Land Subsidence Analysis Based on 2D Resistivity Modelling of DC Resistivity Method in Curugpanjang, Banten

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Abstract. Land Subsidence is a phenomenon of subsidence of the land surface compared to the reference point. This phenomenon can be caused by natural factors, groundwater extraction, and building factors. Geoelectrical method was used to analyze the subsurface conditions in Curugpanjang consisting of four lines. In this study, the potential value (V) and current strength (I) will be obtained which will be used to calculate the resistivity value. Data processing from the measurement results is carried out using the Res2Dinv software. The subsurface image of the resistivity value obtained shows that the area has the same rock layers, namely groundwater, clay or soil, mudstone, sandstone, tuff, slit-clay, and pumice. The layer that is thought to act as a subsidence area is clay or soil (1–100) m which is found throughout the track with a range of layer depths (0–9) m. The pattern of soil resistivity shown by geoelectric images is an area with layers composed of rocks that have a high level of porosity. High rainfall results in an increase in the volume of water that is absorbed in the rock cavity so it has the potential to cause land subsidence.

Keywords: Geoelectrical · Land Subsidence · Resistivity · Wenner Configuration

1 Introduction

Land subsidence is the slow deposition or rapid subsidence of discrete segments of the soil surface due to sediment consolidation which results in the movement of soil material below the surface experiencing an increase in effective stress [1, 2]. Land subsidence can occur due to a large amount of groundwater has been lost from certain rock types, also influenced by endogenic and exogenic factors. Groundwater extraction is one of the causes of land subsidence, which begins with the compaction of the aquifer system [1].

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Fig. 1. Land subsidence in Curugpanjang

In 2022 land subsidence occurred in Curugpanjang Village and caused some damage as shown in Fig. 1. This phenomenon occurred due to an earthquake of 5.5 SR that hit Lebak Regency in February [3]. In addition, land subsidence in Curugpanjang occurs due to heavy rainfall. The impact of land subsidence in Curugpanjang is damage to houses up to 43 houses and damage to the main road section Sampay–Cikulur [4].

Investigation of subsurface lithological conditions is needed to analyze the causes of land subsidence [5]. In this case, the investigation in question is to utilize the geoelectric method. The resistivity geoelectric method is one of the geophysical methods based on the application of electrical concepts to earth problems [6, 7]. This method has been widely used in exploration activities such as determining aquifers, analyzing the structure of the earth's layers, and searching for minerals [8]. In addition, this method was chosen because of its ability to detect rock types based on their resistivity values [9, 10]. In general, rock resistivity is divided into three, namely a thin resistive surface layer, a middle conductive layer, and a more resistive basement [11, 12]. This research was conducted to determine the cause of land subsidence by analyzing the structure of the subsurface layer using the geoelectric resistivity method.

2 Location and Method

Geographically, the research location is at the coordinates of 6º22′52.82″S 106º08′44.71″E which is shown in Fig. 2a. This research was conducted in March 2022 using the Wenner configuration resistivity geoelectric method with four lines, namely Line CK-1, Line CK-2, Line CK-3, and Line CK-4, where Line CK-4 intersects another line. Figure 2b shows the shape of the trajectory used in the study. A total of 16 current and potential electrodes were installed at a distance of 5 m each. The blue line is the subsidence path found at the research site.

The geoelectric method utilizes an electric current that is injected into the soil layer through two current electrodes to produce a potential field [13]. The potential value that arises as a result of this process will be measured using two potential electrodes that are plugged into the ground surface [14]. This value is processed using an algorithm to obtain a 2D modeling of the subsurface structure of the earth. The software used in

