Estimated Yield Potential of Robusta Coffee (*Coffea canephora* Pierre ex A. Froehner) at Bogor District

Ade Astri Muliasari[1*], *Helianthi* Dewi[2]

[1]Technology and Management of Plantation, College of Vocational Studies. Bogor Agricultural University, 16128 Indonesia
[2]Ecotourism, College of Vocational Studies. Bogor Agricultural University, 16128 Indonesia

Abstract. Bogor District is one of the Robusta coffee (*Coffea canephora* Pierre ex A. Froehner) producing areas in West Java. To estimate crop yield of Robusta coffee, planters usually count the amount of a given crop harvested in a sample area. Then the harvested crop is weighed, and the crop yield of the entire field is extrapolated from the sample. Recently by utilizing the geographic information system (GIS) used to determine the level of regional suitability combining with land productivity. It will help in analysing, planing and taking various policy for development Robusta coffee. This study aimed to estimate of yield potential of Robusta coffee. This research was conducted from November to December 2020 at Bogor District. The land suitability class for Robusta coffee in Bogor which was in the moderately suitable (S2) class of around 2% (5,227.78 ha), marginal (S3) 33% (99,189.20 ha) and not suitable (N) 65% (194,808.40 ha). The yield potential of Robusta coffee is obtained 105,030,473.1 kg or 105,030.47 tons. The highest yield potential of Robusta coffee is in Cigudeg and Sukamakmur subdistricts.

1 Introduction

Coffee has been viewed as a tropical commodity that links producing countries of coffee along the equator that's affects substantial policies and investments to sustainably manage economic and environmental resources for the coffee sector, increase export earnings, and ensure stable production have had a tremendous role in country's integration into and success in the global market. Two main species of coffee are of economic importance worldwide: *Coffea Canephora* Pierre ex A. Froehner and *Coffea arabica* L. Viet Nam, Brazil, Indonesia, Uganda and India are the five largest producers of Robusta coffee. Robusta coffee is considered to be easier and less costly to produce. It produces fruit more quickly and yields more per tree than Arabicas. Robusta has a stronger, harsher, and bitter taste, and contains twice as much caffeine as Arabica beans [1].

About 60% of the total coffee production has been exported to various countries. Currently, the national coffee production is still dominated by robusta coffee which reaches 90% [1]. Total production of robusta coffee in Indonesia reached 534,360 tons from 896,680 hectares (ha) with an average productivity value of 0.562 tons/ha/year in the last five years

[2]. In many tropical and subtropical regions, climate change is fast becoming an environmental disaster for farmers, with decreased water availability, new or altered insect and pest pressures, and increased risks of extreme events threatening crop yields and farmer livelihoods [3].

Bogor district is one of the Robusta coffee producing areas in West Java Province, Indonesia. The area of coffee plantations continued to increase to 6,407.70 ha in 2019. Currently, the area of Robusta coffee reaches 5,833.70 ha with produce 3,698,381.19 kg coffee beans. Areas of Robusta coffee are located in Sukamakmur, Tanjungsari, Cariu, Tenjolaya, Babakan Madang, Cigudeg, Jasinga, Pamijahan [4].

Estimated of crop yield is important for planing and taking various policy decisions. To estimate crop yield of Robusta coffee, planters usually count the amount of a given crop harvested in a sample area. Then the harvested crop is weighed, and the crop yield of the entire field is extrapolated from the sample. Generally, use the conventional technique of data collection for crop monitoring and yield estimated based on ground-based visits and report. Recently by utilizing the geographic information system (GIS) used to determine the level of regional suitability combining with land productivity. It will help in analysing, planing and taking various policy for development Robusta coffee. This study aimed to estimated yield potential of Robusta coffee based on potential land and productivity of Robusta coffee.

2 Materials and Method

The research was held from July to December 2020 at Bogor, West Java. This research was conducted based on Digital Elevation Model (DEM), agroclimate, soil physical/chemical properties, land use and socioeconomics parameter such as protected area, lake, road, river by utilizing GIS. The input data is processed using an interpolation and classification process based on the land suitability criteria of each parameter (Table 1) [5]. Overlays are maps of various themes that can be overlapped to produce new mapping units with new information [6].

After obtaining land suitability, then the appropriate land potential, the next step is to combine it with land productivity data so as to produce an estimate of the potential yield of Robusta coffee. Figure 1 is the flowchart illustrating and procedure for the data analysis land suitability of Robusta coffee. Figure 2. Flowchart and procedure for estimated yield potential of Robusta coffee.

