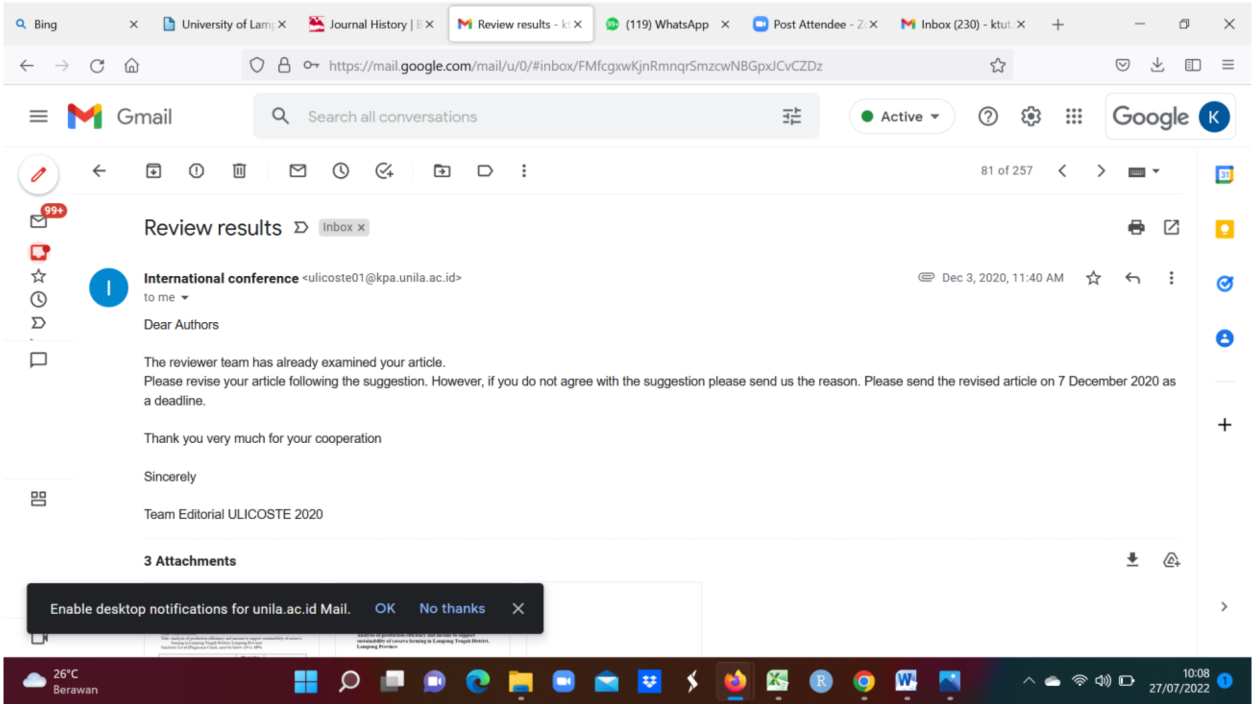

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Analysis of production efficiency and income to support sustainability of cassava farming in Lampung Tengah District, Lampung Province

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Abstract. This study aims to analyze the efficiency of production, income, and cassava farmers in Lampung Tengah Regency, Lampung Province. Lampung Tengah Regency was chosen as the research location with the consideration that the district is a center for cassava production in Lampung Province. The number of respondents was 60 respondents who were taken using *simple random sampling*. Data collection was carried out in July 2020. The data used in this study are primary and secondary data. Data analysis used the production function *stochastic frontier* with the *Frontie*r 4.1 program, income analysis, and R/C ratio. The result showed that cassava farming in Lampung Tengah Regency on average, is not efficient both technically and economically but was profitable with R/C > 1.

Keywords: production efficiency, income, cassava.

1. Introduction

The food crop sub sector has a very important role in realizing national food security, absorption of labor, providers of industrial raw materials and food. One of the important commodities in the food plant group is cassava. Indonesia is the second largest producer of cassava after Thailand. It's just that Indonesian cassava is mostly consumed domestically (Hermanto, 2015).

The harvested area for cassava in Indonesia in 2015 was 0,95 million hectares and the production reached was 21,80 million tons with a productivity of 22,95 tons /ha. In 2016, the harvested area for cassava is projected to be 1,11 million hectares with a productivity of 20,23 tons/ha, so the national cassava production is expected to reach 25 million tons. The opportunity for cassava development is very wide, given the availability of quite extensive land, based on data from BPS in 2005, it shows that there is a potential dry land area of 25.955.901 hectares consisting of 10.775.051 hectares of tegal land, 3.839.093 hectares and temporary undeveloped land for an area of 11.341.757 ha. These lands are available potential for the development of cassava cultivation/ farming areas (Outlook for Indonesian cassava, 2016).

