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GEOELECTRICAL RESISTIVITY FOR AGRICULTURAL WATER RESOURCES IN BUNGAYYA VILLAGE, SELAYAR ISLANDS REGENCY, SOUTH SULAWESI

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Abstract

Water demand for the agricultural sector in island regions continues to increase in line with population growth and land-use intensification (Kodoatie, 1996; Todd & Mays, 2005). One sustainable alternative for water supply is the utilization of groundwater, particularly deep aquifers. This study aims to identify the potential and characteristics of subsurface aquifers using the geoelectrical resistivity method with a Schlumberger configuration in Bungayya Village, Bontomatenne District, Selayar Islands Regency, South Sulawesi Province. Measurements were conducted at a single vertical electrical sounding (VES) point (GL_01) with a maximum current electrode spacing of AB/2 up to 100 m. The inversion results indicate two main subsurface layers: a surface limestone layer with resistivity values ranging from 126 to 1515.1 Ωm at depths of 0–15 m, and a sandstone layer of the Walanae Formation with resistivity values of 10–126 Ωm at depths of 15–70 m. The sandstone layer is interpreted as a deep aquifer capable of storing and transmitting freshwater with sufficient discharge for agricultural irrigation. Based on the interpretation results, groundwater drilling is recommended to a depth of approximately 70 m. The findings demonstrate that the geoelectrical resistivity method is effective as a preliminary approach for groundwater exploration, particularly in areas characterized by carbonate and sedimentary geological conditions (Telford et al., 1990; Loke, 2000).

Keywords: *geoelectrical resistivity, Schlumberger, aquifer, groundwater, agricultural irrigation*

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1. Introduction

The increasing demand for domestic and irrigation water is closely linked to population growth, technological advancement, and the intensification of agricultural activities (Gleeson et al., 2020; He et al., 2023). In small island regions such as the Selayar Islands Regency, surface water availability is generally limited and highly dependent on seasonal rainfall variability, making water supply increasingly vulnerable to climate variability and prolonged dry periods. Under such conditions, groundwater plays a crucial role in sustaining agricultural productivity and ensuring water security for local communities (Jasechko & Perrone, 2021).

Groundwater development in island environments is commonly conducted through shallow dug wells tapping unconfined aquifers or drilled wells targeting deeper aquifer systems. However, numerous studies have shown that drilling activities without adequate subsurface characterization often result in low-yield or non-productive wells, particularly in heterogeneous geological settings such as carbonate terrains (Cao et al., 2022; Hussain et al., 2023). This emphasizes the need for effective and reliable preliminary investigation methods capable of delineating subsurface hydrogeological conditions prior to groundwater exploitation.

Among available geophysical techniques, the geoelectrical resistivity method has been widely applied for groundwater exploration due to its effectiveness in mapping subsurface resistivity variations associated with lithology, porosity, and fluid saturation (Loke et al., 2020; Pazdirek et al., 2021). Recent studies indicate that the Schlumberger electrode configuration remains particularly suitable for groundwater investigations in sedimentary and carbonate environments, where resistivity contrasts between aquifer zones and surrounding rocks can be clearly resolved (Adepelumi et al., 2022; Rao et al., 2024).

Despite these advances, research focusing on groundwater potential assessment in small island settings with carbonate-dominated geology remains limited. In particular, there is a lack of site-specific studies in the Selayar Islands Regency that integrate geoelectrical resistivity data to characterize aquifer distribution and determine optimal well depths for agricultural irrigation. Consequently, the spatial configuration and productivity of groundwater-bearing zones in Bungayya Village are still not well understood, hindering sustainable groundwater development in the area.

To address this research gap, this study aims to evaluate groundwater potential in Bungayya Village, Bontomatenne District, Selayar Islands Regency, using the geoelectrical resistivity method with a Schlumberger configuration. The results are expected to provide a scientific basis for identifying prospective aquifer zones and optimal drilling depths, thereby supporting sustainable groundwater utilization for agricultural irrigation in small island environments.

Regionally, the study area is part of the Selayar Member of the Walanae Formation (Tmps), which is composed of massive limestone, coral limestone, calcarenite, and intercalations of marl and sandy limestone. These units are generally white to brownish in color and locally contain mollusk fossils. The total thickness of the formation is estimated to reach approximately ±2000 m. Geomorphologically, the area is characterized by low hills with an average elevation of about 150 m above sea level.

The carbonate and sedimentary lithological characteristics strongly influence the local hydrogeological system, particularly in the formation and development of aquifers.

