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APPLICATION OF GEOCHEMICAL AND GEOPHYSICAL DATA IN IDENTIFYING THE SUITABILITY OF RAIN RICE FIELDS AT THE SUMATRAN INSTITUTE OF TECHNOLOGY. CASE STUDY: SOUTH LAMPUNG, INDONESIA

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ABSTRACT
South Lampung Regency is the second centre of rice production in Lampung Province based on the 2016 census results. The superior commodity in agriculture in South Lampung Regency is rice. To increase rice productivity, it is necessary to conduct a land suitability study. The purpose of this research is to study the suitability of rainfed lowland rice at the Sumatra Institute of Technology. The methods used are geophysical and geochemical. The results obtained based on the resistivity value showed that the soil in the study area was andosol soil. This fertile soil comes from weathering of tuff rocks. This soil is suitable as a medium for the growth of rainfed rice plants. The land suitability map which based on soil pH and temperature shows that the research area are consists of class S1 (highlysuitable) indicating that the land is suitable and meets the requirements in land suitability and class S2 (moderate suitable) which needs to be fertilized such as organic fertilizers and inorganic fertilizers such as fertilizers. NPK. These results can later be used to prepare ITERA in developing rainfed lowland rice plants.

INTRODUCTION

South Lampung is the second largest rice production center in Lampung Province in the last six years which has increased (BPS, 2016). Jati Agung sub-district is the sub-district with the highest order with the highest number of agricultural business households, namely 10,653 households (Central Bureau of Statistics, South Lampung, 2013). Rainfed lowland rice farming is one of the strategic agricultural sectors that can increase food productivity which is the staple food of the Indonesian population that cannot be replaced (Handayani, *et al*., 2017).

The Sumatra Institute of Technology commonly known as ITERA is located in Jati Agung village, South Lampung based on a geological map included in the Lampung Formation (QTl) with a flat morphology and a thickness of about 200 meters (Mangga, et al., 1993). The Lampung Formation is a Pliocene-Pleistocene formation that is composed of tuffaceous claystone, pumice tuff, tuffaceous sandstone, rhyolitic tuff, and solid tuff (Mangga, et al., 1993). Santoso, et al. (2019) stated that the level of soil fertility around ITERA is from low to moderate.

Rainfed rice fields are rice fields that only rely on rainfall as their irrigation system and are generally barren because of poor nutrients (Amaliah, 2018). Geochemical data such as pH and soil temperature are parameters used in the evaluation of land suitability that has the potential to increase the productivity of rainfed lowland rice (Karimi *et al*., 2018), providing information on land use opportunities as an important prerequisite for land use planning and development (OA, *et al*., 2020). As an agricultural resource, the soil has a function, namely as a supplier of nutrients and as a medium for plant growth (Lestari, 2017). If a plant lacks (deficient) nutrients, it will experience growth disorders and diseases due to nutrient deficiencies. In summary, the correlation between soil pH and nutrient availability is shown in **Table 1**.

Table 1. Relationship of nutrient deficiency (Taufiq, 2014).

Soil pH	Poor Nurient
4-5	Mo, Cu, Mg, B, Mn, S, N, P, K
5-6	Mo, Mg, S, N, P, K, Ca
6-7	Mg
7-8	Cu, B, Fe, Mn, Zn
8-9	Cu, B, Fe, Mn, N, Zn
9-10	Cu, Fe, Mn, Mg, Ca, Zn

Geophysical studies of geoelectrical resistivity methods need to be carried out in this study This is to see what types of lithology make up the soil layer in the research area. Resistivity values are associated with certain geological forms by using known resistivity values of materials, rocks, and soils (Winarni, 2014). From the research that has been done by Santoso, *et al*. (2020) agricultural soil fertility can be measured using magnetic susceptibility and soil pH, if the pH value increases, the magnetic susceptibility also increases. Santoso, *et al*. (2020) only conducted research at several points in ITERA. Therefore, it is necessary to add measurement points to represent land suitability. The purpose of this study was to identify soil types and analyze the suitability of rainfed paddy fields in ITERA.

GEOLOGICAL SETTINGS

The research area of the Sumatra Institute of Technology (ITERA) campus area is located in Jati Agung Village, South Lampung, which is on the border between Bandar Lampung City and South Lampung Regency with an area of approximately 275 hectares (Farishi, *et al*., 2019). The geological condition of the research area can be seen using the Geological Map of the Tanjungkarang Sheet in **Figure 1**.