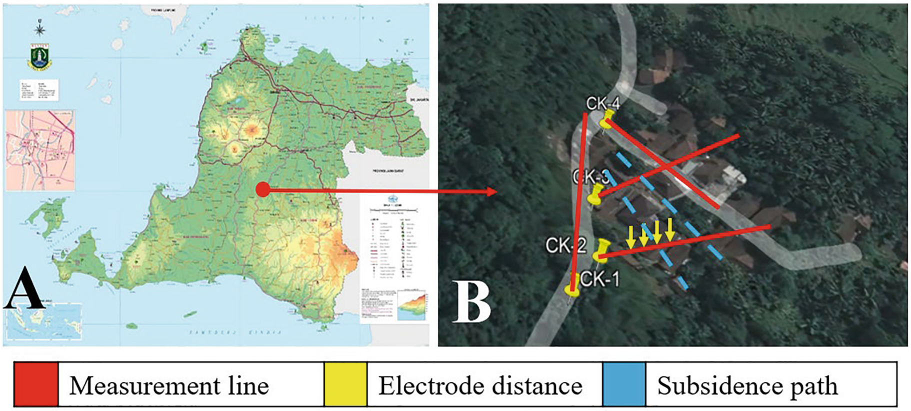

Fig. 2. (a) Location research (b) Line measurement

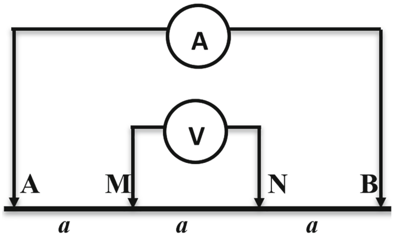

Fig. 3. Wenner configuration schematic

processing resistivity data is Res2Dinv [15, 16]. Figure 3 shows the schematic of the resistivity geoelectric method.

where:

A, B = Current electrode

M, N = Potential electrode

a = Space between electrode

Variation of apparent resistivity value (ρ) can be found in the equation [14]

$$\rho = K\frac{V}{I} \tag{1}$$

which K is the geometric factor of the electrode configuration [10, 17].

The 2D model that has been obtained from the processing process is analyzed and compared with the real situation at the research site so that conclusions can be drawn on the causes of land subsidence.

3 Results and Discussions

Figure 3 is the result of field data processing which shows the lithological conditions of the four paths that are used as data collection points. Each measurement has a depth and length of a track length of 13.5 m and 80 m.

The resistivity value on Line CK-1 is ±0.421–5701 Ωm with an error of 9.3% for 25 iterations. The CK-2 line has a resistivity value of ±0.00107–1689 Ωm with an error presentation of 18.5% for 25 iterations. The resistivity value on Line CK-3 is ±0.00381–1747 Ωm with 19.2% error presentation and 25 iterations. The resistivity value on Line CK-4 is ±0.932–1310 Ωm with an error presentation of 29%, and 25 iterations (Fig. 4).

Line CK-1 is a track that has a higher resistivity value than other lines. This track consists of Andesite rocks at a depth of ±3.88–13.5 m with a resistivity value of ±2000 Ωm. However, to a depth of ±9 m, a small part of Line CK-1 is composed of rocks with low resistivity values up to ±200 Ωm such as clay, tuff, sandstone, slit-clay, and pumice. The CK-2 line indicates rocks with low resistivity are at a depth of ±3–13.5 m. These

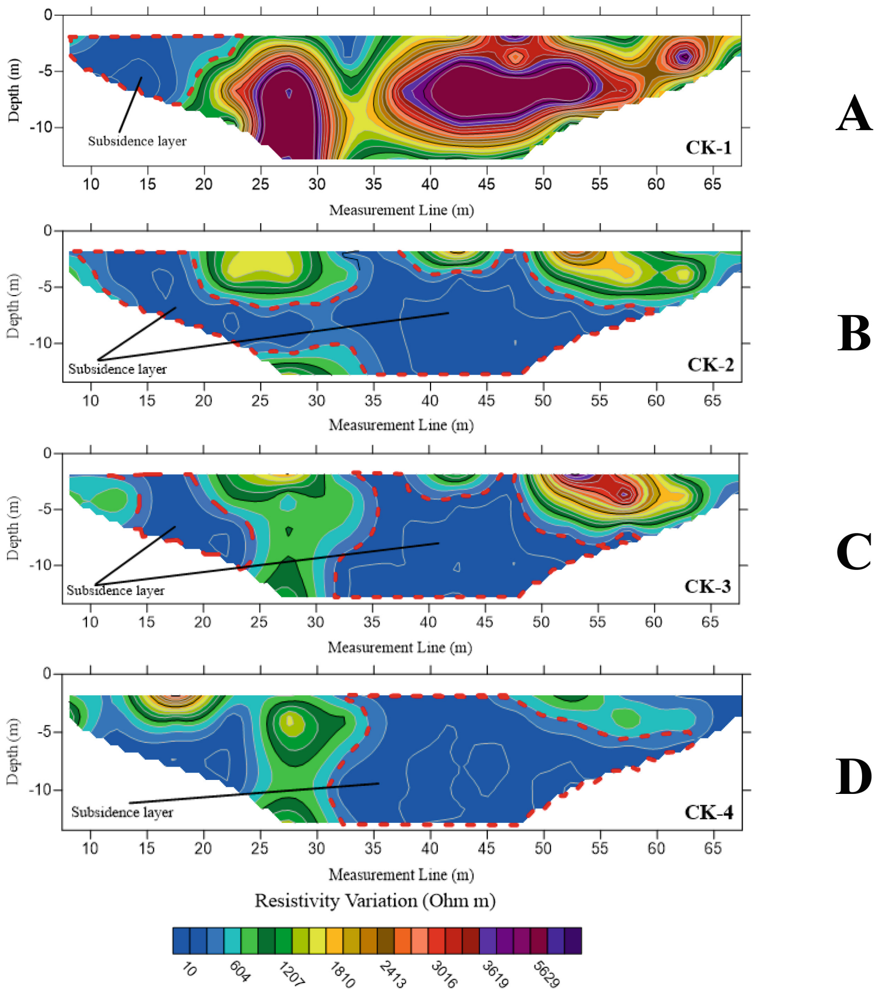

Fig. 4. 2D cross-sectional model (a) Line CK-1 (b) Line CK-2 (c) Line CK-3 (d) Line CK-4