Table 1. Land suitability class criteria for Robusta coffee

Land characteristics	Land Suitability Class			
	Very suitable (S1)	Suitable (S2)	Marginal suitable (S3)	Not Suitable (N)
Agroclimate				
Rainfall (mm)	1,500-2,000	2,000-2,500	2,000-3,000	<1,000 >3,000
Dry month (<60 mm/month)	2-3	3-4	4-5 1-2	<1>5
Altitude (m above sea level)	300-500	500-600	600-700	> 700
Slope (%)	0-8	8-25	25-45	>45
Soil Physical properties				
Effective depth (cm)	>150	100-150	60-100	<60

soil texture	sandy loam	loamy sandy	clay	sand
Drainage	well drained	moderately well drained	somewhat poorly drained, somewhat excessively drained	very poorly drained, excessively drained
Soil Chemical properties				
pH	5.5-6.0	6.1-7.0	7.1-8.0	>8
CEC (me/100 g)	>15	10-15	5-10	<5
Base Saturation (%)	>35	20-35	<20	

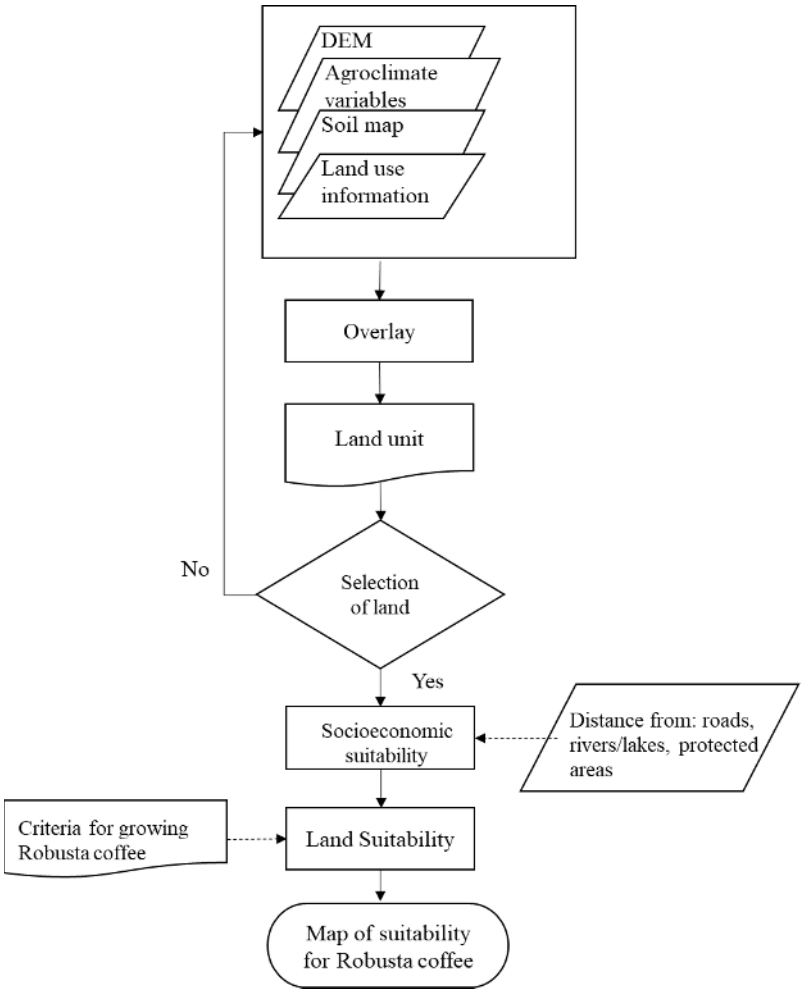

Fig. 1. Flowchart for the study method and data analysis

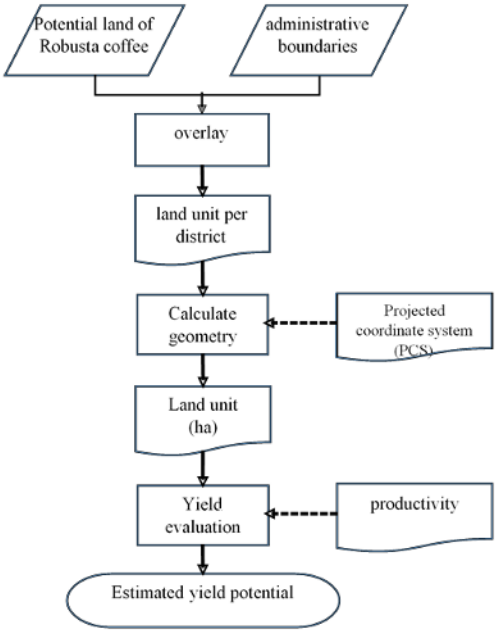

Fig. 2. Flowchart of estimated yield potential of Robusta coffee

3 Results and discussions

The area of land suitability class for Robusta coffee which was based on each parameter (agroclimate, soil physical and chemical properties) is presented in Table 2. The suitability class for Robusta coffee in Bogor which was in the moderately suitable (S2) class of around 2% (5 227.78 ha), marginal (S3) 33% (99 189.20 ha) and not suitable (N) 65% (194 808.40 ha) is shown in Figure 3.