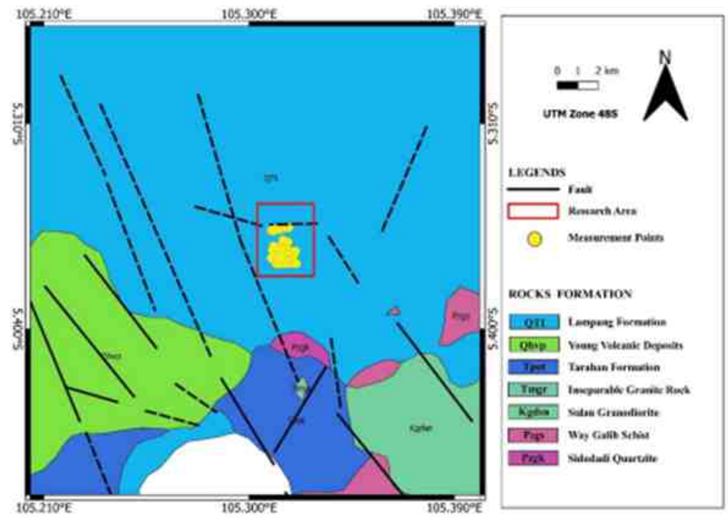

Figure 1. Geological map of the research area (Mangga, et al., 1993).

The research area based on the geological map of the Tanjungkarang Sheet (Mangga, *et al*., 1993) is included in the rock revealed that the Quaternary is Pliocene-Pleistocene which consists of one type of formation, namely the Lampung Formation (QTL). The Lampung Formation is a formation composed of tuffaceous claystone, pumice tuff, tuffaceous sandstone, rhyolitic tuff, and solid tuff. Pumice tuff is yellowish gray to grayish white, coarse-grained, poorly sorted, and composed of pumice and rock fragments (Rizka and Satiawan, 2019). Tuff is composed of rhyolite-dacite, white to brownish in color, volcaniclastic, and closed (Santoso *et al*., 2019). Tuff is also a relatively shallow part of the surface or in the overburden and this rock can act as an aquifer. Fine-grained tuffaceous claystone contain clay, is impermeable and cannot become (Rizka and Satiawan, 2019). Meanwhile, tuffaceous sandstones are yellowish white, medium fine-grained, poorly sorted, subrounded, show a cross structure, and are generally composed of dacite (Santoso, *et al*., 2019) and have permeable properties with good porosity so that they can become depressed aquifers (Rizka *et al*., 2019).

DATA AND METHODOLOGY

The method used in this study is a combination of geoelectric resistivity and geochemical analysis. The resistivity geoelectric method is used to determine the lithology of the constituent rocks that make up the research area based on the resistivity value. The tools used in data collection in the field include ARES resistivity meters, electrodes, cables, hammers, batteries, meters, GPS, generators, and laptops. Software such as Res2Dinv, Surfer, and QGIS is used to convert apparent resistivity data into actual resistivity. The Wenner-Schlumberger configuration is a configuration that uses four electrodes placed in a straight line so that it has a fairly good horizontal coverage and penetration depth. Can be seen in **Figure 2** shows that the distance between the electrodes P1-P2 is a, the spacing between C1-P1 = P2-C2 is na, and the distance between the current electrodes C1 and C2 is 2*na*+*a*, so the electrode spacing is constant.

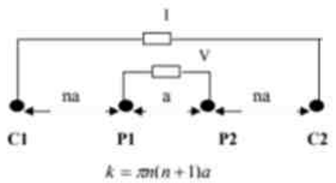

Figure 2. Geological map of the research area (Mangga, et al., 1993).Wenner-Schlumberger configuration electrode arrangement (Unde and Tathe, 2020).

Direct current will flow through a medium, so the ratio of potential difference (V) to current (I) is constant and depends on the medium. This constant is a resistance (R) which is written in the following equation (Supandi, 2021):

$$R = \frac{v}{I} \tag{1}$$

Field data acquisition was carried out in three paths, which can be seen in **Figure 3** which consists of path 1 and path 2 using the length of a stretch of 192 meters parallel to the 48 electrodes and the distance between the electrodes is 4 meters. Track 3, uses a stretch length of 480 meters with 48 electrodes and the distance between the electrodes is 10 meters. The cross-section obtained is a cross-section of the resistivity distribution that describes the subsurface.

