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Development of climate and land requirements for compatibility of land cocoa plant specification based on satellite image

Development of climate and land requirements for compatibility of land cocoa plant specification based on satellite image

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Abstract. Cocoa as leading plantation commodities, which is quite essential for the national economy that decreasing productivity from 2012 to 2018. The low productivity of cocoa is caused by the fact that cocoa plants that are planted do not meet the optimum growth requirements. Land quality as an optimal growth factor varies greatly in land and time quality, so it requires an in-depth study, one of which is the parametric approach. This approach analyzes the land requirements (soil and climate) for the suitability of specific cocoa plantations in particular regions, so this study aims to determine the characteristics of the land that correlate with cocoa productivity in a specific region. Also, this study aims to establish a land index through a deductive parametric approach in the PolewaliMandar Regency as a sample of research locations. Primary data were obtained from direct observation, while secondary data were obtained from related institutions. In addition, the determination of the profile location based on production data and cocoa crop distribution through satellite imagery and the Global Positioning System (GPS). Qualitative and quantitative analysis using regression data analysis was used. The results showed that the climate and soil conditions of the Polewali Mandar Regency were very suitable for the level of land suitability. All parameters tested in this study illustrate that land characteristics (climate and soil) in the PolewaliMandar Regency is very suitable for the optimum growth requirements of cocoa plants.

Introduction

Cocoa is one of the mainstays of plantation commodities whose role is quite essential for the national economy, especially as a provider of employment, a source of income, and the country's foreign exchange[1]. Cocoa is currently the third-largest source of non-oil and gas foreign exchange after rubber and palm oil. Cocoa is one of the commodities of plantation products which has a vital role in economic activities in Indonesia. Based on statistical data 2017. The total area of cocoa plantations in Indonesia in 2015 reached 1. 722.315 ha and decreased in 2016 to 1.701.351 hectares. Production of cocoa beans continued to decline from 740.513 tons in 2012 to 656.817 in 2016. The total area of cocoa plantations in Indonesia before 2017 for the past four years has tended to decrease, falling around 0.21 to 1.9 percent per year, even though the trend of increasing cocoa production in previous years has always been growing. In 2000, cocoa production only reached 421.142 tons, while in 2010, it had reached 837.918 tons. In 2017 cocoa production could only reach 300.000 tons. Cacao plants are the main plantation commodity in several regions in Indonesia, including West Sulawesi Province[2].

The area of West Sulawesi cocoa plantations in 2018 is 138,606 hectares, with a total production of 57,650 tons. However, cocoa farmers face various complex problems, including low land productivity. The average productivity of cacao plants 650 kg/ha/year, is still very far from the productivity potential that reaches 2,000-2,500 kg/ha/year [3]. In addition to cultivation techniques, the low productivity of cocoa is one of the reasons for cocoa plants being planted on inappropriate land[4]. It often happens that a commodity which is cultivated in an area can grow in a fertile manner, but is unable to produce optimally because the requirements for generative growth are not fulfilled by the land concerned. The selection of suitable land to achieve optimal productivity can be made well if done through the land evaluation stage by developing land requirements[5].

Geographic Information System (GIS) is a computer-based information system designed to work using data that has spatial information (referenced spatial)[6]. By utilizing GPS, which is one of the GIS devices, a certain area will be obtained, so fertilization based on the field will be more precisely implemented. Even on cocoa, the use of aerial photographs will allow one by one to see tree stands so that the number of plants that still need fertilization can be counted significantly.

Land evaluation is critical. The level of suitability of land for plants affects the productivity of plants, including cacao plants. The results of the land suitability evaluation for cocoa plants are used as a consideration in developing and increasing cocoa productivity in Polewali Mandar.

2. Materials and methods

The study of developing land suitability requirements for cocoa in Polewali Mandar District uses a quantitative method with a deductive approach. This research took place in July-August 2019 in Tapango District, Tubbi Taramanu (Tutar), and Binuang. The selection of research sites is based on existing cocoa production data in Polewali Mandar District. According to the Badan Pusat Statistik (BPS, 2018), the most abundant harvest and production area are located in Tapango, Tutar, and Binuang Districts. Determining the location of representative profiles is based on production data, cocoa crop distribution (satellite imagery), slopes, and altitude. Sampling maps will be presented in the form of maps through satellite imagery.

