Land suitability assessment for *Coffea arabica* on the land overgrown by *Uncaria gambir*

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**Abstract.** Aornakan I and Kuta Tinggi villages are villages located in Pak-pak Bharat Regency, North Sumatra Province. Currently, the villagers are planting *Uncaria gambir* and *Coffea arabica*. This study aimed to evaluate land for coffee plantations on land overgrown with gambier in Pak-pak Bharat Regency. Sampling was carried out purposively on land overgrown with gambier plants in Aornakan I Village, Pargetteng-getteng Sengkut Sub-district and Kuta Tinggi Village, Salak Sub-district, Pakpak Bharat Regency. The evaluation of land suitability for coffee uses the matching method, namely by analysing laboratory data and data measured in the field with the characteristics of the land for coffee. The results showed that the land evaluation for *Coffea arabica* was marginally suitable (S3) with the limiting factor was the root zone media (rc) in terms of soil texture.

1. **Introduction**

Indonesia is known as a producer of *Coffea arabica* and *Coffea robusta*. Coffee is grown in several areas in Indonesia, such as: Java, Sumatra, Bali, Kalimantan, Sulawesi, Maluku and Papua. Indonesia is also one of the coffee producing countries in the world. Every year Indonesia exports coffee to several countries. Indonesia relies on the largest coffee-producing provinces in Indonesia, one of which is North Sumatra Province. Pak-pak Bharat Regency is one of the regencies in North Sumatra Province that produced coffee. At present, the community in the Pak-pak Bharat plant gambier and coffee with an agroforestry system. Each type of coffee grows based on the requirements of certain land characteristics. *Coffea robusta* is suitable for growing on mineral soils at an altitude of 300-900 meters above sea level, while *Coffea arabica* is grown on mineral soils at an altitude of more than 1,000 meters above sea level [1]. Coffee is very popular in Indonesia, especially for the type of *Coffea arabica*. *Coffea arabica* is the choice of many farmers because it has many advantages over other coffee, such as the process of planting to harvesting which only takes approximately 2 years [2].

Coffee is a type of plant that contains caffeine and can be processed into delicious drinks. Currently, coffee is the most popular drink in the world after water and tea [3]. In addition, coffee is also one of the plantation products that has a fairly high economic value among other plantation crops and plays an important role as a source of foreign exchange for the country [4]. *Coffea arabica* and *Coffea robusta* are the two main species produced in Indonesia [5]. *Coffea arabica* grows in an altitude between 1000-2000 m while the *Coffea robusta* type grows in the lowlands between 400-700 m [1,6].
To increase coffee production in Indonesia, one of the efforts that need to be considered is knowing the suitability of the coffee plantation land. Land evaluation is an assessment of the characteristics of a land to determine the potential of the land, so that the use of the land can be maximized. Land use that is not in accordance with its capabilities can cause land degradation, therefore land evaluation is an important thing to do so that land use is in accordance with its capabilities [7]. Land suitability class is divided into four, namely S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable) and N (not suitable). Class S1 is land with this classification that does not have serious limitations for implementing the required management or only has insignificant boundaries and has no significant effect on land productivity. Class S2, the land has rather serious boundaries to maintain the level of management that must be applied. The existing limiting factors will reduce land productivity and reduce the level of profit. Class S3, the land has serious limitations to maintain the level of management that must be applied. The level of input required exceeds the required requirement exceeds the requirement that has a suitability level of Class S2, although it is still within the limits of normal requirements. Class N, this land has a permanent limiting factor. This limiting factor cannot be corrected [1,7,8].

Various studies on coffee have been carried out both in Indonesia and abroad [2–6]. However, to determine the suitability of Coffea arabica land when planted together with gambier plants, especially in Pak-pak Bharat Regency, it has not been done. Therefore, this study aimed to evaluate the suitability of Coffea arabica on land overgrown with gambier in Pak-pak Bharat Regency. It is hoped that farmers can develop this commodity in accordance with the potential of the land that has been evaluated, so that the production will be obtained. and ultimately can improve the economy and people's welfare.

2. Methodology
This research was conducted in Aornakan I and Kuta Tinggi villages. These two villages are villages located in Pak-pak Bharat Regency, North Sumatra Province. This research was conducted from April 2020 to April 2021. The method used in this research is a survey method that This research was conducted from April 2020 to October 2020. The data used in this study include primary data and secondary data. Primary data was obtained through land surveys and interviews with farmers, while secondary data was obtained from related agencies and literature studies. implementation of this research. Soil sampling was carried out purposively on land overgrown with gambier in Aornakan I Village, Pargetteng-getteng Sengkut Sub-district and Kuta Tinggi Village, Salak Sub-district, Pakpak Bharat Regency.