Table 2. The suitability of land in area (Ha) based on the category of very suitable (S1), quite suitable (S2), marginal (S3), and not suitable (N) for each parameter of Robusta coffee in Bogor

Parameter	Land Area Suitability Class (Ha)			
	S1	S2	S3	N
Rainfall (mm/year)	8,466.18	94,017.16	99,465.85	97,276.22
Dry Month (mm/month)	97,760.18	111,592.64	77,703.10	12,169.49
Altitude (meters above sea level)	48,608.30	111,296.86	80,314.49	59,005.77
Slope (%)	105,120.00	106,266.57	53,763.79	34,075.05
Effective depth (cm)	114,129.59	137,250.63	46,900.03	945.17
Soil texture	51,212.78	173,578.10	64,347.20	10,087.33
Drainage	264,649.90	4,984.59	19,505.08	10,085.84
pH	125,087.21	18,484.69	154,708.34	945.17
Base Saturation (%)	201,220.51	97,059.73	0.00	945.17
CEC (me/100 g)	187,513.12	110,767.13	0.00	945.17

Climate is a key determinant of successful coffee production. Rainfall and dry months data in the study area were based on agroclimatic variables required criteria for Robusta coffee. The average rainfall in Bogor district ranging from 232-517 mm/month, so it was considered the rainy season, with the highest peak of rain was in April. Meanwhile, the lowest average rainfall happened in June-September, which reached 32.6-99.5 mm/month, with the lowest rainfall occurring in July. Various coffee bean characteristic subcomponents (e.g. insect damage and mouldy beans) and different bean sizes were also examined and were affected by a range of rainfall and temperature predictors across the flowering, growing and harvest seasons [7].

Indonesia especially bogor district is subject to high variability in rainfall, like Vietnam with droughts and floods common and anticipated to intensify under climate change [8]. Climatic conditions that reduce coffee bean profitability (e.g. because of increased defects) has widespread and high cumulative impacts. The average dry month ranging 1-6 month, its can be affects the process of primordial flower formation, initiation of flowering, pollination, and fertilization [9]. During the flowering process, coffee requires a dry month for the success of the pollination process so that it can produce fruit. If rain drops during the pollination period, usually the pollen will clump, and the flowers will be damaged so that pollination will not occur or fail to become fruit.

Robusta coffee is grown between 300-700 m above sea level. Altitude, a known surrogate variable for temperature, is the main driver of the epidemics of coffee leaf rust (CLR) diseases. Incidence and severity were highest in the lowland fields than highland, where poorly managed plantations of local varieties which are grown under the open sun were also more dominant. CLR intensity decreased with the increase in altitude at the highlands, where well-managed and improved varieties are grown under the shade [10]. The elevation a coffee is grown at directly affects the physical characteristics of the beans [11].

The parameters of the observed physical properties of the soil included effective depth, soil texture, and drainage speed. Soil texture was determined by the size of the soil particles represented by the percentage of sand, silt, and clay in the soil [12]. The texture was the relative ratio between the fractions of sand, silt, and clay, i.e., soil particles which effective diameter was 2 mm. This parameter was one of the most essential soil characteristics that affected soil moisture, drainage, infiltration, and retention of nutrient and water capacity [13].

The land suitability class was the S2 class which the highest limiting factor was rainfall and drainage speed parameter. The area for this suitability is 5,227.78 ha for the S2 class, 99,189.20 ha for the S3 class and 194,808.40 ha for not suitable (Fig. 3). The highlands areas are not recommended for Robusta coffee growing.

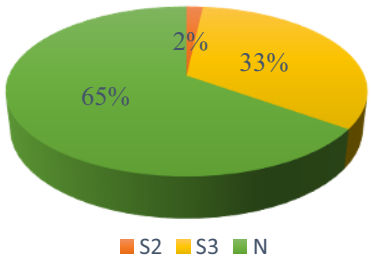

Fig. 3. Proportion of land suitability class for Robusta coffee

Based on the results of the analysis of potential land suitability maps and the availability of land for the development of Robusta coffee plants in Bogor Regency, it can be seen that the land that can be used as coffee commodity development is included in the S2 and S3 class categories because there is no S1 land suitability class. Referring to the data in Table 2 regarding the average productivity of Bogor coffee where several sub-districts that are centers of Robusta coffee production have their respective productivity, while for other districts using the average productivity converted to the potential area of suitability, it will produce potential results such as in Table 3.

