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Analysis of land carrying capacity and production factors of cocoa (*Theobroma cacao* L.) in Banggai Regency

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ABSTRACT

This study aimed to determine the carrying capacity of land and production factors in the development of cocoa production in the Banggai Regency of Central Sulawesi. This research was conducted in 23 sub-districts of the Banggai Regency. Determination of respondents using cluster sampling method or grouping based on area or population location with 114 cocoa farmers. The research data were obtained from primary data, i.e., interviews, questionnaires. In contrast, secondary data were obtained from the Central Statistics Agency, the Banggai Regency Agriculture Office, and the Center for Research and Development on Agricultural Land Resources. The variables analyzed include regional economics (used LQ and SSA), land carrying capacity (DDL), and the production factors were land area (X1), number of workers (X2), fertilizer costs (X3), and pesticide costs (X4). Thus, this study indicated the direction of land allocation based on the regional economy, land carrying capacity, and cocoa production factors. Overall, cocoa plants could be developed in the Banggai Regency with an area of 419,236.9 hectares. However, there was a need for sound land use data management and intensive cocoa cultivation assistance to increase comparative and competitive human resources and improve the economy for the welfare of the cocoa farming community in the Banggai Regency.

INTRODUCTION

The conversion of agricultural land poses a threat to the plantation sector nationally because it permanently impacts agricultural land (Sunartomo, 2015). The increasing population and development activities carried out have taken up the role of agricultural land (Putra & Nasir, 2015). With the conversion of agricultural land to other uses outside of crops, there is very little chance of returning to agricultural land, especially the plantation sub-sector. Changes in land use cause the amount of land used are not suitable for its ability so that it affects the carrying capacity of the land and the quality of the land (Zulfiah et al., 2014). The existence of plantation land provides extensive benefits economically, socially, and environmentally. Therefore, the loss of plantation land due to land conversion to non-plantation will harm aspects of sustainable agriculture (Katili & Sataral, 2020).

The population of the Banggai Regency has experienced a significant increase, so it is predicted that it will affect the area of plantation land in the Banggai Regency (Katili & Sataral, 2020), which is the causes plantation and agricultural land to decline. The impact of this condition results in the ability of plantation land to meet production needs will continue to decline (Talumingan & Jacom, 2017). Therefore, the development of the Banggai Regency plantation sub-sector must refer to sustainable agricultural development to meet the needs for yields and the availability of plantation land in the future (Katili & Sataral, 2020).

Banggai Regency has 9,672.70 km2 consisting of 23 sub-districts, 291 villages, and 46 urban villages with 376,808 people (BPS

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Banggai, 2020). Banggai Regency has a cocoa crop productivity in 2018 of 510 tons/ha, then increased productivity in 2019 as much as 642 tons/ha, and in 2020 experienced a decrease in productivity of 626 tons/ha (BPS Banggai, 2020).

The land's carrying capacity is assessed to compare the regional pressure from human activities and the area's ability (Pridasari & Muta'ali, 2018). One of the efforts that can be performed is to study the land's carrying capacity with an approach to land needs and availability. Carrying capacity analysis will provide balancing data between land use and conservation (Hariyanto, 2017). The current condition is increasingly limited resources so that this is expected to be a serious concern. However, the utilization of resources must not risk the right to meet the needs of future generations (Rustiadi et al., 2018). Thus, if all aspects are carried out in a land-use plan, the conversion of plantation land functions can be suppressed as optimally as possible. In addition, the resulting product will also be maximized so that it impacts increasing the economy of the Banggai Regency population.

MATERIALS AND METHODS

The research was conducted in the Banggai Regency (Figure 1) at 0°30"-2°20" latitude and 122°23"- 124°20" east longitude in 23 sub-districts carried out from February to May 2021. The population in this study was farmers cocoa in Banggai Regency. The sample of farmers was selected using a grouping method based on the area or population location (cluster sampling) (Hindarti et al., 2012)with a sample of 114 people.