Geochemical data used in this study are pH and temperature data to analyse the suitability of rainfed rice fields in the study area. Data retrieval of pH and temperature using a pH meter as many as 56 points in the research area which can be seen in **Figure 3** Surfer software is used in geochemical methods in determining the distribution map of pH and temperature of the research area. Land use suitability analysis is characterized by the process of selecting the most suitable area for land use to create a suitability map for rainfed lowland rice (Everest *et al*., 2021).

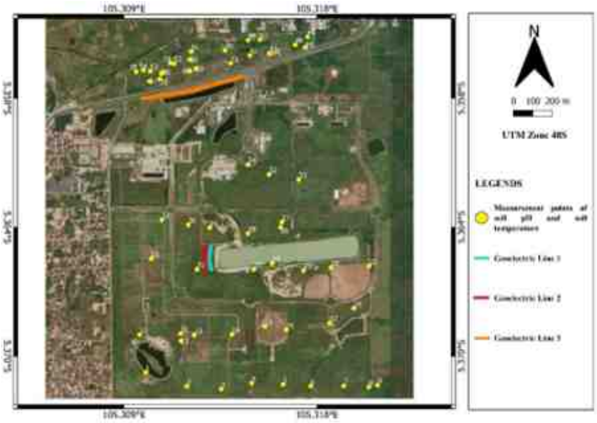

Figure 3. Map of the design of the soil resistivity measurement of the research area.

RESULT

In the field of geophysics, the Wenner-Schlumberger configuration resistivity geoelectric method is used in determining the lithology of the rocks making up the research area where the measurement process is carried out in three paths to represent the research area for measuring geochemical data, namely pH and soil temperature. The data derived from field measurements is the apparent resistivity value which is then processed using the Res2Dinv software, it is hoped that the resulting data can represent the subsurface conditions of the research area (Fikriyah, 2018) using the resistivity reference value contained in **Table 2**.

Table 2. Rock resistivity range in ITERA (Rizka and Satiawan, 2019).

Resistivity Value (Ωm)	Lithology	Description
< 20	Tuffaceous claystone	Fine-grained tuff containing clay. It is impermeable.
20-80	Tuffaceous sandstones	Tuff containing medium-coarse grained sand. It is permeable.
80-150	Tuff	Coarse-grained tuff rock that lies in a relatively shallow part of the surface.
> 150	Tuff	Tuff rock is fine-grained and compact.

The value of soil resistivity is influenced by several factors including soil type, soil depth, and soil temperature (Mandala, *et al*., 2018). Based on the resistivity value range table above, the three paths have the same lithology of constituent rocks, namely tuffaceous clay, tuffaceous sandstone, and tuff with resistivity ranges ranging from 1 - 488 m with different depths on each track.

The results of processing using the Res2Dinv software obtained information that the rocks contained in ITERA have rock types in the form of tuff. For track 1 (**Figure 4**) and track 2 (**Figure 5**) the results obtained tend to be the same. The tuff rock in ITERA consists of tuffaceous clay that has a low resistivity value (<20 m) at a depth of 18 – 36 meters. The low resistivity value is because the measurement area is adjacent to an artificial reservoir so the rock is suspected of having water seepage so that the resistivity continues to decrease in that state. Tufa sandstone (20 – 80 m) at a depth of 1 – 18 meters. Then the tuff is fine-grained and compact (80 – 236 m) at a depth of 7 – 13 meters which is thought to be compressed by the rock layers above it.

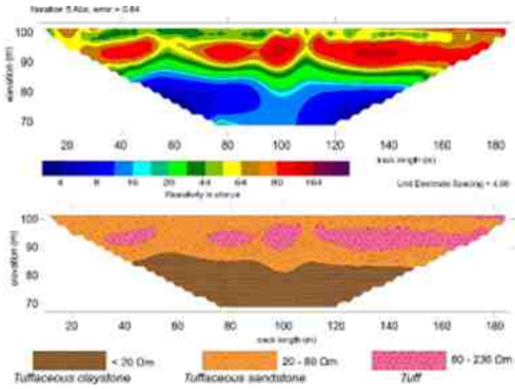

Figure 4. Results of 2D subsurface model representation of track resistivity data 1.