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2. Method

Location and Time of Study

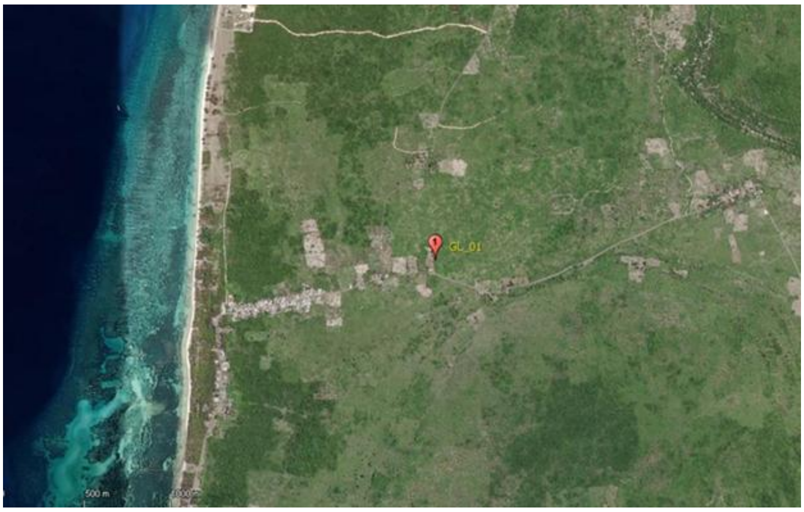

Figure 1. Location of the Study Area

Regionally, the study area belongs to the Selayar Member of the Walanae Formation (Tmps), which consists of massive limestone, coral limestone, calcarenite, and interbeds of marl and sandy limestone. These units are typically white to brownish in color and locally contain mollusk fossils, with an estimated thickness of approximately ±2000 m (Sukamto, 1982). Geomorphologically, the area forms low hills with an average elevation of around 150 m above sea level, developed as a result of uplift and dissolution processes in carbonate rocks (Sukamto, 1982; IAGI, 1994).

Such carbonate and sedimentary lithologies significantly influence the local hydrogeological system, particularly in the formation and development of aquifers. Carbonate rocks and sandstones generally exhibit good porosity and permeability due to fractures, dissolution cavities, and granular textures, making them favorable media for groundwater storage and transmission (Todd & Mays, 2005; Kodoatie, 1996).

Geoelectrical Method

This study employed the geoelectrical resistivity method using the Schlumberger electrode configuration, which is widely applied for subsurface investigations, particularly in groundwater and lithological studies. In this configuration, the spacing of the current electrodes (AB) is progressively increased up to AB/2 = 100 m, while the spacing of the potential electrodes (MN) is maintained relatively constant, following the condition MN/2 ≤ 1/5 AB/2 to ensure adequate sensitivity to vertical variations in subsurface resistivity. This arrangement allows deeper penetration while preserving reliable voltage measurements (Telford et al., 1990; Taib, 2002).

Apparent resistivity values were calculated from the ratio of the measured potential difference (V) to the injected current (I), multiplied by the geometric factor corresponding to the Schlumberger array. The resulting apparent resistivity data were then interpreted to identify subsurface resistivity contrasts associated with variations in lithology, porosity, and groundwater saturation.

Recent studies demonstrate that the Schlumberger configuration provides good vertical resolution and is particularly effective for detecting aquifer layers, lithological boundaries, and water-bearing formations. Its effectiveness in groundwater exploration and subsurface characterization has been confirmed in various geological settings, including alluvial, peatland, sedimentary, and crystalline terrains (Usman et al., 2025; Fadilah, 2025; Kiswiranti et al., 2023). International studies also report successful application of Schlumberger-based vertical

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electrical sounding (VES) for aquifer delineation and hydrogeological assessment in arid and semi-arid regions (Abd El-Dayem et al., 2023; Koah Na Lebogo et al., 2025).

Moreover, recent advances in resistivity interpretation techniques further enhance the reliability of Schlumberger array data for subsurface modeling, enabling more accurate identification of groundwater potential zones and lithological variations (Wardani et al., 2025; Resta & Novrianti, 2025; Jayaputra, 2026).

Data Processing and Interpretation

Geoelectrical measurement data were processed using Res2DInv and NeoResist Geoelectrical Instrument software packages, which are widely used for two-dimensional resistivity data inversion and subsurface characterization. The data processing workflow included apparent resistivity calculation, two-dimensional inversion modeling, and lithological interpretation, based on correlations between inverted resistivity values and regional geological conditions.

