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Analysis of Land Characteristic and Climate on Coffee Plantations in Mount Pasang Plantation Panti, Jember Regency

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INFORMATION

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ABSTRACT

The characteristics of the land and climate need to be known first before cultivating the soil so that the land can be utilized optimally. Coffee plants have different growing conditions from other plants. The production of coffee plants in the Gunung Pasang Panti Jember plantation has decreased from 2015-2020. This observes pursuits to analyze the land and climate characteristics of coffee plants in the Mount Pasang Panti Jember plantation. The type of research used is descriptive-quantitative with a survey method. Land characteristics data were obtained from direct measurements at the research point. Climate was data obtained from BMKG secondary data. The data obtained will be analyzed descriptively. The findings in this study are the characteristics of the land were still suitable for planting coffee even though there was a limiting factor in the form of an alkaline pH (measurement results between 6-8). The resulting texture is an average of sandy loam, 5-10 RH soil moisture, and high organic matter. Regarding the climate, it can still be tolerated for planting coffee plants. The research carried out during the transitional period between the rainy and dry seasons affects the value of the calculation of rainfall less than usual.

1. Introduction

Soil is one component in a land system that has an important role in land use. Land use that is not under its designation can cause damage to the land. The damage that occurs to the soil is the result of a lack of understanding of the existing soil characteristics so that land use is not appropriate (Sartohadi, et al., 2016). One of the efforts to determine land use to increase crop production yields is to allocate the planting of these plants to suitable land.

Coffee is a type of plantation plant that has been cultivated for a long time and has a high economic value. The requirements and maintenance of coffee plants that are not too difficult make coffee plants the main commodity on plantation land. Coffee cultivation activities are not all land that can be used as coffee plantations and can produce good coffee plant production. This is because coffee plants have growing conditions that must be following the land used. Coffee plants can grow optimally if the place has rainfall between 2,000-3,000 mm/year which also has 3 dry months and sufficient rain. Research Salas et al. (2020) also concludes that climatology, soil, physiography, and socioeconomics are aspects that influence coffee growth.

Panti sub-district is one of 31 sub-districts in Jember Regency, representing hills area influenced by volcanic geomorphic process. Panti sub-district is also a coffee-producing area because most of its area is a plantation area. Based on data from the National Agency of Statistic or Jember Regency in Figures for 2017, 2018, 2019, and 2020, the area and yield of coffee production in Panti District from 2016-2019 fluctuated and was followed by production yields which decreased on average every year. This decrease could be caused by several factors. Problems that occur in coffee plants include several aspects, namely raw materials, production, marketing, and infrastructure. Not only that, the physical condition of the

soil is also a factor that can affect the yield of coffee production as well as its chemical condition. This aspect is an important aspect in the development and productivity of coffee plantations because it affects the growth and yield of coffee production.

One of the plantations that cultivate coffee plants in Panti District to date is the Mount Pasang Plantation which is located in Kemiri Village and Suci Village. The Gunung Pasang plantation is managed by the Regional Plantation Company (PDP) Kahyangan, Jember Regency (Fig. 1). The area of Gunung Pasang Plantation is 1,069,571 hectares which are divided into 4 afdeling. The type of coffee in this plantation is Robusta coffee which is grown at an elevation of about 300-900 masl (meters above sea level).

In addition, the Gunung Pasang plantation has a latosol soil type, where this soil is soil derived from volcanic rocks that have undergone a weathering process. This is also marked by the location of the Mount Pasang plantation at the foot of Mount Argopuro. Andisol soil type formed from volcanic ash parent material and inceptisol soil type is fertile soil. Volcanic soil, latosol or podsol soil, and clay are good soil types for coffee plants (Hartono et al., 2018; Mighty, 2015).