Table 3. Yield potential of Robusta coffee in Bogor district

Sub District	Productivity (kg ha^{-1})	Land area (ha)	Yield Potential (kg)
Babakanmadang	800.0	1,809.356	1,447,485.144
Bojonggede	874.5	238.225	208,339.819
Caringin	874.5	3,136.408	2,742,945.235
Cariu	950.0	5,308.086	5,042,681.661
Ciawi	874.5	851.006	744,247.921
Cibinong	874.5	22.312	19,513.767
Cigombong	874.5	2,043.351	1,787,012.493
Cigudeg	912.1	9,549.057	8,709,694.909
Cijeruk	874.5	601.676	526,195.417
Cileungsi	874.5	2,261.127	1,977,468.615
Cisarua	874.5	17.072	14,930.873
Ciseeng	874.5	2,313.424	2,023,204.632
Citeureup	874.5	2,309.388	2,019,675.476
Gunungputri	874.5	2,021.208	1,767,647.686
Gunungsindur	874.5	2,738.552	2,395,000.563
Jasinga	800.0	10,726.810	8,581,446.342
Jonggol	874.5	9,036.056	7,902,482.796
Kemang	874.5	262.340	229,430.122
Klapanunggal	874.5	6,363.919	5,565,565.036
Leuwisadeng	874.5	222.925	194,959.045
Megamendung	874.5	428.815	375,020.502
Nanggung	874.5	1,785.176	1,561,226.029
Parung	874.5	1,159.888	1,014,380.247
Parungpanjang	874.5	5,205.681	4,552,628.234
Rancabungur	874.5	5.486	4,798.381
Rumpin	874.5	5,468.600	4,782,563.976
Sukajaya	874.5	4,534.958	3,966,047.780
Sukamakmur	891.6	9,630.534	8,587,066.079
Sukaraja	874.5	255.154	223,145.117
Tajurhalang	874.5	904.382	790,927.577

Tanjungsari	911.2	8,486.797	7,733,254.037
Tenjo	874.5	4,719.208	4,127,182.979
Total			105,030,473.100
Yield potential			105,030.473 ton

Based on Table 3 Yield potential lands for Robusta coffee development were located in Cigudeg, Sukamakmur, Jasinga, Tanjungsari, Jonggol, Klapanunggal, Cariu, Rumpin, Parung panjang, Tenjo, Sukajaya, Caringin, Gunung Sindur, Ciseeng, Citeureup.

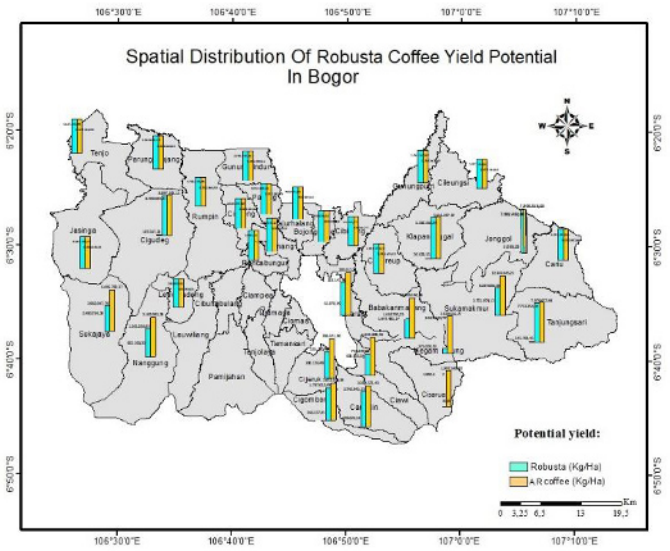

Fig. 4. Spatial distribution of Robusta Coffee Yield potential in Bogor

4. Conclusion

Based on data analysis, land suitability class for Robusta coffee in Bogor which was in the moderately suitable (S2) class of around 2% (5,227.78 ha), marginal (S3) 33% (99,189.20 ha) and not suitable (N) 65% (194,808.40 ha). The potential yield of Robusta coffee in Bogor district reached 105,030,473.1 kg or 105,030.47 ton. The highest potential for Robusta coffee is found in Cigudeg and Sukamakmur subdistricts.

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