3. Results and discussion

3.1. Land characteristics of research sites

Climate is a factor which includes rainfall, rain, temperature, humidity, solar radiation, and wind speed between these elements have a complicated relationship. Climate influences the growth and production of cocoa; therefore, this element needs to be considered in making land suitability assessments.

3.2. Rainfall

Based on the data obtained at the research location, it can be seen that the rainfall that occurs in the three representative places is relatively the same. Rainfall will determine the growth and production of cocoa plants. Polewali Mandar Regency has two seasons, namely the rainy season occurs in October to March with an average rainfall of 1750 mm - 2000 mm / year, while the dry season occurs from April to September.

Table 1. Monthly rainfall at the sample location

No.	Month	Month Precipitation (mm)		
		TubbiTaramanu (Tutar)	Tapango	Anreapi
1	January	109.2	104.1	105.3
2	February	146.6	142.1	142.2
3	March	131.8	130.6	130.5
4	April	223.5	223.0	221.8
5	May	234.0	231.6	232.3

6	June	198.7	198.7	200.5
7	July	144.0	142.3	144.2
8	August	53.3	52.2	53.0
9	September	128.0	125.6	128.1
10	October	168.1	169.2	167.4
11	November	223.1	219.7	221.3
12	December	204.5	202.2	204.0

Source: Majene BMKG data after processing, 2018

Determination of climate classification at this research location uses the method according to Schmidt-Ferguson with climate type and Q value. Tubbi Taramanu District (Tutar). Monthly average rainfall that occurs ranges from 111.5 - 241.92 mm / month, with an average annual rainfall of 1964.8 mm/year. Tutar sub-district based on the Schmidt-Ferguson climate classification has a Dry Month of 5 months and a Wet Month of 6 months. Thus, the District of Tutar based on the Schmidt-Ferguson climate classification has a value of Q = 83%, which is in the interval of values (Q) between 60-100 with climate category D with moderate climate characteristics.

Tapango District has a monthly average rainfall that occurs in the range of 108.17 - 240.75 mm/month, with an average annual rainfall of 1941.3 mm/year. Tapango District has a Dry Month of 5 months and a Wet Month of 6 months. Tapango District, based on the Schmidt-Ferguson climate classification, has a value of Q= 83%, which is in the interval of values (Q) between 60-100 with climate category D with moderate climate characteristics.

Anreapi District Monthly average rainfall occurs in the range of 110.08 - 240.92 mm/month, with an average annual rainfall of 1964.8 mm/year. Based on the climate classification, Schmidt-Ferguson has a Dry Month of 5 months and a Wet Month of 6 months. Thus, Anreapi District, based on the Schmidt-Ferguson climate classification, has a value of Q = 83%, which is in the interval of values (Q) between 60-100 with climate category D with moderate climate characteristics.

Based on Table 1 shows that the rainfall in the research location for the last ten years is evenly distributed every year. The average rainfall a year at the representative site is 1952 mm / year. This is very following the requirements for growing cacao plants. Based on rainfall data for the last ten years (Table 2), it can be seen on the average Dry Month (BK) and Wet Month (BB). According to Mohr's Classification, the Dried Month is determined if the rainfall is <60 mm and the Wet Month if the rainfall is>100 mm. The data can be used to assess climate classification in Polewali Mandar Regency. The average number of dry and wet months is presented in table 2.

Table 2. Number of Dry and Wet months during the period 2009-2018

	Years									
Months type	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
BK	7	9	6	6	6	3	6	4	4	6
BB	5	3	6	6	6	9	6	8	8	6

Source: Majene BMKG data after processing, 2018

The criteria for land suitability with rainfall and wet month parameters for cocoa are presented in table 3.