The potential productivity of cassava is high in aggregate but is not balanced with the actual productivity of the farmers. The difference in the use of production factors and the managerial ability of farmers causes differences in the productivity of cassava. The use of production factors need to be considered to increase farmers income and will provide maximum profit and production efficiency. Land area is the variable most responsive to the production (frontier) of cassava farming (Anggraini 2016). The low price of cassava can lead to low farmer income because the cost of farming production is not proportional to the income earned. The ability of farmers to detect farming problems is still low, while the success of farming is determined by the decisions taken. The allocation of the use of production factors needs to be considered in order to achieve production efficiency, increase productivity and income.

Coelli (2005) stated three sources of productivity growth, namely technological changes, increased technical efficiency and economies of scale. (Kumbakar 2002) examined the relationship between technical efficiency and productivity, namely that commodity production is affected by efficient input allocation, or the absence of technical inefficiency problems and agricultural production factors. Based on these problems, it is necessary to conduct research on the efficiency of cassava farming production in Lampung Province.

So many research about production efficiency and income, but research on production efficiency and income related to farming sustainability has not been widely carried out. Therefore, research on production efficiency and income to support the sustainability of cassava farming needs to be done.

Research Method

This research was conducted in Lampung Tengah Regency Lampung Province. The location of this study was determined purposively with the consideration that Lampung Province is the largest cassava producing province in Indonesia. The research time on July 2020. This study used a survey method at the location of cassava production centers in Lampung Province. The sample farmers were estimated to be 60 cassava farmers who were taken by *simple random sampling*. Analysis of the data used to answer the first objective of cassava farming used the production function *stochastic frontier* with the frontier 4.1 program using computer assistance. The *stochastic frontier* production function model for efficiency and technical inefficiency in cassava farming is as follows.

$$\text{Ln Y} = \ln b0 + b1lnX1 + b2lnX3 + \cdots + b9lnX9 + b1lnZ1 + b2lnZ2 + b3LnZ3 + b4ln + b5lnZ5 + b6lnZ6 + ei + \text{Ui} \quad \text{...........................(1)}$$

Description:

Y	= Cassava production (kg)
$b0$	= Intercept
$b1, b2 \ldots bn$	= Estimator variable parameter /regression coefficient
$X1$	= Land area (ha)
$X2$	= Seed (kg)
$X3$	= NPK fertilizer (kg)
$X4$	= Urea fertilizer (kg)
$X5$	= SP36 fertilizer (kg)
$X6$	= KCl fertilizer (kg)
$X7$	= Pesticides (gba)
$X8$	= Labor (HOK)
$Z1$	= Age of farmer (years)
$Z2$	= Formal education level Farmer (years)
$Z3$	= Farming experience (years)
$Z4$	= Participation in counseling
$Z5$	= Number of dependents(person)
$Z6$	= Distance to factory (km)
ei	= Errors due to random factors
Ui	= Technical inefficiency factors

Passel et al (2006) describe factors affecting technical inefficiencies related to age, education, experience, credit and markets. Similar research also performed (Fauziyah 2010; Bare, 2012; Nahraini et al., 2013). Economic efficiency is obtained by using cost function parameter estimation. The variable used is the weighted price of each variable using the formula for the total cost of each input

divided by the production of each farmer. The function of the overall economic efficiency estimation model can be written as follows :

$$Ln\ Ci = \ln b0 + b1 \ln X1 + b2 \ln X2 + b3 \ln X3 + \ldots + b8 \ln X8 + Ui \ldots\ldots (2)$$

Description:

Ci	= Total production cost (Rp)	$X5$	= SP36 fertilizer price (Rp/ kg)
$X1$	= Land rental price (Rp / ha)	$X6$	= KCl fertilizer price (Rp/kg)
$X2$	= Seed price (Rp / kg)	$X7$	= Pesticide price (Rp/kg)
$X3$	= NPK fertilizer price (Rp / kg)	$X8$	= Labor price (Rp/kg)
$X4$	= Urea fertilizer price (Rp / kg)	b	= Regression coefficient
		Ui	= *error*

