Land Suitability Evaluation Of Liberika Coffee On Sub Optimal Land, Langsa Timur Sub District, Langsa, Aceh

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Abstract. In Indonesia so far, Arabica and Liberika coffee are better known, but in fact there is one other type of coffee that has a distinctive taste of jackfruit, namely Liberika coffee. Liberika coffee is known as an adaptive coffee growing in the lowlands. This study aims to assess the land suitability class for Liberika coffee on sub-optimal land. The survey and soil sampling were taken at representative points purposively based on the presence of liberica coffee plants growing at the sampling location. The physical and chemical properties of the soil were observed and analyzed using the specified methods and parameters. The results showed that the actual land suitability class for Liberica coffee was not suitable (N) with the limiting factor of nutrient retention. The potential land suitability class is S2el with a permanent elevation limiting factor.

1. Introduction

Changes in agricultural land to non-agricultural which are increasing due to various factors are the main problems to achieve food security in Indonesia. This condition encourages the community to take advantage of sub-optimal lands that have not been widely used. The main problems of plant cultivation on sub-optimal land are low soil pH, low available nutrients and low soil fertility**.**

One type of agricultural commodity that is adaptive to sub-optimal land is liberica coffee [1]. Farmers in Jambi and Riau have been growing liberica coffee on peatlands since 1940 [2]. In contrast to arabica and robusta that grow in the highlands, adaptive liberica grows in the lowlands [1]. Liberica coffee is able to adapt well to peatlands [3], is more resistant to leaf rust and coffee berry borer pests [4]. In addition, it is also able to bear fruit throughout the year [5]. Another advantage of Liberika coffee is the distinctive taste of jackfruit. So that coffee consumers know it by the name of jackfruit coffee [6].

In Langsa, currently there are many sub-optimal lands that have not been utilized for plant cultivation activities. The land is spread in the Districts of East Langsa, Langsa Lama, and Langsa Baro with conditions experiencing degradation due to pressure from population growth and the ongoing development of the Langsa City. To be sustainable, the land needs to be managed properly. One of the management that can be done is by cultivating adaptive plants with high production.

Liberika coffee was once cultivated by farmers in East Langsa District in the early 1980s which was cultivated on lowland land with varying areas. However, the introduction of oil palm and rubber plants caused the Liberica coffee plants to be cut down and replaced with these two plants. At this time in several villages in Langsa there are still liberica coffee plants that grow wild and are no longer cared for by farmers. In accordance with the Langsa City Qanun No. 23 of 2013 concerning the Langsa City Spatial Plan, that East Langsa District is an area for the development of the agricultural

sector in Langsa City. This is one aspect of legality that can support the cultivation of Liberika coffee plants in East Langsa District.

Before cultivating liberica coffee to become one of the main commodities of plantation crops on sub-optimal land in Langsa City, it is necessary to first carry out an assessment of the suitability of the land. Where in land management requires land suitability assessment to ensure that land can be used productively and sustainably [7]. Land evaluation based on land suitability is important in planning agricultural land use [8] , appropriate land use [9], and efficient use of agricultural land [10].

Evaluation of land suitability is useful for determining locations that have positive characteristics in relation to the success of their production or use [11], systematic grouping of land into certain units according to the characteristics that are potential and obstacles in the use of it systematically. sustainable. The purpose of evaluating the suitability of agricultural land is to predict the potential and limiting factors for crop production [12; 13]. This study aims to assess the land suitability class for Liberika coffee on sub-optimal land in East Langsa District, Langsa, Aceh.

2. Methods

2.1 Place and Time Research

This research was conducted in East Langsa Sub District, Langsa, Aceh. This research was conducted for 6 (six) months, starting in April - September 2022.

2.2 Analysis method

Soil Sampling Point

Soil sampling was carried out in areas covered by liberica coffee, then a soil sampling map was made. This map contains 5 sampling points generated from the existing land use, adjusted to the map scale. This map is used as a reference in soil survey and land observations, especially in determining the soil observation points.