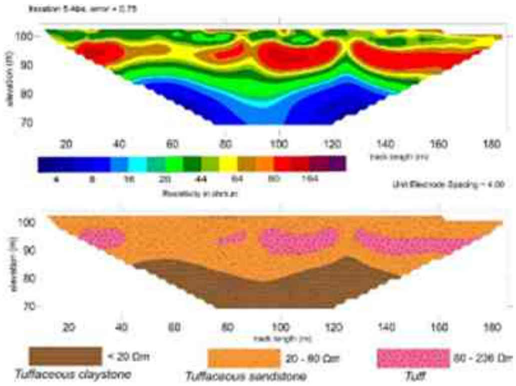

Figure 5. Results of 2D subsurface model representation of track resistivity data 2.

On track 3 (**Figure 3**) there is tuffaceous clay (<20 m) at a depth of 20 – 91 meters. Tufa sandstone (20 – 80 m) at a depth of 1 – 20 meters. Then tuff rocks (80 – 488 m) at a depth of 1 – 14 meters. According to Santoso (2019), the type of tuff in the research area is rhyolite-dacite tuff which is white to brownish in color, volcaniclastic, and closed. After obtaining the rock from the soil, a land suitability

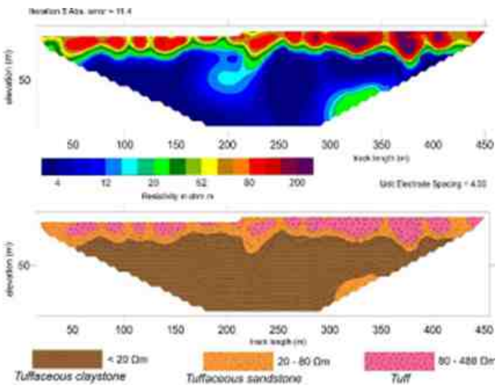

Figure 6. Results of 2D subsurface model representation of track resistivity data 3.

analysis was carried out using the parameters of pH and soil temperature.

According to Muttaqien, *et al*. (2020) determining land suitability for an agricultural crop requires considerations that have their criteria. Classification of land suitability for rainfed lowland rice is carried out by matching several parameters of plant growth requirements, one of which is pH and soil temperature. The results of the land suitability assessment are presented in the form of a land suitability map. The presentation of land suitability classes is based on (FAO, 1976) consisting of class S1 (highly suitable), class S2 (moderate suitable), class S3 (marginal suitable), and class N (not suitable) (Rahmawaty, *et al*., 2019). The criteria for assessing land characteristics for rainfed lowland rice can be seen in **Table 3** below.

 Santoso *et al*.

Table 3. Land characteristics requirements for rainfed lowland rice are based on pH and soil temperature (Wahyunto, et al., 2016).

Land Characteristics	Land Sustainability Class			
	S1	S2	S3	S4
pH (H2O)	5,5-7,0	5,0-5,5 7,0-8,0	5<5,0 >8,0	-
Average annual temperature (°C)	22-25	>25-27 20-<22	>27-29 18-<20	>29 <18

The range of pH values obtained at the time of measurement was from 5.0 – 7.0. According to Salam (2020) at low pH, plants cannot grow and reproduce properly which is directly related to the concentration of H+ indirectly due to various changes in soil chemistry caused. Likewise, at a pH that is too high, plants will be difficult to grow and develop because of the concentrated concentration of OH- ions various changes in soil chemistry caused. The difference in pH values is caused by changes in the solubility of soil constituents with the pH of the environment in the soil (Sutarman and Miftakhurrohmat, 2019).

The distribution pattern of soil pH values in **Figure 7** uses Surfer software where soils that have a pH of 5.0 – 5.5 are called acid soils marked in the black area to the south. Acidic soil caused by low rainfall causes a high probability that the P status in the soil is not available because it is bound by Al and Fe and long-term use of fertilizers (Karamina, *et al*., 2017). Soils that have a pH of 5.6 – 6.5 have slightly acidic soil properties marked in the blue and brown areas in the East and South. Meanwhile, pH 6.6 – 7.0 is neutral, marked in green and cream areas in the West and North. The blue, brown, and green areas are good and suitable for planting rainfed rice so no special treatment is needed, maybe only a little fertilizer containing magnesium (Mg) is needed to provide protein synthesis in the leaves.