Results obtained from application *frontier* 4.1 with a cost function model is *Cost Efficiency* so that to get economic efficiency uses the formula:

$$EE = \frac{1}{CE} \ldots\ldots (3)$$

Description:
EE = Economic efficiency
CE = *Cost efficiency*

Analysis of price efficiency or allocative efficiency is obtained from the calculation of economic efficiency divided by technical efficiency written with the formula:

$$EH = \frac{EE}{ET} \ldots\ldots (4)$$

Description :
EH = Price efficiency
EE = Economic efficiency
ET = Technical efficiency

The income analysis is calculated to see how much the farmer's income is and the R/C value of cassava farming to see the feasibility of farming to calculate income using the following formula:

$$\pi = TR - TC \ldots\ldots (5)$$
$$\pi = (Y.Py) - (X.Px) \ldots\ldots (6)$$

Description :
π = Farmer income
TR = Total revenue (Rp)
TC = Total *Cost* (Rp)
Y = Output (kg)
Py = Price of cassava (Rp)
X = Input (kg))
Px = Input Price (Rp)

The R / C formula used is:

$$R/C = \frac{TR}{TC} \ldots\ldots (7)$$

Description:
R / C = Ratio revenue and cost
TR = Total Revenue or total revenues (Rp)
TC = Total Cost (Rp)

3. Results And Discussion

3.1 Analysis of Cassava Production Efficiency

The results of the parameter estimation are presented in Table 1. Based on Table 1, the variables that have a significant effect on production in Lampung Tengah Regency are the variable land area (X1), seeds (X2), NPK fertilizer (X3), KCL fertilizer (X6), pesticides. (X7), and labor (X8). The urea (X4) and SP36 (X5) fertilizer variables did not significantly affect production, meaning that the use of fertilizers was not efficient. The use of inefficient fertilizers needs to be paid attention to the dosage and time of fertilization. Based on the regression results in Table 1, the production function is *frontier* as follows:

Ln Y: 7,8280 + 0,3825 lnX1 + 0,2953 lnX2 + 0,0129 lnX3 + 0,0032 lnX4 +0,0029 lnX5 -0, 0065 lnX6 – 0,0230 lnX7 + 0,2972 lnX8 + Ui

Table 1. Estimation results of the production function of *stochastic frontier* cassava farming in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	Coefficient	*t-ratio*
Intercept	7,8280 ***	19,6829
Land area (X1)	0,3825 ***	5,4839
Seeds (X2)	0.2953 ***	4.2013
NPK Fertilizer (X3)	0.0129 ***	2.9858
Urea fertilizer (X4)	0.0032	1.4671
SP36 Fertilizer (X5)	0.0029	0.4637
KCl Fertilizer (X6)	-0.0065 ***	-3.8502
Pesticides (X7)	-0.0230 ***	-6.6436
Labor (X8)	0.2972 ***	18.0172
sigma-squared	0.6417 ***	8,1777
Gamma	1,0000***	3,5728
OLS Log Likelihood	-22,2586	
Log Likelihood MLE	-3.8368	

Source : Primary data, processed research results, 2020
Information: * = 90% confidence level (t-table = 1.6630)
** = 95% confidence level (t-table = 1.9833)
*** = 99 % (t-table = 2,6349)

The results of the *stochastic frontier* production test can produce the factors that affect the production of cassava farming and the level of technical efficiency of each farmer. The distribution of the technical efficiency of cassava farming in Lampung Tengah Regency in 2020 is presented in Table 2.

Table 2. The distribution of the efficiency level of cassava farming in Lampung Province.

Technical Efficiency	Lampung Tengah		Information
	Amount (people)	(%)	
<0,70	31	51,67	Not efficient
0,70 – 0,90	20	33,33	Quite efficient
> 0,90	9	15,00	Very efficient
Total	60	100.00	
Average	0,70		
Min	0,15		
Max	1,00		

Source: Primary data, processed research results, 2020

Based on Table 2, cassava farming in Lampung Tengah Regency is on average quite technically efficient with a value of 0,70. However, most of them are not efficient. The average efficiency level value of 0,70 means that farmers still have the opportunity to increase their efficiency by 30 percent.

