Identification of the slip area of a landslide using resistivity geoelectric method

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Abstract. Research on the tracking of the slip area of a landslide using resistivity geoelectric method with Wenner configuration that aims to determine the subsurface structure which is alleged potential as the slip area has been done. Measurements took place in the Dusun II of Kalora Village, Subdistrict of Kinovaro, District of Sigi by taking three measurements trajectory. Based on the results of 2D modelling using software Res2Dinv for every trajectory obtained two layers, with the first layer of resistivity value ranges <500 Ωm identified as dry sand and the second layer resistivity values ranges > 500 Ωm that identified as a conglomerate rock. Based on the 2D cross-sectional area of research, which was thought as the field boundary slip was between 7-8 m depth on the path I with the West-East direction

1. Introduction

Landslide disasters are seen as events caused by natural processes or human activities that can result in the loss of lives and property, damage to the environment, facilities, and infrastructure as well as public facilities. Landslides are defined as the displacement of slope-forming material in the form of rock or mixture, moving downward or downhill. The principle of landslides occurs when the driving force on a slope is greater than the holding force [1].

Retaining forces are generally influenced by rock strength and soil density. While the driving force is influenced by the magnitude of the slope angle, water, load and density of rocky soil. Factors that cause landslides are high rainfall, external loads such as buildings, increased slope steepness due to natural erosion or excavation and the presence of slip areas [2]. The potential for landslides is also supported by human activities such as deforestation, land development from forests into residential areas, and land use on slope areas that are not appropriate. All these factors are related to one another. One of the locations that is vulnerable to landslides is Kinivaro District, located in Sigi Regency.

Gawalise Mountains are a series of mountains located east of Palu City. In this area are scattered several residential areas, one of them is the Dusun II settlement, Kalora Village, Kinovaro District, Sigi Regency, which is vulnerable to the land movement. Weathering of the land that is above the slip area in the mountains with a gentle slope to a steep potential for land movement in the rainy season with high-quantity rainfall. High rainfall can cause ground movement because the motherland will enter and accumulate at the bottom of the slope, as well as causing downward movement that can endanger the safety of the community.

A landslide is a weathering process due to high rainfall which has the nature of passing water so that the soil becomes saturated with water. The water finally flows in the contact plane which acts as the slip
area (slip surface). Due to saturation of weathering soils, the weight of the soil mass increases, this causes the balance of the slope is disturbed and the slope moves to find a new balance so that a landslide disaster occurs [3]. One of the causes of landslides is due to the weathering process in rocks. This weathering moves through a field called the slip area.

The level of landslide susceptibility also depends on the slope of the location [4] [2] [5]. The slope is very sloping with the category between 5° - 15° [6]. Usually, landslides move in a certain area. This field is called the slip surface or shear surface. The shape of the slip area often approaches the arc, in this case, the landslide is called a rotational slide that is rotating. There is also a landslide that occurs in a slip area that is almost straight and parallel to the face of the land, in this case, the landslide is called a translational slide. Such landslides usually occur when there is a rather hard layer parallel to the slope surface. The slope of the slope will affect the slip area causing landslides.

The slip area in the landslide area is marked by the presence of 2 layers of soil/rock. Hard layer (waterproof) with a soft layer. The impermeable layer acts as a soft slip layer that acts as an avalanche material. Landslide material is characterized by low resistivity values and landslide fields are characterized by materials that have high resistivity [7]. The slip area is obtained from the resistivity contrast between 2 adjacent rocks. The slip area has characteristics, namely interdependent rock fields, fields located between soil cover with bedrock, and boundary fields between soft soils and dense soils.

2. Methods

The location of the study using the geoelectric method of the Wenner configuration type obstacle was carried out in Hamlet II, Kalora Village, Kinovaro District, Sigi Regency, Central Sulawesi Province. The geographical position of the research location is 0°52'33.631"LS - 0°52'37.445"LS and 119°49'13.033"BT - 119°49'16.808" East.

Data obtained from measurements in the field using the geoelectric method of Wenner configuration resistivity are in the form of the current value (I) and a potential difference (∆V) at the measurement point[8][9][10] The results of the measurement of resistivity are then converted to the Res2Dinv program so that a 2D cross-section of the subsurface resistivity distribution is obtained. The inversion results are then interpreted based on the distribution of resistivity values.