The evaluation of the suitability of coffee land uses the matching method [1,7–22], namely by matching the data from laboratory analysis and data measured in the field with the characteristics of the land for Coffea arabica. The stages in this research are preparation, determining the location of soil sampling, soil sampling, and laboratory analysis and data analysis. The determination of the sampling location was carried out on land planted with gambier plants by the community. Observations were also made on the morphological properties of the land, the physical properties of the soil and the chemical properties of the soil. To observe the physical and chemical properties of the soil, undisturbed soil samples were taken using a soil sample ring for analysis of the physical properties of the soil. Disturbed soil samples were taken for analysis of soil chemical properties in the laboratory. Soil chemical and physical properties analyzed such as: bulk density, drainage, water availability, permeability, texture, pH H₂O, pH KCl, C-organic, cation exchange capacity (cec). The physical and chemical properties of the soil were analyzed at the laboratory. The physical and chemical properties were analyzed in accordance with the characteristics of the soil needed to evaluate the suitability of coffee plantations. To determine the land suitability class for Coffea arabica, the land characteristics measured from each land were compared (matching) with the criteria for land suitability for Coffea arabica [1]. The characteristics of the land used are the average temperature (°C), altitude, average annual rainfall (mm), drainage, texture, coarse material (%), soil depth (cm), CEC.
(me/100 g), pH H2O, KB (%), C-organic, slope, erosion hazard, inundation, rock on the surface (%), and rock outcrop (%).

According to the land suitability criteria for Coffea arabica [1], the criteria such as: temperature (°C) (S1): 16-20, (S2): 15-16/20-22, (S3): 14-15 /22-24, (N): < 14. Altitude (S1): 1,000-1,500, (S2): 1,500-1,700/700-1,000, (S3): 1,700-2,000/500-700, (N): > 2,000/ < 500. Water availability (wa) Rainfall (mm) (S1): 1,200 1,800, (S2): 1,000-1,200/1,800-2,000, (S3): 2,000-3,000/800-1,000, (N): > 3,000/ < 800. Oxygen availability (oa) (Drainage) (S1): well drained, (S2): moderate, (S3): poorly drained, moderately excessively drained (N): very poorly drained, excessively drained. Root media (rc)texture) (S1): fine, slightly fine, medium, (S2): fine, slightly fine, medium, (S3): slightly coarse, (N): coarse, very fine. Soil depth (cm) (S1): > 100, (S2): 75-100, (S3): 50-75, (N): < 50. Nutrient retention (nr): Soil CEC (me/100g) (S1): > 16, (S2): 5-16, (S3): < 5. Base saturation (%) (S1): > 50, (S2): 35-50, (S3): < 35. pH H2O (S1): 5.6-6.6, (S2): 6.6-7.3, (S3): < 5.5-7.4, (N): < 5.5-7.4. C-organic (%) (S1): > 2.0, (S2): > 0.8-2.0, (S3): > 0.8. (Slope) (S1): < 8%, (S2): 8-15 %, (S3): 15-30 %, (N): > 30 %. Erosion hazard (eh) (S1): very low, (S2): low-moderate, (S3): high, (N): very high.

3. Result and Discussion
The results of land evaluation for Coffea arabica on each land are presented in Table 1 to Table 4. The recapitulation of actual and potential land suitability classes is presented in Table 5 is marginally suitable (S3) with the limiting factor of land being the root zone media (rc). in this case the soil texture.

**Table 1. Evaluation of actual and potential land suitability of Coffea arabica in land 1.**

| Land Characteristic | Field Data/Laboratory | Actual Land Suitability | Potential Land Suitability |
|---------------------|------------------------|-------------------------|---------------------------|
| Temperature (tc)(°C) | 22.07 °C               | S2                      | S2                        |
| Altitude (meters above sea level) | 986                  | S2                      | S2                        |
| Availability of water (wa): | | | |
| Rainfall (mm)        | 2524                   | S2                      | S2                        |
| Oxygen availability (oa): | | | |
| Drainage             | well drained           | S1                      | S1                        |
| the root media (rc) : | | | |
| Texture              | slightly coarse        | S3                      | S3                        |
| Soil Depth (cm)      | 100                    | S1                      | S1                        |
| Nutrient Retention (nr): | | | |
| Cation Exchange Capacity (me/100g) | 18.54                | S1                      | S1                        |
| Base Saturation (%)  | 12.33                  | S3                      | S2                        |
| pH H2O               | 5.69                   | S1                      | S1                        |
| C-Organic            | 3.44                   | S1                      | S1                        |
| Slope (%)            | 13-16%                 | S3                      | S2                        |
| Erosion Hazard (eh)  | high                   | S3                      | S2                        |
| Land Suitability Evaluation | | | |
|                         | S3rc, nr, eh           | S3 rc                   |