2.3 Soil Survey and Land Observation

Soil survey tools used are as follows: soil drill, digital soil pH, soil knife, hoe, machete, camera and tally sheet and writing utensil. The materials used include: soil profile cards, plastic bags, rubber binders, paper labels, maps (administration, slopes, soil types and land cover), climate data from the Central Statistics Agency for Langsa City for 10 years (2011–2020), and soil samples for laboratory analysis. Soil survey method by observing soil properties at 5 points of soil sampling. Field observations were carried out to take soil samples and to determine land characteristics such as elevation and slope. Approximately 1 kg of soil sample is taken for laboratory analysis.

2.4 Soil Laboratory Analysis

Soil samples were air-dried for 3 days at room temperature and then filtered through a 2 mesh sieve. Soil reaction parameters (pH H_2O) were determined with a pH meter extracted in a 1:2.5 soil and water solution. Organic carbon content and available N were measured using the Walkley and Black method; and Kjeldahl method; available P content was calculated using the Olsen method, Cation Exchange Capacity (CEC) was evaluated with 1N NH4OAc pH 7.0 (ammonium acetate) on a dry sample of 105°C, and base saturation was calculated. All soil data and selected land characteristics data are entered into a spreadsheet.

2.5 Land Suitability Assessment and Interpretation Data

Land suitability assessment is carried out by comparing the characteristics and quality of the land based on the criteria developed by [14] (Table 1) to select the actual land suitability class and limiting land use factors. This indicates that the land will be classified into one of the suitability classes very suitable (S1), moderately suitable (S2), marginally suitable (S3) , or not suitable (N). Furthermore, optimization of the limiting factor of the actual land suitability class is carried out to obtain a potential land suitability class.

Table 1. Selected land suitability criteria for Coffea liberica

Land use requirements/ land characteristics	Unit	Land suitability class			
		S1	S2	S3	N
Climate					
Annual rainfall	mm	1.500–2.000	1.250 2.000-2.500	1.250 2.000–3.000	<1.000 >3.000
Dry month length (<60 mm/month)	bulan	2-3	3-4	4-5	>5
Elevation	m asl	300–500	600–800; 0–300	1-2 800–1.000	<1 >1,000
Slopes	%	0–8	8–25	25–45	>45
Soil Physical Properties					
Effective depth	cm	>150	100-150	60-100	<60
Texture (pipette)		Sandy loam, Clayy loam, Dusty clay,	Loamy sand, Sandy clay, Dusty clay	Sandy clay	Dusty clay Sand, Heavy clay
Soil Chemical					
Soil Reaction (pH H_2O Extraction)		5.5–6.0	6.1–7.0	7.1–8.0	>8.0
C-organic (Walkley & Black)	%	2–5	1–2; 5–10	0.5–1.0; 10–15	<0.5; >15
N availability (Kjeldahl)	%	>0,21	0,1-0,2	<0,1	-
P availability (Bray II)	ppm	>16	10–15	<10	-
Cation exchange capacity (NH4.OAc pH 7 Extraction)	cmol kg^{-1}	>15	10–15	5–10	<5
Base saturation (NH4.OAc pH 7 Extraction)	%	>35	20–35	<20	-

Source: [14]

Remarks: S1 = highly suitable, S2 = moderately suitable, S3 = marginally suitable, N = not suitable, m asl = meters above sea level, ppm = part per million

3. Results and Discussion

3.1 Biophysical Condition of Research Site

The average air temperature in Langsa City for a period of 10 years (2011-2020) is 26.60 C, with the maximum temperature occurring in June, which is 32.6o C and the minimum temperature occurring in February, which is 22.2o C. The average annual rainfall is 1,535 mm with the lowest rainfall of 1,093 mm and the highest of 1,744 mm. The highest monthly rainfall during this period occurred in September, namely 340.12 mm and the lowest rainfall occurred in February, which was 60.57 mm. The peak of the rainy season occurs in October-November-December (OND), while the peak of the dry season occurs in April-May-June (AMJ). Monthly average rainy days are 13 days, a maximum of 20 days in November and a minimum of 7 days in February with a dry month of 2 months/year [15]. Based on the climate classification, the Langsa City area belongs to the C climate type (slightly wet) with a Q value of 46.34%. According to [16], the rainfall required for Liberika coffee ranges from 1,250 – 3,500 mm/year. The dry month (rainfall less than 60 mm/month) is about 3 months/year with a slope of less than 10%.