Similar research on technical efficiency, Fauziah (2010) on tobacco in Madura provides a technical efficiency index between 0,56 to 0,99 with an average of 0,78. Saptana et al., (2010) found that the average technical efficiency was 0,90 for Central Java red chili. A study by Banani et al., (2013) on shallots in Brebes found that technical efficiency levels ranged from 0,65 to 0,99, with an average of 0,80. Darmansyah et al., (2013) on Cabbage in Rejang Lebong Regency produces technical efficiency between 0,78 to 0.99, with an average value of 0,91. Meanwhile, Abiola and Daniel (2014) examined the technical efficiency of melons in Nigeria giving an index between 0,43 to 0,97, with an average of 0,84. A study conducted by Baree (2012) on onions in Bangladesh produced a technical efficiency index ranging from 0,58 to 0,99 with an average of 0,83. A study by Taiwo (2014) about the technical efficiency of cassava in Nigeria resulted in a technical efficiency level ranging from 0,42 to 0,97 with an average of 0,904. Kareem and Isgn (2016) regarding the technical efficiency of cassava in Ghana produced a technical efficiency level of between 9,1 to 99,6 with an average of 95,6. This efficiency value means that cassava farmers in Lampung Tengah can still improve technical efficiency by 30 percent.

Technical efficiency can be increased by fostering ideal cropping patterns and cultivating seedlings. The majority of the cassava spacing applied by farmers in Lampung Tengah Regency was 50 cm x 50 cm and 30 cm x 40 cm. Based on the recommendation of cropping patterns in monocultures, the ideal can be done with a distance of 1 m x 1 m; 1 m x 0,8 m; 1 m x 0,75 m and 1 m x 0,7 m. Whereas for less fertile soils, dense spacing is used 1 m x 0,5 m, 0,8 m x 0,7 m. Multiple row spacing in an intercropping planting pattern that supports cassava plants planted at a spacing of 0,6 m x 0,7 m x 2,6 m (Sundari, 2010). Spacing that is too dense will affect the decline in production. Then to use the seeds must be in the form of stem cuttings from the bottom to the middle. To achieve the cropping pattern and superiority of a cassava seed, it is necessary to have an educational strategy for farmers to be able to add insight and knowledge, so that it can influence production results more optimally.

Table 3. Estimated parameters of technical inefficiency factors of cassava farmers in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	Coefficient	*t-ratio*
Intercept	7,8280 ***	19,6829
Age (Z1)	-0,1432	-0,3791
Level education (Z2)	0,0788	0,3305
Farming experience (Z3)	-0,1138	-0,5795
Number of dependents (Z4)	1,0187 ***	3,3586
Participating farmer (Z5)	-1,1454	-1, 6673
Distance to factory (Z6)	-0,7300 *	-1,9169
sigma-squared	0,6417 ***	2,7071
Gamma	1,0000 ***	1,5708
Log Likelihood OLS	-22,2586	
Log Likelihood MLE	-3,8368	

Source : Primary data, processed research results, 2020
Information: * = 90% confidence level (t-table = 1.6630)
** = 95% confidence level (t-table = 1.9833)
*** = 99 % (t-table = 2,6349)

These factors are technical inefficiency factors which are analyzed using the technical inefficiency model of the *stochastic frontier* production function. Estimated parameters of factors affecting the technical inefficiency of cassava farming are presented in Table 3. Based on the results in Table 3, the gamma value in Lampung Tengah Regency is 1,000, which means that 1,000 percent of the errors in the stochastic frontier production function are caused by technical inefficiency. The variables that affect the technical inefficiency factor in Lampung Tengah Regency are the number of dependents (Z4) and the distance to the factory (Z6).

The results of the calculation of Table 3 show that the variables that have a significant effect on cassava production are the number of dependents (Z4) and the distance to the factory (Z6), while other variables have no significant effect. The t-count value of the number of dependents (Z4) is greater than the t-table, which is 3,3586. These results indicate that the variable number of dependents of cassava farmer families in Lampung Tengah Regency has a significant effect on cassava production with a confidence level of 99 percent. This means that if the number of family dependents is increased by one percent, it will reduce the level of efficiency by 1,0187 percent.

Table 4. Estimation results of the production cost function of *stochastic frontier* cassava farming in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	coefficient	*t-ratio*
Intercept	14,9370 ***	12,0278
Land rental price / output (X1)	0,3222	1,0006
Seed / output price (X2)	-0,0632	-0,2635
Price of NPK fertilizer / output (X3)	0,0353 **	2,5965
Price of urea / output fertilizer (X4)	-0,0422	-1,3970
Price of fertilizer SP36 / output (X5)	0,0572 ***	4,6989
Price of KCl / output fertilizer (X6)	0,0335 *	1,9986
Pesticide price / output (X7)	0,0556 *	1,9425
Labor / output wage (X8)	-0,0393 **	-2,2494
sigma-squared	0,7254 ***	3,5001
Gamma	0,8890 ***	9,4821
Log Likelihood OLS	-49,8120	
Log Likelihood MLE	-48,1753	