Based on Table 1, it can be seen that in land 1, based on data on land characteristics (drainage, soil depth, CEC, pH H2O, C-organic) the land suitability criteria is highly suitable (S1). For land characteristics such as temperature, altitude and rainfall are moderately suitable (S2). For land characteristics in the form of texture, base saturation, slopes and erosion hazard, including marginal suitable (S3). Therefore, the actual land suitability class on land 1 is S3 with the limiting factors being texture, base saturation, slope and erosion hazard. Texture is a limiting factor that is difficult to overcome, so the potential land suitability class on land 1 is S3 with the limiting factor is texture (rc).
Table 2. Evaluation of actual and potential land suitability of *Coffea arabica* in land 2.

| Land Characteristic                      | Field Data/Laboratory | Actual Land Suitability | Potential Land Suitability |
|-----------------------------------------|-----------------------|-------------------------|---------------------------|
| Temperature (t°C)                       | 21.31°C               | S2                      | S2                        |
| Altitude (meters above sea level)       | 913                   | S2                      | S2                        |
| Availability of water (wa):             |                       |                         |                           |
| Rainfall (mm)                           | 2524                  | S2                      | S2                        |
| Oxygen availability (oa):               | well drained          | S1                      | S1                        |
| the root media (rc):                    |                       |                         |                           |
| Texture                                | slightly coarse       | S3                      | S3                        |
| Soil Depth (cm)                         | 100                   | S1                      | S1                        |
| Nutrient Retention (nr):                |                       |                         |                           |
| Cation Exchange Capacity (me/100g)      | 12.67                 | S2                      | S1                        |
| Base Saturation (%)                     | 17.95                 | S3                      | S2                        |
| pH H₂O                                  | 6.203                 | S1                      | S1                        |
| C-Organic                               | 4.48                  | S1                      | S1                        |
| Slope (%)                               | 10-15%                | S2                      | S1                        |
| Erosion Hazard (eh)                     | Currently             | S2                      | S1                        |
| Land Suitability Evaluation             |                       | S3 rc, nr               | S3 rc                     |

Based on Table 2, it can be seen that in land 2, based on data on the characteristics of the land (drainage, soil depth, pH H₂O, C-organic) the land suitability criteria is highly suitable (S1). For land characteristics such as temperature, altitude and rainfall, CEC, slope and erosion hazard is moderately suitable (S2). For land characteristics in the form of texture and base saturation, including marginal suitable (S3). Therefore, the actual land suitability class on land 2 is S3 with the limiting factors being texture and base saturation. Texture is a limiting factor that is difficult to overcome, so the potential land suitability class on land 2 is S3 rc.

Table 3. Evaluation of actual and potential land suitability of *Coffea arabica* in land 3.

| Land Characteristic                      | Field Data/Laboratory | Actual Land Suitability | Potential Land Suitability |
|-----------------------------------------|-----------------------|-------------------------|---------------------------|
| Temperature (t°C)                       | 19°C - 20°C           | S2                      | S2                        |
| Altitude (meters above sea level)       | 980                   | S2                      | S2                        |
| Availability of water (wa):             |                       |                         |                           |
| Rainfall (mm)                           | 2524                  | S2                      | S2                        |
| Oxygen availability (oa):               | well drained          | S1                      | S1                        |
| the root media (rc):                    |                       |                         |                           |
| Texture                                | slightly coarse       | S3                      | S3                        |
| Soil Depth (cm)                         | 100                   | S1                      | S1                        |
| Nutrient Retention (nr):                |                       |                         |                           |
| Cation Exchange Capacity (me/100g)      | 22.58                 | S2                      | S1                        |
| Base Saturation (%)                     | 10.82                 | S3                      | S2                        |
| pH H₂O                                  | 6.55                  | S1                      | S1                        |
| C-Organic                               | 4.50                  | S1                      | S1                        |
| Slope (%)                               | 0-7%                  | S1                      | S1                        |
| Erosion Hazard (eh)                     | Low                   | S1                      | S1                        |
| Land Suitability Evaluation             |                       | S3 rc, nr               | S3 rc                     |
Based on Table 3, it can be seen that on land 3, based on data on the characteristics of the land (drainage, soil depth, pH H$_2$O, C-organic, slope and erosion hazard) the land suitability criteria are highly suitable (S1). For land characteristics such as temperature, altitude and rainfall, CEC is moderately suitable (S2). For land characteristics in the form of texture and base saturation, including marginal suitable (S3). Therefore, the actual land suitability class on land 3 is S3 with the limiting factors being texture and base saturation. Texture is a limiting factor that is difficult to overcome, so the potential land suitability class on land 3 is S3 rc.