The slope class data of the research location was obtained from the Topographic Map with a scale of 1:50,000. Based on the slope class map, the slope class of the research location ranges from 0-8%. The elevation ranges from 10 – 30 meters above sea level.

3.2. Soil Physical and Chemical Properties

a) Physical Properties of Soil

Soil physical properties are one of the important factors in considering soil classification and mapping, soil and plant management and land suitability classification. The results of measurements in the field showed that the effective depth at the study site ranged from 110 - 160 cm. The results of

laboratory analysis showed that the soil samples at the study site had four texture classes, namely Silty clay loam, Loam and Silt loam (Table 2). According to [16] the effective depth for Liberica coffee >150 cm with loamy soil texture is a suitable condition for the cultivation of Liberica coffee plants.

Table 2. Physical properties of the soil at the research site

Point of View Code	Effective Depth (cm)	Texture (%)			Texture Class
		Clay	Dust	Sand	
1	155	25	67	8	J
2	110	3	58	39	H
3	160	47	32	21	G
4	120	1	60	39	E
5	130	1	84	15	H

Remarks: E, G, H, J (Silty clay loam, Loam, Silt loam)

b) Soil Chemical Properties

The results of the analysis of the chemical properties of the soil at each observation point are presented in Table 3. The reaction of the soil H_2O (actual soil pH) at each observation point ranged from 3.01-3.80. Soil acidity (pH) can be used as a measure of the availability of nutrients and the level of activity of microorganisms and the toxicity of certain nutrients to plants. From the results of the analysis shown in Table 3, soil pH which is categorized as acidic dominates all observation points.

Soil reactions are closely related to nutrient solubility, plant tolerance, nutrient absorption, micro-organism activity, and ion fixation in the soil. According to [17] if the soil is too acidic, nutrient absorption and plant growth are generally less than optimal. In acid soils, plants are usually deficient in P (due to fixation) and micro-nutrients, such as Zn, B, and Mo.

Table 3. The results of the analysis of the chemical properties of the soil at the research site

Point of View Code	Soil Reaction pH H_20 (1:2,5)	C-Organik (%)	N-Availability (%)	P-Availability (mg/kg)	Cation Exchange Capacity (cmol/kg)	Base saturation (%)
1	3,14 A	4,26 VL	0,21 VL	0,20 L	20,40 L	10,15 L
2	3,20 A	1,85 VL	0,08 L	0,60 L	16,80 L	10,48 L
3	3,80 A	1,36 VL	0,13 VL	0,85 L	13,20 L	32,27 M
4	3,01 A	3,41 VL	0,11 VL	1,05 L	18,80 L	9,89 L
5	3,43 A	4,36 VL	0,32 L	0,80 L	22,40 L	10,36 L

Remarks: A= acid; M= moderate; L = low; VL = very low

Table 3 also shows that the results of soil analysis at each observation point have C-organic and N-total values ranging from 1.36-4.26% and 0.08-0.32% which are included in the very low and low criteria. As for the available P value, it ranges from 0.20 to 1.05 mg kg-1 which is classified as low. The levels of available P in the soil are generally low and vary by soil.

The value of Cation Exchange Capacity (CEC) ranged from 13.20-22.40 cmol kg-1 which was classified as low. [18] stated that one of the factors that affect the CEC value of the soil is the humus content of the soil and the type of clay minerals. A low CEC value indicates that the soil fertility is low. The low value of CEC is thought to be due to the low content of organic matter at the research site. According to [19], soils with moderate to high organic matter usually have a relatively higher soil CEC than soils with low organic matter.