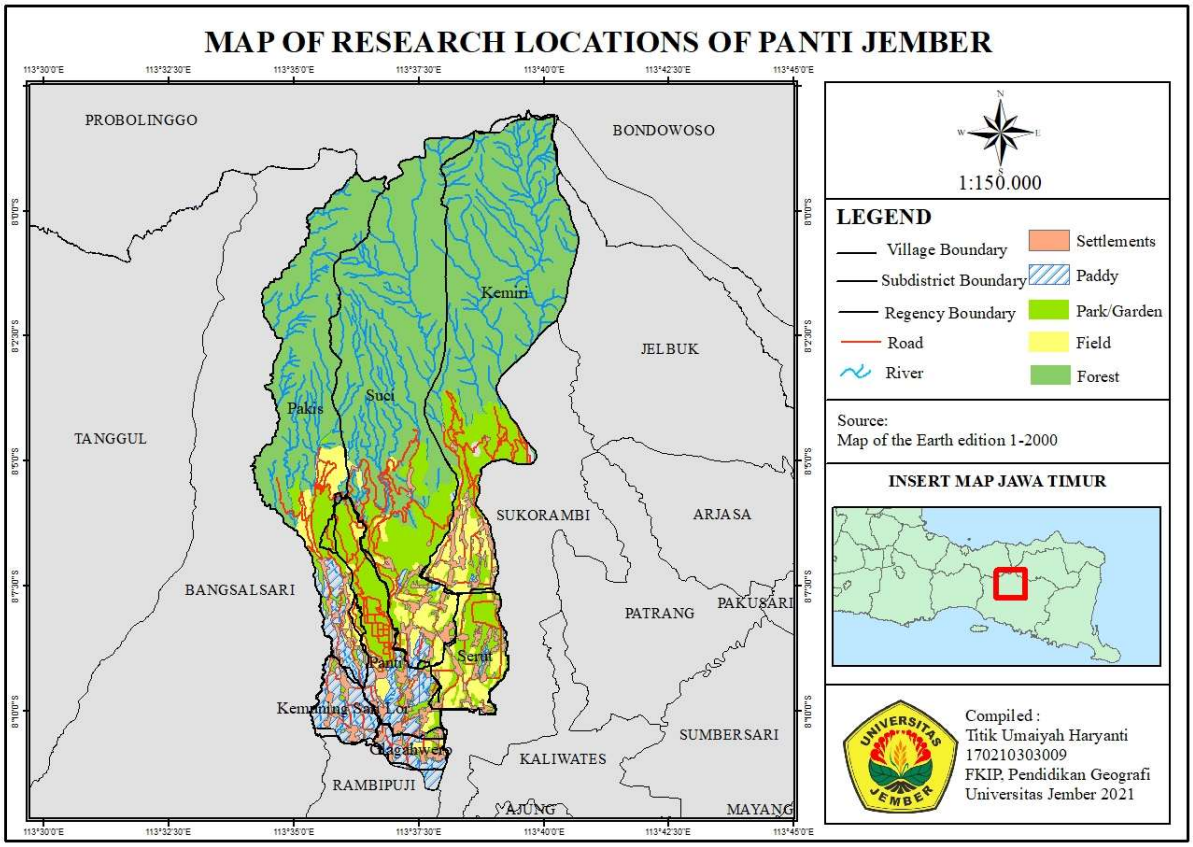

Fig. 1. Research area map

Based on the data of the Gunung Pasang plantation, it could be seen that the coffee production in 2015 was 141,137 kg, in 2016 it was 69,740 kg, in 2017 it was 142,753.5 kg, in 2018 it was 81,889 kg, in 2019 it was 141,045 kg, and in 2020 it was 47,777 kg. This decline in coffee production is a matter that needs to be considered, as it will affect all parties that depend on the activities of the Gunung Pasang plantation.

The cause of the decline in coffee production in the Panti District is the changing weather conditions. Syakir and Surmaini (2017) explained that climate change can directly affect the growth and production of coffee and can indirectly encourage the development of pests and diseases of coffee plants. Therefore, an increase in temperature and a decrease in rainfall can cause coffee production to decrease, which is indicated by the amount of coffee that is not suitable for harvesting or fruit loss.

According to Holyman, et al. (2017) explained that there are 4 limiting factors that affect coffee growth, such as a) high erosion that occurs especially in hilly areas, b) poor yard conditions due to poor drainage, c) low nutrients due to too acidic soil, d) coffee plants forced to grow in areas where the temperature is not suitable.