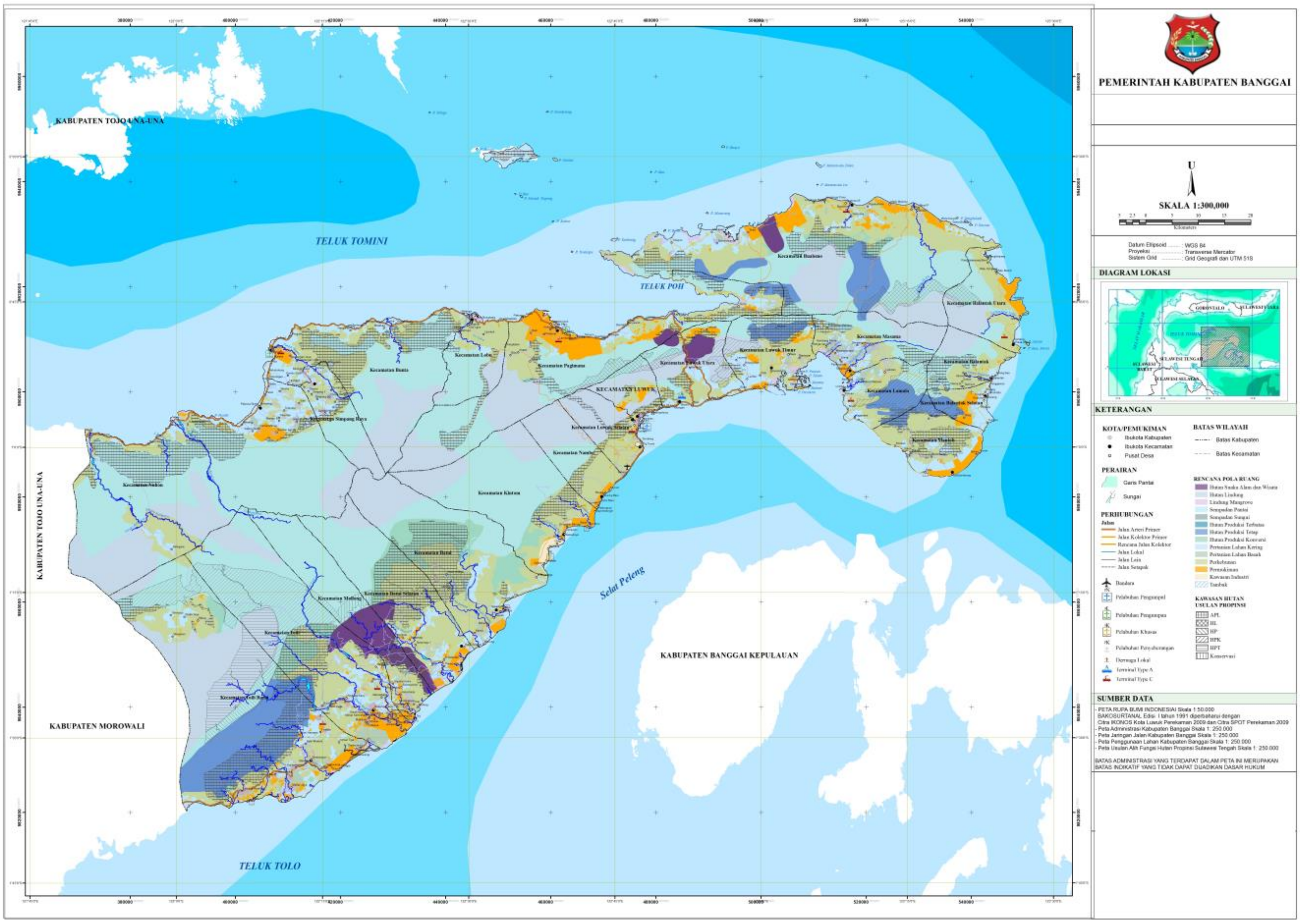

Figure 1. Banggai Regency map as study location

The data used in this study were primary data and secondary data: primary data obtained from direct interviews in the field using a questionnaire. While the secondary data obtained from institutions that are considered competent in the form of data from the Banggai Regency Central Statistics Agency, Banggai Regency Agriculture Service, Center for Research and Development of Agricultural Land Resources, and other scientific references. Regional economic analysis used LQ (Location quotient) and SSA (Shift Share Analysis) analysis (Rusyana et al., 2020) and to analyze the carrying capacity of the land used DDL analysis (land carrying capacity) (Katili, 2020), and to analyze the factors of production used multiple regression analysis (Syathori & Verona, 2020).

Location quotient analysis (LQ)
LQ analysis was used to determine the base commodity, and if the LQ value is> 1, then the commodity is a base commodity in that region. Mathematical LQ analysis based on location division analysis was formulated as follows (Katili, 2020) :

$$LQij = \frac{Xij/Xi}{Xj/X \ldots}$$

Where :
Lqij : Location Quotien
Xij : indicator value of harvested area/planted area/production of the jth commodity in the i-th region
Xi : the total number of activity indicators of harvested area/planted area/commodity production in the i region
Xj : the number of activity indicators of harvested area/planted area/production of the jth commodity in all regions
X : the sum of all harvested area/planted area/commodity production indicator values throughout the region.