The Base Saturation Value (BS) ranges from 9.89-32.27% which belongs to the low criteria. The low base saturation at the study site was caused by the low pH of the soil. [20] stated that acidity will decrease and fertility will increase with increasing family planning. The rate of release of trapped cations for plants depends on the BS level of the soil. The BS value of soil ranging from 50% -80% is classified as having moderate fertility and the BS value <50% is said to be infertile.

3.3 Classification of Land Suitability Criteria for Liberica Coffee Plants

The suitability of the liberica coffee land was assessed based on the characteristics of the land. After all the characteristics of the land are assessed and then compared with the criteria or requirements for growing Liberika coffee plants based on the criteria developed by the [14] in order to obtain the actual land suitability class, limiting factors, improvement of limiting factors, and potential land suitability at each observation point in the location study.

3.4 Assessment of Actual and Potential Land Suitability Class

The results of the analysis of land suitability classes for Liberika coffee plants at the study site are presented in Table 4. The land suitability criteria used are divided into two criteria, namely soil physical properties and soil chemical properties. In terms of land suitability analysis, the chemical properties of the soil become the first priority to be considered, then only the physical properties of the soil [21].

Table 4. Land suitability for Liberica Coffee

Land use requirements/ land characteristics	Land suitability class				
	LGS1	LGS2	LGS3	LGS4	LGS5
Climate					
Annual rainfall	S1	S1	S1	S1	S1
Dry month length (<60 mm/month)	S1	S1	S1	S1	S1
Elevation	S2	S2	S2	S2	S2
Slopes	S1	S1	S1	S1	S1
Soil Physical Properties					
Effective depth	S1	S2	S1	S2	S2
Texture (pipette)	S1	S1	S1	S1	S1
Soil Chemical					
Soil Reaction (pH H_2O Extraction)	N	N	N	N	N
C-organic (Walkley & Black)	S1	S2	S2	S1	S1
N tersedia (Kjeldahl)	S1	S3	S2	S2	S1
P availability (Bray II)	S3	S3	S3	S3	S3
Cation exchange capacity (NH4.OAc pH 7 Extraction)	S1	S1	S2	S1	S1
Base saturation (NH4.OAc pH 7 Extraction)	S3	S3	S2	S3	S3

Remarks: S1 = highly suitable, S2 = moderately suitable, S3 = marginally suitable, N = not suitable, m asl = meters above sea level, ppm = part per million

3.5 Actual Land Suitability Class

The results of the analysis of the actual land suitability class at the research site are presented in Table 5. From Table 5 it can be seen that at the five observation points that have been carried out, the results of the evaluation of the actual land for liberica coffee plants obtained that the adjustment class is N with the limiting factor of soil chemical being nutrient retention (nr). This is due to the pH value of the soil which is classified as acidic. The low pH value of the soil in the study area was caused by the intensive level of leaching.

Table 5. Results of land suitability analysis for Liberica coffee

Point of View Code	Conformity Class Actual	Limiting Factors	Repair Effort	Conformity Class Potential Land
1	Nnr	nutrient retention	+; ++	S2el
2	Nnr	nutrient retention	+; ++	S2el
3	Nnr	nutrient retention	+; ++	S2el
4	Nnr	nutrient retention	+; ++	S2el
5	Nnr	nutrient retention	+; ++	S2el

Keterangan : 1. Limiting Factors; nr = Chemical Properties.
2. Improvement of Limiting Factors : + = Liming, ++ = application of urea, phosphate and potassium, Mn, Cu and Fe fertililizers;
3. el = elevation

3.6 Assessment of Potential Land Suitability Class

Potential land suitability is land suitability where improvement or conservation efforts have been made to increase the land suitability class so as to eliminate the limiting factor that caused the previous suitability class to be low [22]. Improvement efforts made must be in line with the level of land suitability assessment to be carried out. The results of the assessment of potential land suitability classes for liberica coffee plants at the study site are presented in Table 5.