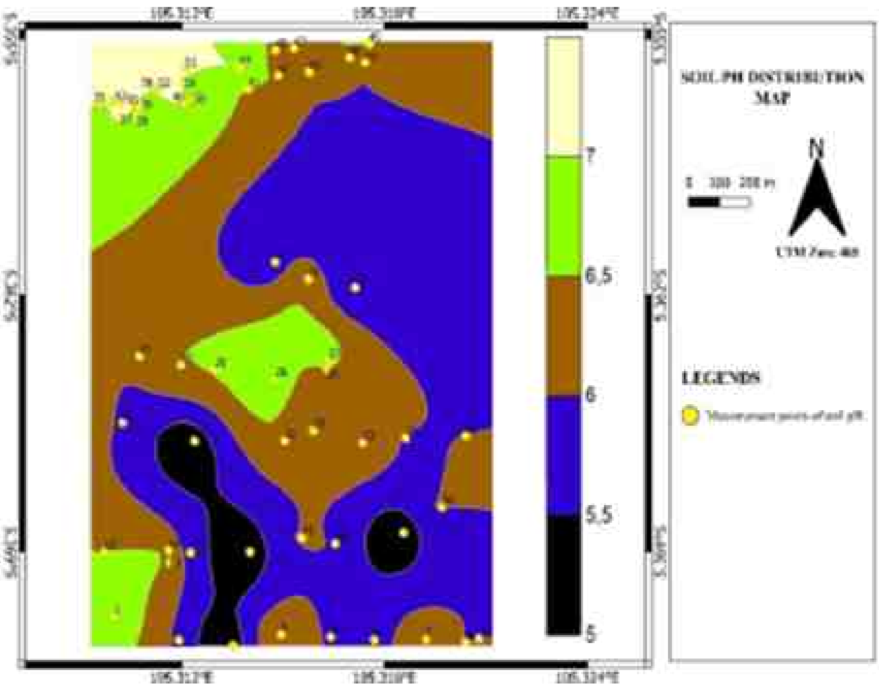

Figure 7. Map of the distribution of soil pH.

The land suitability class map based on soil pH in **Figure 8** consists of the S1 class depicted in the black area on the north and the S2 class depicted in the blue area on the south. Areas with a suitability class of S1 do not have limiting factors so there is no need for special treatment where the land is very feasible and suitable for planting rainfed rice. As for the land suitability class for S2 rice plants based on the Regulation of the Minister of Agriculture Number: 40/2007 recommends the provision of organic fertilizer (manure and straw compost) with a combination of inorganic fertilizer (NPK fertilizer) containing P element so that the availability of P nutrients is available (Trigunasih and Wiguna, 2020) to improve soil conditions and fertility so that they can be upgraded to the S1 class. These elements can affect the physical, chemical, and biological properties of the soil which can increase crop yields, cation exchange capacity, plant P nutrients, and soil pH. Because in rice plants, element P is the main element that is needed.

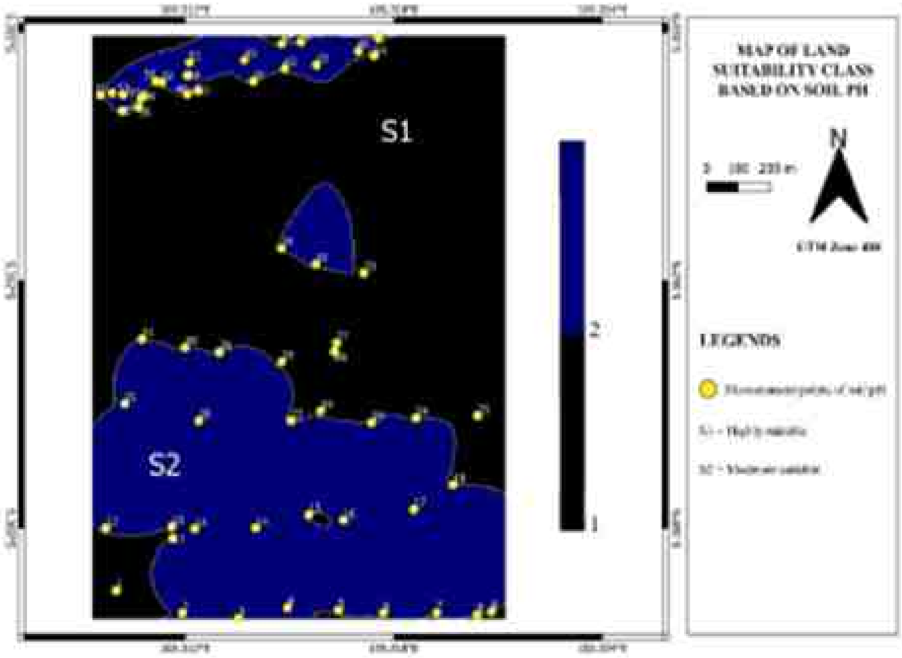

Figure 8. Map of land suitability classes based on soil pH.