The interpretation of the location division analysis results is as follows: if the LQij value is > 1, this condition indicates a concentration of activity in harvest/planting area/production of the *j* commodity in the *i* sub-region or the *j* activity concentration in the *i* sub-region. It can also be interpreted that the *i* region can export the *j* activity products to other regions. If the value of LQij = 1, then the *i* region has a share of the *j* activity, which is equivalent to the share of the *j* sector in the entire region. Alternatively, it can be interpreted that the product or exchange of trade products only occurs within the region. Relatively, region *i* can only meet its internal needs without being able to export to other regions. If the LQij value < 1, then the *i* sub-region has a relatively small share compared to the *j* activity share in the entire region, or the *j* relative market share in the *i* region is lower than the *j* average activity in all regions.

Shift-Share Analysis (SSA)
This analysis looks at how the development of a commodity in a specific area is increasing or not. The shift-share analysis equation was formulated as follows:

$$SSA = \underbrace{\left(\frac{X \ldots (t1)}{X \ldots (t0)} - 1\right)}_{a} + \underbrace{\left(\frac{Xi(t1)}{Xi(t0)} - \frac{X \ldots (t1)}{X \ldots (t0)}\right)}_{b} + \underbrace{\left(\frac{Xij(t1)}{Xij(t0)} - \frac{Xi(t1)}{Xi(t0)}\right)}_{c}$$

Where :
a :share component
b :proportional shift component
c :differential shift component
X :total activity value of harvested area/planted area/regional commodity production in aggregate.
Xi :total activity value of harvested area/planted area/commodity production in the *i* sub-district unit
Xij :value in the *i* region and activity of harvested area/planted area/*j* production
*t*1 : end of year point
*t*0 : starting year point.

Land carrying capacity analysis (DDL)
Determination of the carrying capacity of the land was performed by comparing the availability and demand for land. Availability of land was determined according to information on the actual total production of each commodity in an area. For this sum, price is used as the conversion aspect because each commodity has various units. Meanwhile, land needs are calculated based on the population's decent living needs. Thus, the calculation of the Permen LH No. 17 of 2009 was made with the following stages:

Calculation of land availability with the formula:

$$SL = \sum \frac{(Pi \; x \; Hi)}{Hb} \times \frac{1}{Ptvb} \qquad (1)$$

Information:
SL :availability of land (ha)
Pi :actual production of each type of commodity (unit depends on commodity) commodities calculated include plantations.
Hi :unit price for each type of commodity (Rp/unit) at producer level
Hb :unit price of rice (Rp/kg) at producer level
Ptvb : commodity productivity (kg/ha)

In this calculation, the conversion factor used to equalize non-rice products with rice was the price.

Calculation of land demand with the formula:

$$DL = N \; x \; KHL_L \qquad (2)$$

Information:
DL : total land requirement equivalent to rice (ha)
N : total population (people)
KHL_L : land area needed for decent living needs per resident:
a. The land area needed for decent living needs per resident was the need for

decent living per resident divided by local rice productivity.

b. The need for decent living per population was assumed to be 1 ton of rice equivalent/capita/year.

c. Regions that did not have information on local rice productivity can use data on the average national rice productivity of 2400 kilograms/ha/year.

Table1. The results of the analysis of the combination of location quotient (LQ) and shift-share (SSA) of cocoa commodities in Banggai Regency

Subdistrict	LQ – SSA of Cocoa
Toili	–
Toili Barat	–
Moilong	–
Batui	–
Batui Selatan	–
Bunta	–
Nuhon	–
Simpang Raya	–
Kintom	–
Luwuk	+
Luwuk Timur	–
Luwuk Utara	–
Luwuk Selatan	+
Nambo	–
Pagimana	–
Bualemo	+
Lobu	–
Lamala	+
Masama	+
Mantoh	+
Balantak	–
Balantak Selatan	–
Balantak Utara	–

Note: (-) = Non-cooperative and competitive; (+) = Comparative and competitive

Determination of land carrying capacity status

Land carrying capacity status was obtained by comparing land availability (SL) and land demand (DL) if SL > DL, the carrying capacity of the land was declared surplus. If SL < DL, the carrying capacity of the land was declared deficit (PERMENLH NO 17, 2009).