Source : Primary data, processed research results, 2020.
Note: * = 90% confidence level (t-table = 1.6759)
** = 95% confidence level (t-table = 2.0086)
*** = confidence level 99% (t-table = 2.6778)

Based on Table 4, the variables that have a significant effect on the profits of cassava farming in Lampung Tengah are the price of NPK fertilizer/output (X3), the price of fertilizer SP36 / output (X5), the price of KCl/fertilizer output (X6), pesticide price / output (X7) and wages for labor / output (X8). Economic efficiency is obtained through an analysis of the cost of production inputs using weighted prices, namely by dividing the variable costs of inputs by the total production. Based on the results in Table 4, the frontier production cost function is as follows:

$$\text{Ln } C: 14{,}9370 + 0{,}3222 \ln X1 - 0{,}0632 \ln X2 + 0{,}0353 \ln X3 - 0{,}0422 \ln X4 + 0{,}0572 \ln X5 + 0{,}0335 \ln X6 + 0{,}0556 \ln X7 - 0{,}0393 \ln X8 + Ui.$$

The results of the analysis show that the constant in the model that affects the economic efficiency factor is 14,9370 with the t-count value greater than the t-table, meaning that the variable value of land rental price/kg, the price of seeds/kg, the price of NPK/kg, the price of urea/kg, the price of SP36/kg, the price of KCl/ kg, the price of pesticides/kg, and the price of labor/kg are equal to zero then the value of farming profits cassava amounted to 14,9370 percent. The results of the estimation of the production cost function of *stochastic frontier* cassava farming in Lampung Tengah Regency are presented in Table 5.

Table 5. Distribution of the economic efficiency of cassava farming in Lampung Tengah Regency in 2020.

Economic Efficiency of	Lampung Tengah		Information
	Amount (person)	(%)	
<0,70	44	73,34	Not efficient
0,70 – 0,90	16	26,66	Quite efficient
> 0,90	0	0,00	Very efficient
Total	60	100,00	
Average	0,46		
Min	0,14		
max	0,88		

Source : Primary data, processed research results, 2020

After obtaining the results of the factors that affect the benefits of cassava farming, it will be obtained the value of economic efficiency. Based on Table 5, the average cassava farming is not economically efficient (0,46). This is because farmers are less able to allocate inputs properly so that they are not able to equalize input prices with marginal product. Although allocatively (price) it is efficient. The distribution of price efficiency in Lampung Tengah Regency is presented in Table 6.

Table 6. Distribution of the efficiency of cassava farming prices in Lampung Tengah Regency in 2020.

Price efficiency	Lampung Tengah		Information
	Amount (people)	(%)	
<0.70	21	35,00	Not efficient
0.70 - 0.90	15	25.00	Quite efficient
> 0.90	24	40.00	Very efficient
Total	60	100.00	
Average	0.96		
Min	0.15		
Max	1.00		

Source: Primary data, processed research results, 2020.

Based on the results of research the efficiency distribution of cassava farming prices in Lampung Tengah Regency, it was obtained 35 percent with an average of 0,96 in Lampung Tengah Regency. This means that cassava farming is included in the very efficient category in terms of price.

3.2 Cassava Farming Income

In this research, apart from discussing production efficiency, it also discusses the income of cassava farming in Lampung Tengah Regency, Lampung Province. Income is measured as revenue minus production costs. Analysis of cassava farming income is presented in Table 7.

Table 7. Revenue, costs, income and R / C farming of cassava in Lampung Tengah 2020.

Description	Unit	Price (Rp)	Lampung Tengah	
			Farming per 1 ha	
			Amount	Value (Rp / yr)
Revenue				
Production	kg	957,25	22.270,99	21.318.907,44
Production Costs				
I. Cash Cost				
NPK fertilizer	kg	2.959,01	327,77	969.865,67
Urea fertilizer	kg	2.376,31	366,13	870.049,62
TSP /SP36 fertilizer	kg	5.114,65	170,31	871.075,29
KCl Fertilizer	kg	5.694,69	200,97	1.144.439,18
Pesticides	HOK	65.681,82	79,89	5.247.442,46
TKLK	Rp			1.240.776,08
Cost transportation	Rp			69.615,14
PBB				10.911.498,72
Cash Cost Amount				
II. Cost Calculated				
Seedlings	kg	6.318,06	407,25	2.573.040,18
Land rent	Rp			6.172.391,86
TKDK	HOK	65.681,82	9,68	635.718,11
Depreciation of Equipment	Rp			151.038,92
Cost Calculated Amount				9.532.189,07
III. Cost Amount				20.443.687,79
Income				
I. Income on Cash Costs				10.407.408,72
II. Income on Costs Amount				875.219,65
R/C on Cash Costs				**1,95**
R/C on Cost Amount				**1,04**