Table 3. Criteria for land suitability classes with rainfall parameters for cocoa

Parameter	Land Suit Classification			
	Very appropriate	Appropriate	Less suitable	Not suitable
Rainfall (mm/year)	1500-2500	1250->1500 >2500-3000	1100-<1250 >3000-3500	<1100, >3500
Wet Month (Mont/year)	7-9	10-11	5-6	<5

Source: Wahyunto et al., 2013[7]

Based on table 3 shows the criteria of land suitability class with rainfall parameters for cocoa plants in Polewali Mandar Regency is very appropriate. Rainfall strongly determines plant growth and production. Cacao plants are susceptible to drought[8][9]. Also, land for cocoa cultivation in Polewali Mandar Regency is generally dry land. Thus, evenly distributed rainfall determines the success of cocoa plants.

3.3. Air temperature, humidity and altitude

According to Majene BMKG Station (2018), the average temperature of the Polewali Mandar Regency varies between 26-28 ° C with a relative humidity of 78.8%. Polewali Mandar is at an altitude of 0-700 Meters Under Sea Level (MUSL) (Badan Pusat Statistik (BPS), 2018). Land and climate significantly affect the production and quality of cocoa, especially the altitude and availability of water. The air temperature also influences the physiological process of cocoa. Low air temperature will inhibit the formation of shoots and flowers. Meanwhile, high temperatures can inhibit shoot growth and encourage branch growth and result in little leaves. Based on satellite imagery, the topographic and slope conditions are presented in figures 1-6.

