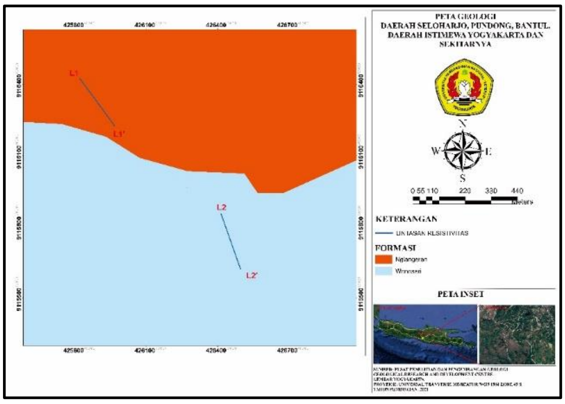

Figure 7. Geology Map

Geological conditions in the form of rock types that develop on a slope can influence the incidence of landslides by up to 20%. Lithological data or rock types sourced from the Yogyakarta Geological Map Sheet of the Center for Geological Research and Development shows that the Seloharjo area, Pundong District has lithology in the form of Nglanggeran Formation and Wonosari Formation rocks. In resistivity track 1, it is included in the Nglanggeran Formation with rocks in the form of volcanic breccia and in track 2 it is included in the Wonosari Formation with rocks in the form of limestone.

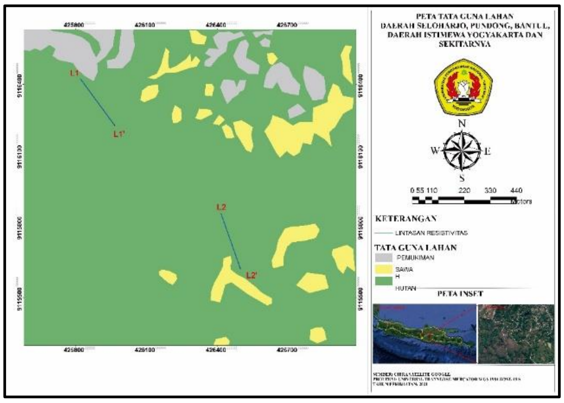

Figure 8. Land Use Management Map

Land use on the land surface greatly influences the sustainability of the hydrological cycle. Land use has an influence of up to 20% on the occurrence of landslides. At the research location, land use is dominated by forests and residential areas and rice fields are also found. Resistivity paths 1 and 2 are on forest land.

Rainfall condition is one of the parameters of high landslide disasters where the influence of rainfall reaches 30% in the soil vulnerability level weighting system. Rainfall data was obtained from BPS Bantul Regency, which shows that the intensity of rainfall in Pundong District reached 2629 mm/year which is considered high rainfall. Regional or broad scale rainfall intensity results in Pundong District only having one rainfall intensity value that develops in the research area.

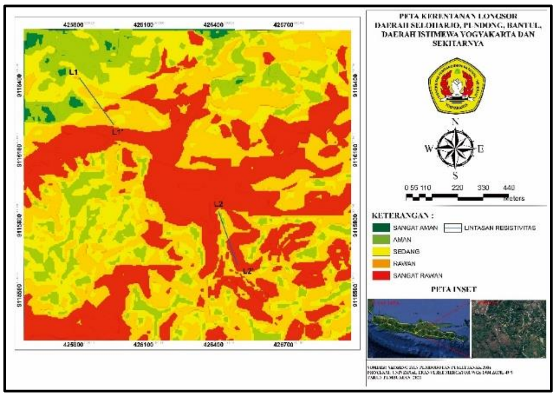

Figure 9. Soil Vulnerability Map

The landslide susceptibility map was obtained based on the parameters and weighting of each parameter according to the Center for Soil and Agroclimate Research and Development in 2004. The parameters used were slope level, rainfall, soil type, rock type and land use. The results obtained are variations in the level of landslide susceptibility in the Seloharjo area, Pundong District, Bantul. On the resistivity path 1, the level of landslide susceptibility is moderate to prone. Meanwhile, route 2 has a landslide vulnerability level of prone to very prone.

IV. CONCLUSION

Identification of land movements in the Seloharjo area, Pundong District was carried out based on geophysical studies and geographic information systems. Based on the subsurface interpretation in resistivity track 1, it shows that the landslide slip area is in the same direction as the slope, so it has a high potential for landslides, then in the area of resistivity track 1 it has a slope of more than 25%, cambisol soil, lithology in the form of volcanic breccia of the Nglanggeran Formation , the area is forested, and the rainfall is high so it has a moderate to high level of landslide vulnerability. Based on the condition of the subsurface slip area and the landslide parameters, it is indicated that the direction of the landslide is towards the northwest, so mitigation is needed in the form of maintenance and strengthening of the slopes in this area.

The area on resistivity track 2 has a slope of 8 to 45%, regosol soil type, lithology in the form of Wonosari Formation limestone, land in the form of forest, and high rainfall so it has a level of landslide susceptibility that is prone to very prone. However, the subsurface conditions of resistivity track 2 are based on the interpretation of resistivity values, the direction of the slip plane is opposite to the slope of the slope, so there is no potential for landslides.

V. THANK-YOU NOTE

The author would like to thank all respondents who were willing to take the time to fill out the questionnaire. Thanks are also addressedfor friends and lecturers, especially the Coordinator of the Mining Engineering Master's Study Program at the National Development University "Veteran" Yogyakarta.

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