Multiple linear regression analysis

The data collected was primary data obtained through interviews with sample farmers using a list of questions. Assuming that capital, seeds, and plant age were relatively uniform in their effect on production, the variables used in this study were cocoa production (Y), land area (X1), number of workers (X2), fertilizer costs (X3), and pesticides costs, (X4). Furthermore, the function was converted into multiple linear regression, which was analyzed using the Minitab 16 program. The formula units used were as follows:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$$

Where :

a : constant

Y : production level of cocoa farmers (Kg)

X1 : land area (Ha)

X2 : number of workers (person)

X3 : fertilizer cost (Rp)

X4 : pesticide cost (Rp)

b1, b2, b3 b4 : Number of parameters to search for

RESULTS AND DISCUSSIONS

The LQ-SSA analysis of cocoa commodities in the Banggai Regency

The data used for location quotient analysis was the production of cocoa plants, with the scope of the study area being all sub-districts in Banggai Regency. The LQ analysis of cocoa plants in the Banggai Regency showed that several sub-districts were the basis of comparative strength (> 1). Furthermore, a Shift-Share analysis was carried out to determine the growth of cocoa commodities in each sub-district in the Banggai Regency. The results of the SSA analysis of cocoa commodities in the Banggai Regency, several sub-districts had a positive value (+0.1). This means that cocoa commodities had developed in a region or were competitive.

The combination of LQ and SSA values (Table 1) was used to determine which areas were the advantages of cocoa commodities. If the LQ value > 1 and the SSA value > 0 (+), then the commodity is superior. A superior commodity has a concentration of activity in a certain area. It can supply these commodities to other areas, and this commodity has experienced a high impact on growth from time to time (Miradani, 2010).

Based on the combined LQ-SSA analysis of cocoa commodities in the Banggai Regency, six comparative and competitive sub-districts were obtained, namely Luwuk, South Luwuk, Bualemo, Lamala, Masama, and Mantoh sub-districts. This means that the cocoa plants in the six sub-districts can be superior to other sub-districts so that they experience concentration and economic growth that affect from time to time.

Carrying capacity of cocoa plantations in Banggai Regency

Analysis of the carrying capacity of agricultural land becomes very important for development planning which can provide an overview of the relationship between population, availability, and the need for land use (Mubarokah et al., 2020). For example, based on the results of the calculations in Table 2 above, the carrying capacity of the Banggai Regency's cocoa plantations had been obtained (SL > DL). However, the cocoa commodity in Banggai Regency was categorized as a surplus, which means the cocoa plant was experiencing an excess. Therefore, to ensure the availability of resources to meet the needs of a decent living for the population, the community must maintain, improve and manage current and future resources more optimally (Mulyani et al., 2016).

Table 2. The carrying capacity of cocoa planted land in Banggai Regency

Commodity	Land availability (SL)	Land requirement (DL)	Assumption	Land Carrying Capacity Status (DDL)
Cocoa	143200,0	37113,0	SL > DL	*surplus*

Factors of cocoa production in Banggai Regency

The production factors can be divided into four types: land area, number of workers, fertilizer costs, and pesticide costs. The production function shows the relationship between the number of production factors (input) and the amount of output. This relationship is a technical relationship between input and output. In general, economics pays attention to the production function on a micro basis, namely seeing the relationship between inputs and outputs in a production (Muin, 2017).

Based on the Table 3, the multiple regression equation obtained from the results of the analysis were: $Y = 5.09 - 0.043(X1) + 0.193(X2) + 0.0681\ (X3) + 0.0361\ (X4)$. The regression equation means that the effect of number of workers, fertilizer costs, and pesticide costs on cocoa production is positive. This means that if the size of the land were increased, it would increase the production of cocoa farmers, and if the number of workers, the total cost of fertilizer, and the total cost of pesticides were added, it would be followed by an increase in cocoa. The regression coefficient value for the variable land area was 0.043, indicating that if the land were added by 1 ha, it would increase production by 0.043 kg. Increasing the area of land, the amount of cocoa production would increase. An increase in land use would increase the number of cocoa trees planted, thereby increasing cocoa production. If one factor were not available, then farm production would not work (Daniel, 2002). The regression coefficient value for the number of workers was 0.193, indicating that if one person added the workforce, it would increase production by 0.193 kg. This means that the labor variable (X2) positively correlated with cocoa production (Y). It was supported by the results of the study stating that the energy variable had a positive and significant effect on cocoa production (Setiawan, 2013).

The regression coefficient value for fertilizer costs was 0.0681, and this indicated that if the amount of fertilizer used were increased, it would increase production by 0.0681 kg. This means that the variable cost of fertilizer (X3) positively correlated with cocoa production (Y). Furthermore, Masna et al. (2018) also explain that fertilizer costs significantly affect cocoa farming income and income.