rocks include clay, tuff, sandstone, slit-clay, and pumice which are mostly found in the middle of the track.

Line CK-3 is the point of greatest damage due to the land subsidence phenomenon (Fig. 1). If viewed from the results of 2D modeling in Fig. 3, it can be concluded that Line CK-3 has similarities with Line CK-2. The difference between these two lines is the trajectory point, where Line CK-3 is in the center of residential areas so that the total load on the ground surface is greater than Line CK-2. This is an estimate of the high use of water through wells in the house so that the extraction of water under the soil layer is very high. This situation triggers a large potential for damage when land subsidence occurs.

Line CK-4 has a rocky composition similar to Line CK-2 and Line CK-3. The CK-4 line is dominated by rocks that have low resistivity. This trajectory was made to cut Line-CK3 and it was found that the results were in accordance with the conditions at the research site, namely major damage in the center of residential areas.

Figure 5 shows the relationship between the four paths in 3D. The transverse red line that intersects Line CK-2 and Line CK-3 is the land subsidence line in the research location. Land subsidence that occurs in Curugpanjang is caused by the slow compression of alluvial deposits, rock characteristics, and groundwater extraction for daily needs (extraction). Excessive extraction of groundwater will increase the tension between soil grains in unconsolidated aquifers.

From the geotechnical aspect, land subsidence is a deformation process that has the potential to occur in soft layers such as clay. This type of clay rock has the greatest shrinkage swelling power so its presence is the main factor that determines its expansive nature or can experience changes in volume due to changes in water content in it [18].

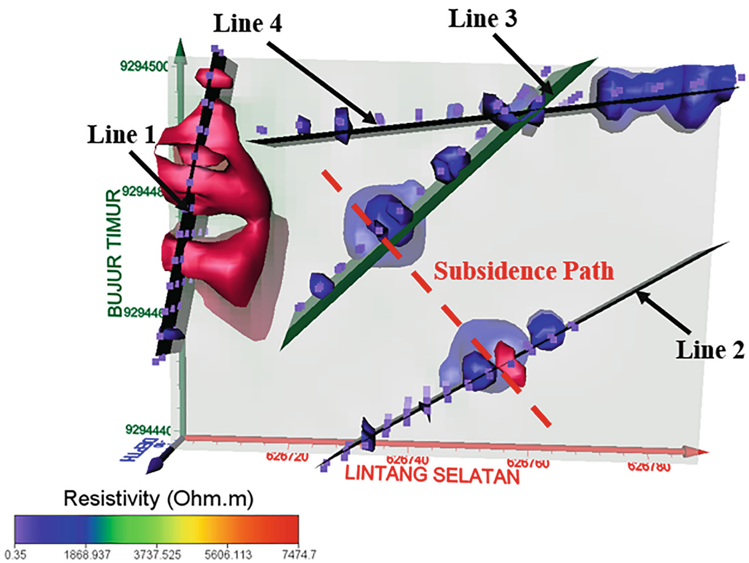

Fig. 5. 3D view

In addition, pumice (Pumice) also has a major influence on the occurrence of land subsidence because it has high vesicular properties, and contains a large number of cells (cellular structure) due to the expansion of the gas foam contained in it. The high porosity value without water consolidation makes it easy to crush when spontaneously loaded. High rainfall in Curugpanjang Village increases the volume of water that settles on the clay layer below the soil surface. This situation is coupled with the intensity of earthquakes that often occur in Lebak Regency in 2022 so that the condition of the soil layer becomes unstable.

4 Conclusion

Land subsidence that occurs in the Curugpanjang area is influenced by the physical and mechanical properties of the soil as well as excessive groundwater extraction. The measurement depth achieved in this study is 13.5 m with a rock resistivity value of around 0.00107–5701 Ωm. The subsurface structure is dominated by rocks that have low resistivity so land subsidence has the potential to occur. This rock has a resistivity of about 0.00107–200 Ωm including groundwater, mudstone, clay, tuff, sandstone, crevice clay, and pumice.

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