Potential land suitability classes can be increased by providing technological inputs that can minimize the influence of existing limiting factors. There are three levels of technology that can be applied, namely: Low input (Li), Medium input (Mi) and High input (Hi). Land improvement efforts at the research site are carried out based on the classification of the existing limiting factors. There are various kinds of limiting factors that exist in the field, some can be improved and some are permanent. Improvement efforts were made so that the cultivation of Liberika coffee plants at the research site could be carried out and produce optimal results.

The results of the assessment of potential land suitability at the study site at all observation points became the main limiting factor that caused the land to be unsuitable for use, namely nutrient retention (acid soil pH). Of the five observed sample points of observation, potentially all sample points can still be upgraded with the given technological input. Nutrient retention at all sample points causes the actual land suitability class to be N. The N suitability class can be increased to S2 suitability class if the land to be developed for Liberika coffee cultivation is improved by giving dolomite lime (contains a lot of $CaCO_3$ and MgO_3) which is a base source, as well as the addition of urea, phosphate and potassium fertilizers. Low nutrient availability can be ameliorated through fertilization on liberica coffee plants by maximizing nutrient absorption by coffee roots and minimizing nutrient loss from the coffee root zone [23]. According to [24], land management can be accomplished by adding organic matter and fertilizing according to the recommended fertilizer dose.

All sampling points, the actual land suitability class is S2el, in this case no improvement can be made because the elevation limiting factor cannot be changed and is permanent so that the potential land suitability class remains S2el. To increase production yields based on the suitability of the land, it is necessary to improve the limiting factors, such as the ability of the soil to hold nutrients which are relatively low due to the influence of soil pH (nr), so lime is needed to increase the ability of nutrient retention. With this improvement effort, it is possible to increase the actual land suitability from unsuitable (N) to quite suitable potential land suitability (S2). As for the condition of elevation (el) it cannot be repaired.

Technologies that need to be applied for the development of Liberika coffee at the research site include: lime application and addition of organic matter to increase nutrient retention ability, complete

fertilization to increase nutrient availability and water management. Water management is a very important thing in the management of agricultural land. This water system regulation is not only to reduce or increase the availability of surface water, but also to reduce soil acidity, prevent acidification of the soil due to the oxidation of the pyrite layer, prevent salinity hazards, flood hazards, and wash off toxic substances that accumulate in the root zone of plants [25].

For the development of Liberica coffee at the research site, there are factors limiting the growth and production of Liberica coffee, including the availability of low to very low Urea, phosphate and Potassium nutrients, low nutrient holding capacity of the soil due to cation exchange capacity, base saturation, and low organic matter content. and high soil acidity. To overcome this problem, fertilization is carried out on Liberika coffee plants with a frequency of twice a year, in the form of inorganic fertilizers containing elements of Urea, phosphate and Potassium, Mn, Cu, and Fe at a dose of 300-400 g/tree/semester and added 500 g of lime. /tree/semester [1]. The recommended fertilization method for coffee plants in principle seeks to maximize the application of nutrients contained by fertilizers by coffee roots, and minimize nutrient loss from the coffee root zone. An effective way is to cover the coffee disc area that has been fertilized with mulch [26].

4. Conclusions

The results of the evaluation of the actual land for liberica coffee plants obtained that the adjustment class is N with the limiting factor of soil chemical being nutrient retention (nr). Efforts to improve class N with the addition of lime/dolomite, organic matter and fertilization can be increased to a fairly appropriate class (S2). All sampling points, the actual land suitability class is S2el, in this case no improvement can be made because the elevation limiting factor cannot be changed and is permanent.

5. Acknowledgements

Thanks expression delivered to the Rector of Universitas Samudra and Institute for Research and Community Service and Quality Assurance Universitas Samudra for the cost this research, through Grant Donation Program of Fundamental Research Fund at Universitas Samudra year 2022

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