Temperature is one of the important factors that affect the process of soil properties involved in plant growth (Onwuka, 2018). Some plants that grow well at high temperatures and some plants that grow well at low temperatures. The higher the soil temperature, the faster the ripening of plants (Ardhana and Gede, 2012).

The distribution pattern of soil temperature values in **Figure 9** uses Surfer software where the soil temperature in the study area ranges from 25 – 32°C. Soil temperature was measured during the day because the soil temperature during the day and night was different. During the day when the soil surface is illuminated by the sun, the air temperature near the ground surface is high while the soil temperature drops at night (Putri, *et al*., 2018) To support the growth of rainfed rice plants according to Putradinantyo, *et al*. (2020) can be seen from the environmental conditions, one of which is the temperature around 24-29°C. This is because temperature affects the absorption of water and photosynthetic nutrients, permeability, permeability, transpiration, enzyme activity, and protein coagulation (Sutarman and Miftakhurrohmat, 2019). According to Meina and Rahmadiningrat (2018), temperatures that are too high cause damage to phytoplankton body tissues, so the photosynthesis process will be hampered. Differences in temperature values in the study area can be caused by external and internal factors. External factors consist of rainfall, wind, humidity, and solar radiation. While the internal factors include soil structure, soil moisture content, soil texture, soil color, and organic matter content in the soil (South and Mosey, 2017).

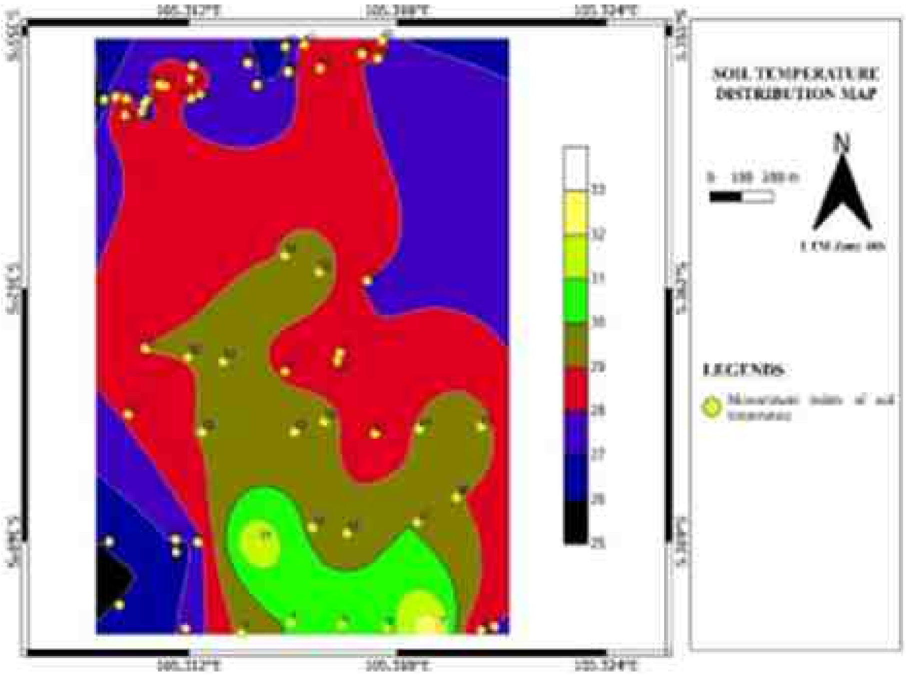

Figure 9. Map of soil temperature distribution.

The land suitability class based on soil temperature according to **Table 3** consists of class S1 which is depicted in the black area to the south which does not need special treatment where the land is feasible and suitable for planting rainfed rice. For the S2 class, it is marked by purple areas in the south and north where it is necessary to water and plant shade trees in the research area and pay attention to light intensity and weather when taking measurements. An S3 class is marked by an area marked by a green area in the south where the limiting factor is very difficult to do, therefore it needs government or private assistance to handle it. For class N in the south, the land is very difficult to handle so the land is not suitable and cannot be planted with rainfed rice.