The findings of Blanco and Aquilar (2015) describe the factors that cause the decline in coffee productivity are improper land cultivation and unsuitable planting for coffee production. In land management, it is hoped that it cannot be separated from the application of fertilizer to the soil. Lack of regional planning to designate potential land for coffee cultivation can disrupt existing ecosystems (Salas López et al., 2020). Based on these conditions, land must be studied further so that cultivation of coffee plants can produce good products and not damage the land used. The level of land

suitability affects the production of crops. According to Bünemann et al. (2018), land evaluation is the first step for sustainable land management, and in countries with low population density, the main purpose of land evaluation is to identify fertile land for agricultural production, while in high population density areas such as Europe, the main purpose is to identify fertile land for agricultural production.

The results of Asharie (2015) related to coffee fields in Jember state that the level of land suitability at the PTPN XII Termite Coffee plantations, PT Kalijompo, and Banjarsengon People's Gardens is an area that is suitable for robusta coffee cultivation with a very suitable class (S1) which is seen from the elevation of the place and the topography of the area. Another study that describes the level of land suitability was conducted by Barus et al. (2015) that not all land is suitable for coffee cultivation.

Based on the explanation above, studies related to soil and climate in volcanic hill areas using GIS applications have not yet been carried out much. An in-depth assessment of the suitability of land is also very necessary to support the development of plantation land, especially in relation to coffee plants. This research aims to analyze the soil characteristics and climatic conditions of Robusta coffee plants in the Gunung Pasang Plantation, Panti District, Jember Regency.

2. Methods

2.1. Methods

The type of research used is descriptive-quantitative research. The research method used is a survey. The field survey was used to identify and measure land in the Gunung Pasang Plantation, Panti District, Jember Regency.

2.2. Samples

The research sample used in this research is purposive sampling technique. Purposive sampling is based on determining specific characteristics according to the research objectives. The number of sample locations studied was 5 location points.

2.3. Data Collection Technique

The data collected in this study consists of primary and secondary data and is quantitative in nature, from which the data will be further analyzed in data analysis. According to Sugiyono (2010) it explained that quantitative data are data obtained by direct measurement or calculation and the data is expressed in numbers. Sources of data in this study are divided into 2, among others.

Table 1. Primary data

No	Data	Data Source	Tool
1	Soil Texture	Survey and measurement	Touch Technique
2	Elevation	Survey and measurement	GPS Garmin Etrex
3	Soil Humidity	Survey and measurement	Soil Moisture Meter
4	Soil pH	Survey and measurement	pH Meter
5	Organic Matter	Laboratory test	Solution H_2O_2 50%

Table 2. Secondary data

No	Data	Data Source
1	Temperature	Meteorology and Climatology Agency of Indonesia
2	Rainfall	Meteorology and Climatology Agency of Indonesia

Table 3. Research indicator classes (Ritung, et al., 2011)

Variable	Indicator	Class
Land condition	Soil texture	Smooth Slightly smooth Currently Rather rough Rough Very smooth
	Soil humidity	Low: 1-4 Medium: 5-7 Height: 8-10
	Soil pH	Very sour: < 4,5 Sour: 4,5-5,5 Slightly sour: 5,6-6,5 Neutral: 6,6-7,5 Slightly alkaline: 7,6-8,5 Alkaline > 8,5
	Organic ingredients	Slight foam : low organic matter Medium foam : medium organic matter Lots of foam : high organic matter

Table 4. Terms of growing robusta coffee plants (Feryy, et al., 2015)

Type	Variable	
Robusta coffee plant growing conditions parameters	Climate	Elevation: 100–600 mdpl Rainfall: 1.250–2.500 mm/th Temperature: 21-24°C
	Soils	Texture: loamy with crumb topsoil structure Humidity: Medium-high Soil pH: 5,5-6,5 Organic matter: Lots of foam

2.3.1. Primary Data

This data can be obtained directly by observing and measuring directly in the field (Table 1).

2.3.2. Secondary Data

Secondary data is data obtained from other sources or did not measure directly. Secondary data serves to support and strengthen primary data (Table 2).

2.4. Data Analysis

The data analysis used is descriptive analysis and classification of data obtained from both direct measurement and secondary data (Table 3).

Table 4 shows climate and soils as a variable to determine terms of growing robusta plants. Climate variable consists of elevation, rainfall, and temperature. Furthermore, soils consist of texture, humidity, soil pH, and Organic Matter.