Table 3. Output of Regression Results

Predictor	Coef	SE Coef	T	P
Constanta	5.0926	0.1983	25.68	0.000
Land area (X_1)	-0.0431	0.1273	-0.34	0.736
Number of workers (X_2)	0.1928	0.1365	1.41	0.161
Fertilizer cost (X_3)	0.06805	0.01510	4.51	0.000
Pesticide cost (X_4)	0.03606	0.01159	3.11	0.002

Table 4. Output of F test

Source	DF	SS	MS	F	P
Regresion	4	29.1554	7.2889	12.60	0,000
Residual Error	109	63.0535	0.5785		
Total	113	92.2090			

The regression coefficient value for pesticide costs was 0.0361, and this indicated that if the amount of pesticide use were added by 1 liter, it would increase production by 0.0361. This means that the pesticide cost variable (X4) positively correlated with cocoa production (Y). In line with the results of research by Slameto (2003), pesticides affect cocoa production. If the pesticide is given at the correct dose, on time, and effectively, the use of pesticides is reduced, and according to recommendations, cocoa production will increase (Saputro & Fidayani, 2020).

Table 5. Simultaneous Correlation Output

Model	S	R-Sq	R-Sq (adj)
1	0.60574	31.6	29.1

To test the simultaneous effect of variables on land area, the number of workers, fertilizer costs, and pesticide costs, the F test was carried out as shown in Table 4. Table 4 above shows that the test with the F test calculation using the SPSS program obtained F count = 12.60 with a significance value of 0.000. Because the significance value was <0.05, so the F count value obtained was significant. Thus, it showed a meaningful relationship between land area, number of workers, fertilizer costs, and pesticide costs on cocoa production.

Based on the calculation results, the correlation coefficient value was simultaneously 31.6 with an R-square value of 29.1. Therefore, it was indicated that the relationship between the variables of land area, number of workers, fertilizer costs, and pesticide costs on cocoa production was in a strong category. The magnitude of the influence of land area, number of workers, fertilizer costs, and pesticide costs could be seen from the coefficient of simultaneous determination (R2), which shows that land area, number of workers, fertilizer costs, and pesticide costs had an effect of 31.6% on cocoa production. Meanwhile, 29.1% was influenced by other factors outside the variables studied.

Table 6. Directions for Cocoa Commodity Development in Banggai Regency

Region of LQ-SSA	DDL status	Factors of production	Area (Ha)	Recommendation
Luwuk, Luwuk Selatan, Bualemo, Lamala, Masama dan Mantoh	*Surplus*	Area, number of workers, fertilizer cost, pesticide cost.	419.236,9	The development is carried out in 4 sub-districts, which are in balance with the land's carrying capacity based on the factors of increasing production with the designated land area.

Directions for cocoa commodity development in Banggai Regency

Directions for the development of cocoa plants in several sub-districts located in areas had potential. For more details, we present it in Table 6. For example, cocoa commodity development in the Banggai Regency was needed in 4 sub-districts, Bualemo, Lamala, Masama, Mantoh.

Therefore, it was necessary to regulate the management to balance the carrying capacity of land based on production factors, i.e., the number of workers, fertilizer costs, pesticide costs, and land area that could be developed in the Banggai Regency was 419,236.9 ha. Furthermore, the two sub-districts, Luwuk and South Luwuk sub-districts, were not directed as cocoa plant development because the two sub-districts had been used as urban land by Bappeda Litbang, Banggai Regency.

CONCLUSIONS

The comparative and competitive economic analysis of cocoa plantation management (LQ-SSA) was found in six sub-districts (Luwuk, South Luwuk, Bualemo, Lamala, Masama, and Mantoh sub-districts). Furthermore, these commodities had experienced a high impact growth from time to time in improving the economy in the region. Calculations on the analysis of the carrying capacity of cocoa plantations in the Banggai Regency were categorized as "surplus," which means that cocoa plants had excess. As a result, the cocoa plant could meet the needs for a decent life for the residents of the Banggai Regency. There was a positive (significant) effect on the variable land area (X1) with a coefficient value of 0.043, then the number of workers (X2) with a regression coefficient value of 0.193, and fertilizer costs (X3) with a regression coefficient value of 0.0681, and the cost of pesticides (X4) coefficient value. Regression of 0.0361 on cocoa production. The direction of land allocation was based on the regional economy, land carrying capacity, and cocoa production factors. Overall, cocoa plants could be developed in Banggai Regency with an area of 419,236.9 hectares. However, there was a need for good land use and management and assistance in managing intensive cocoa cultivation land to increase comparative and competitive human resources and improve the economy for the welfare of cocoa farmers in the Banggai Regency.

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