3. Result and Discussion

Measurements were made on 3 passes. Measurement using a space between the electrodes within 5 meters. Geoelectric measurements of type resistance are performed using the Wenner electrode configuration method. The measurement results in the field are then processed using the Res2Dinv application. The data processing results in the distribution of values of type (ρ) and depth (d) resistance of each subsurface layer in the form of 2D cross-sections.

The 2D modelling results display a cross-section involving topographic effects, this is necessary because the study site has an uneven topography. The topography of uneven measurement location can give effect to the given electricity. In Figure 1, Figure 2, and Figure 3 are displayed the results of 2D cross-section modelling on each measure7ment trajectory.

Measurements on trajectory 1 (Figure 1) are taken parallel to the slope in the direction of the West-East Path, with the intention that the slip area which is generally parallel to the slope can cover as a whole. The results of geoelectric measurements can be explained that the value of the type of resistance which ranges from <500 μm is thought to be dry sand marked in yellow. The resistivity values ranging from> 500 Ωm are thought to be conglomerate rocks marked in red.

Conditions in the field are found conglomerate rocks that appear as outcrops found in stakes 16-21, which also appear in the 2D cross-section with a resistance value of 600-800 800m. Based on the cross-section of the correlation results, dry sand (dry sand) was detected at a depth of 1.25 - 5 meters and conglomerate rocks were found at a depth of 6-12 meters.
Measurements made on trajectory II intersect trajectory I (between electrodes 9 and 17) under the slope in the direction of the South-North Track. Meter 0 is south of the track and leads west. The results of modelling in Figure 2, show this path consists of two layers. The first layer has a resistance value of...
type <500 Ωm. Based on the value of the type of resistance it is estimated that this layer in the form of dry sand (dry sand). Based on the cross-section of the correlation results, the layer was detected at a depth of 9.26-15.9 meters which is marked in green to yellow and the second layer has a resistance of >500 μm. Based on the value of this type of resistance it is estimated that this layer in the form of conglomerate rocks detected at a depth of 1.25-9.25 meters marked in red.

Figure 3 shows measurements on track III consisting of two layers. The first layer has a resistance value of type <500 Ωm. Based on the value of the type of resistance it is estimated that this layer in the form of dry sand (dry sand) is marked in yellow. The second layer has a resistance value of type >500 Ωm. Based on the value of this type of resistance it is estimated that this layer is in the form of conglomerate rocks marked on stakes 2-7 and stakes 11-18 in red with the direction of the South-North Path. The surface shape (topography) of the uneven measurement location will have an effect on the electric current provided. Topographic correction is needed in analyzing and interpreting the slip area closely related to topographic factors [1].

The black line in Figure 1, is an area that is thought to be a slip area. The slip area here is a certain field that moves on landslides. The slip area is at the boundary between the avalanche and the hard layer [11]. The slip area is usually marked by a waterproof layer, the waterproof layer has a high type of resistivity value. The layer that has a high type of resistance is indicated to have little water content [12]. In trajectory I, there is a slip area with a translational geometry structure parallel to the slope. This is based on the geological conditions which are composed of dry sand (dry sand) and conglomerate rocks. As well as the state of the topography which has a slope of 30°, where the slope with an angle of 30° is categorized as a rather steep slope.

Based on Figure 2 and Figure 3, it appears that the cross-section does not have a slip area. This is due to the topographic factor in Trajectory II showing the slope range of 5.7° and Line III around 11.5°. The slope with values of 5.7° and 11.5° is categorized as a gentle slope. Where the category of sloping slopes is less likely there is a slip area. Areas that allow the sliding area are generally parallel to the slope and the slope reaches 25° - 45° the category of the slope is rather steep and the slope is > 45° the steep category.

4. Conclusion
On each track, there are two layers. The first layer of the resistivity value is <500 Ωm which is identified as dry sand and the second layer is the resistivity value of > 500 Ωm which is identified as a conglomerate rock. The slip area is found at a depth of 7–8 m on line I in the East-West direction.

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