3. Results and Discussion

The climatic conditions based on secondary data from the Gunung Pasang plantation area, Panti District, show that the climatic conditions are still suitable for coffee plants. The average rainfall and temperature are slightly high (National Agency of Meteorology and Climatology, 2020) because the measurement time is in the dry season. This can still be tolerated; the temperature conditions are also still following the conditions for growing coffee plants. Table 5 shows the results of the secondary data that has been collected. Table 5 shows climate conditions including elevation impact toward rainfall as well as temperature.

Measurements were made on the soil where coffee plants grow in the Gunung Pasang plantation, Panti District, Jember Regency. Measurements made include soil and climatic conditions. Table 6 shows the results of soil texture measurements. The condition of the soil texture of the five research points is dominated by coarse, dusty, sandy soil texture. The soil texture is included in the classification of clay soil texture. By the requirements for growing coffee plants, clay soil texture is a soil texture suitable for coffee plants. Clay soil texture with a crumb soil surface is considered capable of absorbing nutrients well. Table 6 shows soil texture for each study site, presenting different compositions including sandy loam, clay loam, and dusty loam.

Table 5. Climatic condition data results (National Agency of Meteorology and Climatology, 2020)

Location	Coordinate		Elevation (masl)	Rainfall (mm)	Temperature (^{0}C)
	S	E			
P1	08°06.160’	113°37.854’	378	18, 8	25
P2	08°05.559’	113°37.318’	481	6,4	24,4
P3	08°05.302’	113°37.295’	530	14,5	24,6
P4	08°05.279’	113°37.379’	518	21	24,9
P5	08°05.010’	113°37.303’	564	10,3	24,7

Table 6. Soil texture measurement result

Location	Coordinate		Soil Texture
	S	E	
P1	08°06.160’	113°37.854’	Coarse, dusty, sandy (sandy loam)
P2	08°05.559’	113°37.318’	Coarse, dusty, sandy (sandy loam)
P3	08°05.302’	113°37.295’	Fine, gravel (clay loam)
P4	08°05.279’	113°37.379’	Coarse (sandy loam)
P5	08°05.010’	113°37.303’	Smooth (dusty clay)

Measurement results found high soil moisture were shown at point 1 which produced 10 RH and point 4 is 9 RH. Table 7 shows the overall measurement results, representing soil that has high humidity led to the level of water content in the soil, and it able to minimize the possibility of drought.

The lowest humidity obtained at point 5 is categorized as moderate humidity, affected by weather conditions. Table 7 shows results of soil moisture measurement including coordination for each location.

The results of soil pH measurements obtained that the average was neutral, only point 3 and point 5 were alkaline. Based on the conditions for growing coffee plants, good soil for coffee plants is slightly acidic or close to neutral (5.5 – 6.5). The finding that was found during the study of soil

conditions that could still be tolerated for growing coffee plants was point 1. The high pH at the research point could be adjusted by fertilizing/liming to reduce pH levels in the soil.

Table 8 shows soil pH for each location, indicating similar pH that suitable for coffee plants, including coordinate for each location.

We found an average 50% H_2O_2 for organic matter indicator, representing by lot of foam reaction (Table 9). A lot of this foam indicates that the content of organic matter is high. High organic matter content is also characterized by brown soil color. The content of organic matter is very useful for the production of coffee plants. In general, high organic matter has been found for each location, indicating high porosity and permeability.

3.1. Climate Conditions

The first climatic condition is altitude or elevation. The research area has climatic characteristics that are suitable for growing robusta coffee plants. The average altitude of the study area is 400-600 meter above sea level (masl). Following research conducted by Saidi and Suryani (2021) explained that Robusta coffee can grow properly at an altitude of 100-600 meters above the sea. Climate is a soil-forming factor. If in managing the soil using the wrong organic material, as a result, it has an impact on the high levels of heavy metals that are absorbed by plants. The level of salinity will also be proportional to the increase in heavy metals and the soil formation process will certainly be disturbed. Factors that affect the amount of organic matter in the soil are soil aeration, soil moisture, temperature, organic matter properties, and nutrient availability. The temperature in the study area is around 24 °C which is following research conducted by Lopulisa, et al. (2020) which explains that the average temperature of 24 is a suitable temperature for coffee plants. Fig. 2 shows a time series pattern that related to coffee plantation in Mount Pasang Plantation Panti. During peak of rainy seasons, we found that during 2021, run-off indicator was increased compared to previous studies, indicating this area has been influenced by run-off intensity.