DISCUSSION

Based on the results of the resistivity 2D subsurface lithology in the study area, the soil in ITERA is weathered tuff rocks of the andosol type (**Figure** 11). This soil is suitable for the growth of rainfed lowland rice (Purbajanti and Sumarsono, 2018).

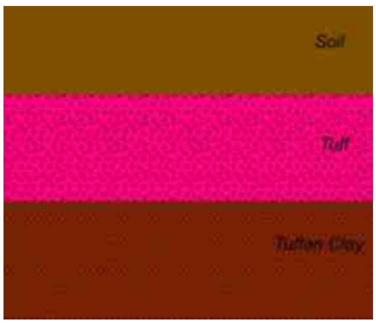

Figure 11. Stratigraphic illustration of the subsurface lithology of the study area.

Based on the results of the land suitability class map of pH and temperature, a new map was made, namely a map of the suitability of rainfed rice fields with a weighting of 75% contribution of pH and 25% contribution of temperature. This is done because soil pH tends to dominate the influence of nutrients contained in the soil, causing pH to be needed for the development of rainfed rice plants. A map of the suitability of rainfed paddy fields based on soil pH and temperature can be seen in Figure 12 below.

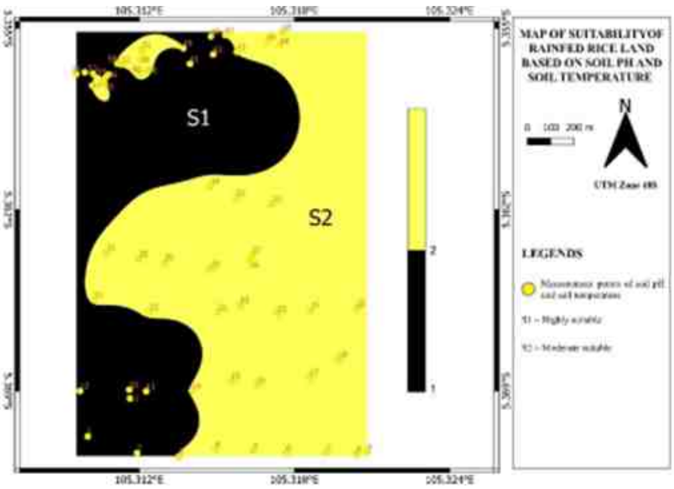

Figure 12. Map of the suitability of rainfed paddy fields based on soil pH and temperature.

After weighting the soil pH and temperature, the soil in the study area is divided into two land suitability classes which can be seen in **Figure 12**, namely S1 class (highly suitable) which does not need to be given special treatment because the land is suitable and suitable for planting rainfed rice according to the pH and temperature. An S2 class (moderate suitable) where on the land farmers can overcome the problems they face so that the land is suitable and suitable for planting rainfed rice, for example, by giving organic fertilizers (manure and straw compost) with a combination of inorganic fertilizers (NPK fertilizer) according to levels to improve soil conditions and fertility. Nutrient deficiency caused by the unavailability of these elements in the soil can be overcome by applying fertilizer. The unavailability of nutrients in the soil can be caused by various processes such as evaporation, erosion, leaching, and loss of nutrients through harvesting. NPK fertilizer as a compound fertilizer is expected to be able to provide the nutrients needed by plants with various nutrient-rich components. This is very possible because NPK fertilizer contains several primary macronutrients such as; Nitrogen (N) 16%, Phosphorus (P) 16%, and Potassium (K) 16%, as well as secondary macronutrients; Magnesium (Mg) 1.5% and elemental calcium (Ca) 5% (Pelawi, 2018). After the weighting that produces a land suitability map based on soil pH and temperature, the planting of plant seeds on the land is ready to be planned according to the direction of the leadership.

CONCLUSION

Based on the results of the 2D subsurface lithology, the resistivity of the soil in the research area is andosol soil originating from weathered tuff rocks which is suitable for the growth of rainfed rice plants. According to the new land suitability map, the soil in the study area is divided into two classes, namely class S1 (highly suitable) and class S2 (moderate suitable). This land is suitable for planting rainfed rice.

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