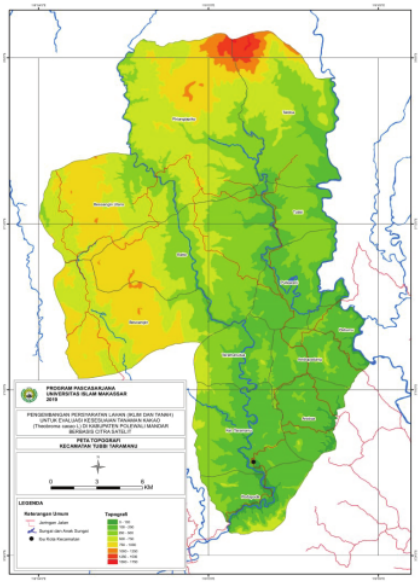

Figure 1. Tutar district

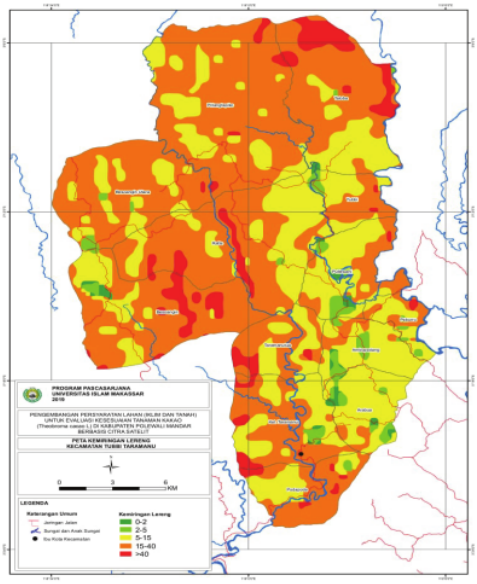

Figure 2. Tutar land slope

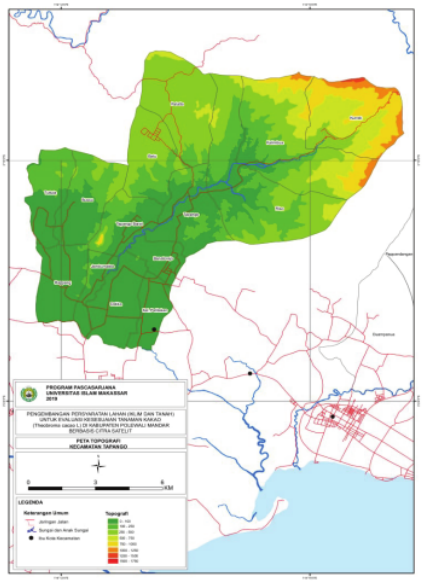

Figure 3. Anreapi district

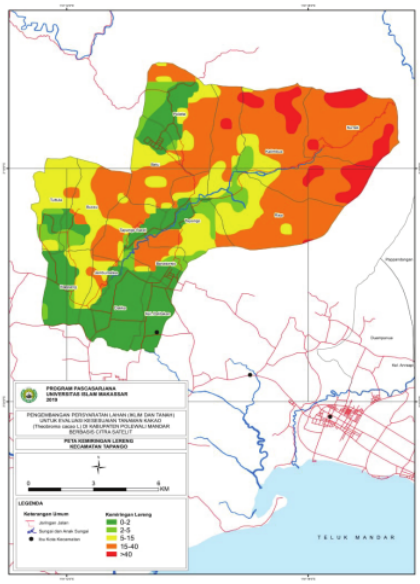

Figure 4. Anreapi land slope

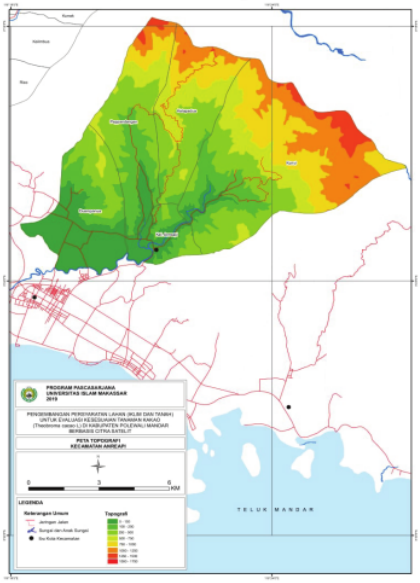

Figure 5. Tutar District

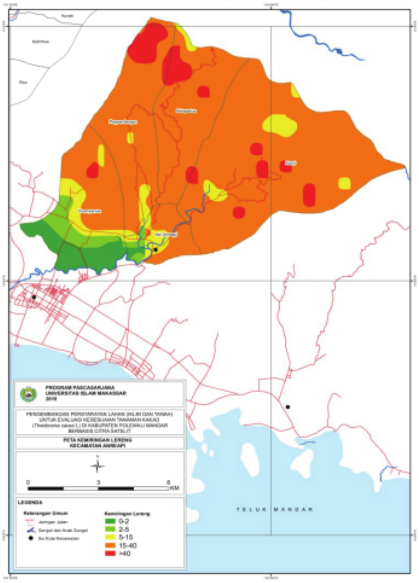

Figure 6. Tutar land slope

Based on figure 1,3 and 5with taking coordinates at the location of the study showed that the site of the cocoa plant is spread at an altitude of 0 - 750 meters above sea level, this indicates that the height of the place in Polewali Mandar Regency is in accordance with the conditions for growing cocoa plants. The slope level at the representative locations of Tutar, Tapango, and Anreapi Districts can be seen in Figures 2,4 and 6. Based on figures 3,4 and 6 with taking coordinates at the location of the

study showed that the site of the cocoa plant is spread at a slope level of 0-15%, this indicates that the slope level in Polewali Mandar Regency is following the conditions for growing cocoa plants.

Table 4. Conformance class criteria for cocoa plants with altitude and slope parameters

Parameter	Land Suit Classification			
	S1	S2	S3	N
Altitudes (MUSL)	0-600	600-700	700-800	> 800
Slope Condition (%)	0 - 8	8 - 15	15 - 45	>45

Source: *Khasril Atrisiandy,* 2015 [10]

Based on table 4, Polewali Regency is very following the requirements for growing cacao plants, especially with the parameters of the height of the place from sea level and slope. This is also the following [11]; the height of the area from the surface of the sea and the level of the hill are also conditions for growing cacao plants for maximum reproduction. The height of the place from the sea level following the requirements for growing cocoa is 0 - 700 MUSLand the slope level is 0-15%. Based on the results of the interpretation of the image map for the research location shows that the height of the distribution of cocoa plants is very following the requirements for growing cocoa plants, this can be seen in figures 1, 3, and 5.

4. Conclusions

Natural conditions in Polewali Mandar regency are very suitable for the level of land suitability. All parameters tested in this study illustrate that the characteristics of land temperature, rainfall, topography, and altitude in Mandar Polewali are very following the optimal growth requirements of cocoa plants. The low productivity of cocoa in Polewali Mandar Regency is due to the lack of knowledge of farmers about proper cultivation techniques, especially land management, fertilization, seed source selection, maintenance, and post-harvest processing.

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