Table 7. Soil Moisture measurement results

Location	Coordinate		Soil humidity
	S	E	
P1	08°06.160’	113°37.854’	10 RH
P2	08°05.559’	113°37.318’	7 RH
P3	08°05.302’	113°37.295’	6 RH
P4	08°05.279’	113°37.379’	9 RH
P5	08°05.010’	113°37.303’	5,5 RH

Table 8. Soil pH measurement results

Location	Coordinate		Soil pH
	S	E	
P1	08°06.160’	113°37.854’	7
P2	08°05.559’	113°37.318’	7,5
P3	08°05.302’	113°37.295’	7,9
P4	08°05.279’	113°37.379’	7,5
P5	08°05.010’	113°37.303’	8

Table 9. Organic material measurement result

Location	Coordinate		Organic matter
	S	E	
P1	08°06.160’	113°37.854’	a lot of foam (High)
P2	08°05.559’	113°37.318’	a lot of foam (High)
P3	08°05.302’	113°37.295’	a lot of foam (High)
P4	08°05.279’	113°37.379’	a lot of foam (High)
P5	08°05.010’	113°37.303’	a lot of foam (High)

3.2. Soil Texture

Sand, clay, and dust fractions are the constituent fractions/materials that make up the soil texture. Soil texture on land planted by coffee plants will affect the level of fertility and plant productivity. The productivity of coffee plants is highly dependent on the supply of water and nutrients contained in the soil. The findings found in the research area related to soil texture, the condition of the soil texture in the study area was under the requirements for growing Robusta coffee plants, indicated by clay textured with crumb soil surface conditions. Following research conducted by Estrada et al. (2017) explained that sandy with clay-textured soils are not recommended for use as coffee plantations because clay-textured soils have limited water availability and limited capacity to provide nutrients. The research area which has an average texture of sandy loam is very good in its ability to absorb water because it has a rough soil surface. Coarse texture also has high permeability.

The research point that obtained measurement results in the form of clay texture, coffee plants also continued to grow. In general, clay-texture is not suitable for coffee plants, however

this study found that several coffee plants are growth with this condition. Clay texture is not recommended because it can create runoff and reduce soil resistance (Kurnianto, 2018). The possibility of these abnormalities will have an impact on the resulting coffee production. Soil conditions in the land unit should not have a significant difference. This is because the formation of soil is through a long process. Soil located on a plot of land is produced based on the parent rock that composes the area. The reason why the hat plant continues to grow even in areas with a clay texture is that it is still surrounded by land where most of it is clay textured. Following Kurnianto (2019), it is explained that clay-textured soil comes from the bedrock that has long lithification capabilities and comes from the alluvial plain so that it plays a role in holding water. This ability causes the nutrient content and aeration in the area to be in good condition, however in general, clay-textured is found at alluvial plain with flat slope morphology.