Res2DInv applies a least-squares inversion algorithm that iteratively minimizes the root mean square (RMS) error between measured and calculated apparent resistivity values, resulting in a representative subsurface resistivity model with improved reliability and resolution (Loke & Barker, 1996; Loke, 2000). Recent studies confirm that this inversion approach is effective in delineating subsurface structures, aquifer geometry, and lithological contrasts in both sedimentary and carbonate environments (Abd El-Dayem et al., 2023; Kiswiranti et al., 2023; Usman et al., 2025).

The inversion results were interpreted by associating resistivity variations with lithological types, porosity, and groundwater saturation levels, a method that has been extensively applied in aquifer investigations and hydrogeological studies. Low resistivity zones are generally interpreted as saturated or clay-rich layers, whereas higher resistivity values indicate compact limestone, sandstone, or unsaturated formations (Soupios et al., 2007; Khalil et al., 2013). Recent research further demonstrates that integrating resistivity inversion with local geological information significantly enhances the accuracy of aquifer identification and subsurface interpretation (Wardani et al., 2025; Koah Na Lebogo et al., 2025; Fadilah, 2025).

In addition, curve-matching techniques were applied to the vertical electrical sounding (VES) curves to validate inversion results and improve the reliability of subsurface layer identification and aquifer thickness estimation. Although curve matching is a classical approach, recent studies indicate that its integration with modern inversion software provides a robust framework for cross-validating resistivity models and reducing interpretation ambiguity (Orellana & Mooney, 1966; Telford et al., 1990; Resta & Novrianti, 2025; Jayaputra, 2026).

4. Results and Discussion

Subsurface Resistivity Section

The inversion results at sounding point GL_01 indicate resistivity values ranging from 10 to 1515.1 Ωm. Based on these values, the subsurface can be divided into two main layers.

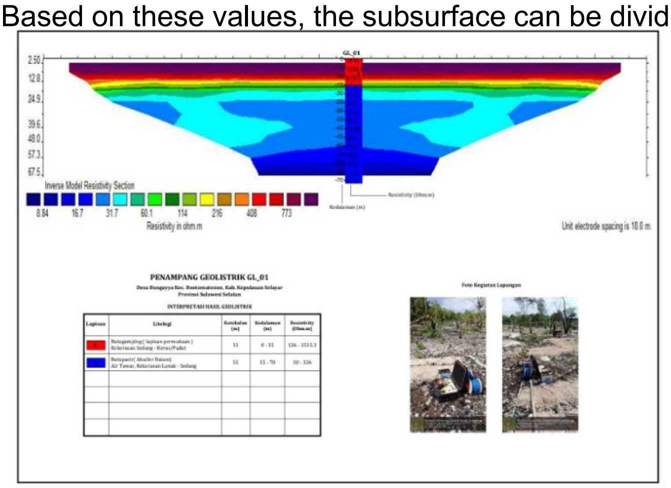

Figure 2. Inverted Geoelectrical Resistivity Section at GL_01

The first layer exhibits relatively high resistivity values (126–1515.1 Ωm) at depths of 0–15 m and is interpreted as compact limestone. This layer has low permeability and contains only a limited amount of groundwater, which is strongly influenced by seasonal conditions.

The second layer shows lower resistivity values (10–126 Ωm) at depths of 15–70 m and is interpreted as sandstone of the Walanae Formation. These resistivity values indicate freshwater-saturated conditions and physical characteristics favorable for a deep aquifer with relatively high and stable discharge potential.

Hydrogeological Implications and Drilling Recommendations

The presence of a water-saturated sandstone layer at intermediate to greater depths indicates significant potential for groundwater development to support agricultural irrigation. Based on the geoelectrical interpretation, drilling is recommended to a depth of approximately 70 m, with well screens installed at intervals of 50–70 m to maximize groundwater yield.

5. Conclusions

Based on the results of this study, the following conclusions can be drawn:

The aquifer layer capable of supplying freshwater for agricultural irrigation in the Bungayya area, Bontomatenne District, Selayar Islands Regency, South Sulawesi Province, is identified as sandstone of the Walanae Formation. This layer exhibits resistivity values of 10–126 Ωm and has the potential to produce groundwater with adequate discharge The geoelectrical interpretation at sounding point GL_01 indicates that groundwater drilling can be conducted to a depth of approximately 70 m, based on the subsurface resistivity distributionpattern.

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