Table 4. Evaluation of actual and potential land suitability of Coffea arabica in land 4.

| Land Characteristic                          | Field Data/Laboratory | Actual Land Suitability | Potential Land Suitability |
|---------------------------------------------|-----------------------|-------------------------|----------------------------|
| Temperature (tc)(°C)                         | 18.34 °C              | S2                      | S2                         |
| Altitude (meters above sea level)            | 975                   | S2                      | S2                         |
| Availability of water (wa): Rainfall (mm)    | 2524                  | S2                      | S2                         |
| Oxygen availability (oa): Drainage           | well drained          | S1                      | S1                         |
| Texture                                     | slightly coarse       | S3                      | S3                         |
| Soil Depth (cm)                              | 100                   | S1                      | S1                         |
| Cation Exchange Capacity (me/100g)           | 12.94                 | S2                      | S1                         |
| Base Saturation (%)                          | 21.35                 | S3                      | S2                         |
| pH H$_2$O                                    | 6.36                  | S1                      | S1                         |
| C-Organic                                    | 4.49                  | S1                      | S1                         |
| Slope (%)                                    | 8-13%                 | S2                      | S1                         |
| Erosion Hazard (eh)                          | Low                   | S2                      | S1                         |
| Land Suitability Evaluation                  |                       |                         |                            |

Based on Table 4, it can be seen that in land 4, based on data on the characteristics of the land (drainage, soil depth, pH H$_2$O, C-organic,) the land suitability criteria is highly suitable (S1). For land characteristics such as temperature, altitude and rainfall, CEC, slope and erosion hazard is moderately suitable (S2). For land characteristics in the form of texture and base saturation, including marginal suitable (S3). Therefore, the actual land suitability class on land 3 is S3 with the limiting factors being texture and base saturation. Texture is a limiting factor that is difficult to overcome, so the potential land suitability class on land 4 is S3 rc.

Table 5. Actual and potential land suitability for Arabica Coffea

| Land | Actual Land Suitability | Potential Land Suitability |
|------|-------------------------|----------------------------|
| 1    | S3rc, nr, eh            | S3 rc                      |
| 2    | S3 rc, nr               | S3 rc                      |
| 3    | S3 rc, nr               | S3 rc                      |
| 4    | S3 nr, rc               | S3 rc                      |

The results of the land suitability assessment in each observation area at the research location (Table 5) as a whole can be said that the four observation areas have an actual land suitability class of S3 (marginally suitable) with the limiting factors were rc, nr, eh on land 1 and actual land suitability...
S3 (marginally suitable) with the limiting factor were rc, nr on land 2,3,4. Nr and eh are limiting factors that can be overcome, so that the potential land suitability on these four lands is marginally suitable (S3 (with the limiting factor rc)). The average temperature and altitude on all lands was S2 (Moderately suitable). Based on the previous study Azhar et al. (2021) that in the area, the coffee business was feasible to develop [23]. Aornakan I Village and Kuta Tinggi Village also were assisted villages by the PETAI NGO during coffee production. The assistance provided by the PETAI NGO has a positive effect on people's understanding of the forms of society participation. The assistance provided by PETAI includes events and providing some training [24].

The map of land suitability for Coffea arabica in Aornakan I Village and Kuta Tinggi Village are presented in Figure 1 to Figure 2.

**Figure 1.** Map of actual land suitability for Coffea arabica in Aornakan I Village and Kuta Tinggi Village.

**Figure 2.** Map of potential land suitability for Coffea arabica in Aornakan I Village and Kuta Tinggi Village.

Based on Figure 1 and Figure 2, it can be seen that the actual land suitability class in Aornakan I Village and Kuta Tinggi Village was marginally suitable (S3) with the limiting factors were rc, nr, eh
and the potential land suitability in Aornakan I Village and Kuta Tinggi Village is S3 with the limiting factor was rc. The limiting factor of land suitability class in the form of rc, is also commonly found in several land evaluation research results in the province of Sumatra [15,16,18,19].

4. Conclusion
Land evaluation for *Coffea arabica* in these two villages (Aornakan 1 Village and Kuta Tinggi Village) was marginally suitable (S3) with the land limiting factor was root media (rc) in this case is soil texture. The average temperature and altitude on all land in these two villages is S2 (moderately suitable).

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