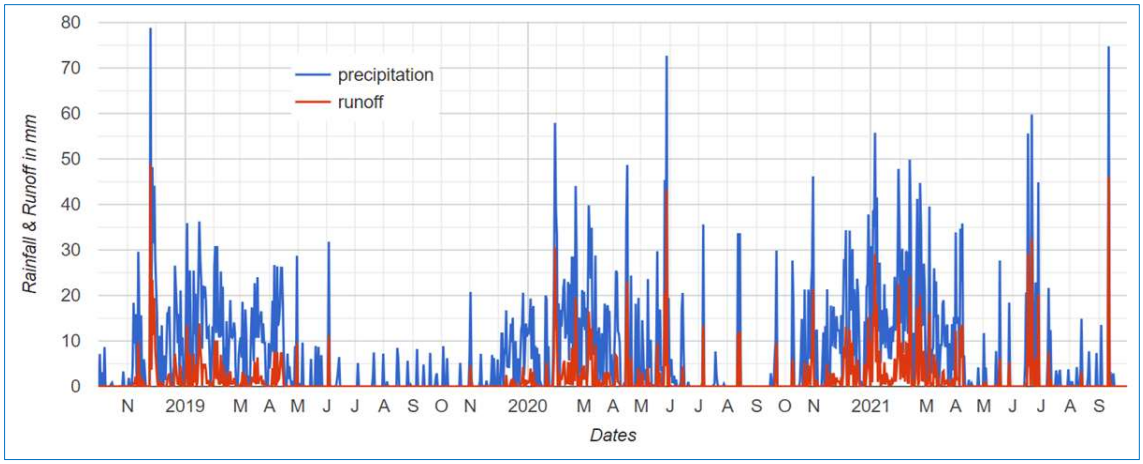

Fig. 2. Rainfall-runoff time series in study area

3.3. Soil Humidity

Soil moisture depends on soil texture with a value of 10 RH, indicating high suitability for soil permeability and dryness level of land. In addition, soil moisture is related to texture of the soil, for example if the soil has a moisture value of 10 RH is indicated the texture is sand. The height of the soil in storing water will affect the level of soil moisture. Factors that affect the humidity of the soil are dominated by climatic factors such as air humidity and temperature (Karamina, 2017). The relationship between air humidity and soil moisture can be found when groundwater rises to the capillary area, it is caused by excessive evaporation in areas that have hot and low humidity and the water enters the soil profile. This situation causes low soil moisture levels. As described above, soil moisture depends on climatic conditions. Knowing in advance how the state of soil moisture is useful for determining suitable soil/land management techniques so that the land can function optimally. The results of the measurement of soil moisture in the research area are relatively moderate due to the timing of the research.

3.4. Soil pH

Soil pH affects the growth of Robusta coffee plants. Rosani, et al. (2020) explained that the high and low acid content of the soil and the value of base saturation also have an impact on plant growth so that the soil pH of land needs to be known. The coffee plant itself requires a slightly acidic soil pH reaction in its growth. Low soil pH can be a limiting factor in coffee growth so that it can affect coffee plant production (Wilson et al., 2015). In the findings, the pH of the soil in the Gunung Pasang plantation was mostly neutral. This condition does not follow the conditions for growing coffee plants where the soil pH must be between 5-6.5 or slightly acidic, but in the study area coffee plants still grow. According to research by Zulfa et al. (2020) coffee plants can grow at a pH of 7 (neutral), however it needs to require several treatments such dregs for coffee to enhance soil quality.

How to maintain the acidity of the soil can pay attention to the organic matter contained therein. The pH at point 4 is a pH above 7, so the soil can be categorized as alkaline and a pH above 7 is also categorized as fertile soil. Organic matter present in the soil and in addition to improving the elements in the soil is the management carried out on robusta coffee plantations. The Robusta coffee plantation in Kemiri Village uses compost fertilizer which has a function as a supporting force to improve soil properties and maintain a stable pH in the soil. Buffer plants around coffee grounds can control pH acidity. Acidic pH tends to have low organic matter, so it is necessary to add organic matter by planting land cover plants.

3.5. Organic Matter

Organic matter present in the soil and in addition to improving the elements in the soil is the management carried out on Robusta coffee plantations. The darker the color of the soil, the higher productivity because it has high organic matter. The presence of soil organic matter will affect the basic properties of the soil, both physical, chemical, and biological (Saptaningsih, 2016). One indicator of soil fertility can be seen from soil that has high organic matter. Organic matter helps provide plants with substances for the formation of soil aggregates helps control erosion and runoff, improves

water-holding and water-passing capacity. Fertile soil tends to have a dark color and this also indicates that the organic matter content in the soil is high. This is in line with the findings of Margolang (2015) that colloids in humus soil cause the color of the soil to be black, where the colloid comes from a high organic matter content, so that most fertile soils are dark black. Organic matter can affect the pH. In line with Dermawan et al. (2018), explaining that the pH that is not following the conditions for growing coffee plants can be overcome by providing organic matter. Another benefit of organic matter is that it makes the soil structure easy to cultivate because organic matter increases soil aggregation.

4. Conclusion

Measurement results obtained from research related to land characteristics for coffee plants, the characteristics of the land for coffee plants were obtained based on the soil texture, dominated by coarse, dusty, sandy soil textures classified as clay soil with high soil moisture of 10 RH. Soil pH resulted in a neutral pH and high organic matter content which was characterized by a large amount of foaming reaction. The climatic conditions at the research site resulted in average rainfall and slightly high temperatures. Land characteristics and climatic conditions indicate that the land in the research location is suitable for coffee plants which are assessed based on the conditions for growing coffee plants.

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Conflict of interests

The authors are not involved in a conflict of interest from funds, personal and institutional or any other relationships from this article.

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