Source: Primary data, research processed results, 2020

Based on Table 7, it can be seen that the largest use of input costs is the cost of labor outside the family (TKLK). This is because in cassava farming, the process of cultivating the land, planting, and harvesting usually uses workers outside the family (TKLK). Cassava production in Lampung Tengah Regency is low (22,270 tons / ha), whereas the potential for cassava farming can reach 40 tons/ha. The low production of cassava in Lampung Tengah Regency is due to: the use of spacing and the use of fertilizers that are not in accordance with the recommendations and the use of seeds from the harvest (not native seeds-F1). Cassava farming income from cash costs in Lampung Tengah Regency is Rp10. 407.408,72/ha with an R/C of 1,95, which means that the cost of one rupiah spent by the farmer for cassava farming in Lampung Tengah Regency will get a profit of Rp1,95. Based on the results of the research, for the sustainability of cassava farming and increasing production efficiency and farmer income, education is needed to farmers through strategies in the short term that can be taken through restructuring the use of production factors (sub-optimal scenario), in the medium term by increasing the area planting, and the use of essential production factors, and in the long term can be done by developing cultivation technology.

4. Conclusion

Cassava farming in Lampung Tengah Regency is mostly not technically efficient nor economically efficient. However, cassava farming in Lampung Tengah Regency is still worthy of being cultivated.

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Analysis of production efficiency and income to support sustainability of cassava farming in Lampung Tengah District, Lampung Province

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Abstract. This study aims to analyze the efficiency of production, income, and sustainability of cassava farmers revenue in Lampung Tengah Regency, Lampung Province. Lampung Tengah Regency was chosen as the research location with the consideration that the district is a center for cassava production in Lampung Province. The number of respondents was 60 respondents who were taken using *simple random sampling.* Data collection was carried out in July 2020. The data used in this study are primary and secondary data. Data analysis used the production function *stochastic frontier* with the *Frontie*r 4.1 program, income analysis, and R/C ratio to know sustainability of cassava farming. The result showed that cassava farming in Lampung Tengah Regency on average, is not efficient both technically and economically but was profitable with R/C > 1 it means the cassava farming in Lampung Tengah district still sustain to cultivate.

Keywords: Cassava, income, production efficiency, sustainability.

1. Introduction

Zulkarnain, et al; (2010), Kristina and Surono (2012), and Kaizan (2014) stated that the food crop sub sector has a very important role in realizing national food security, absorption of labor, providers of industrial raw materials and food. One of the important commodities in the food plant group is cassava. Pusat Data dan Sistem Informasi Pertanian (2018) showed that Iindonesia is the fourth largest producer of cassava after Thailand in the world. It's just that Indonesian cassava is mostly consumed domestically (Hermanto, 2015).

AgricuktuThe harvested area for cassava in Indonesia in 2015 was 0,95 million hectares and the production reached was 21,80 million tons with a productivity of 22,95 tons /ha. In 2016, the harvested area for cassava is projected to be 1,11 million hectares with a productivity of 20,23 tons/ha, so the national cassava production is expected to reach 25 million tons (Kementrian Pertanian Indonesia, 2016). The opportunity for cassava development is very wide, given the availability of quite extensive land, based on data from BPS in 2005, it shows that there is a potential dry land area of 25.955.901 hectares consisting of 10.775.051 hectares of tegal land, 3.839.093 hectares and temporary undeveloped land for an area of 11.341.757 ha. These lands are available potential for the development of cassava cultivation/ farming areas (Kementrian Pertanian Indonesia, 2016).

The potential productivity of cassava is high in aggregate but is not balanced with the actual productivity of the farmers. The difference in the use of production factors and the managerial ability

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of farmers causes differences in the productivity of cassava. The use of production factors need to be considered to increase farmers income and will provide maximum profit and production efficiency. Land area is the variable most responsive to the production (frontier) of cassava farming (Anggraini 2016). The low price of cassava can lead to low farmer income because the cost of farming production is not proportional to the income earned. The ability of farmers to detect farming problems is still low, while the success of farming is determined by the decisions taken. The allocation of the use of production factors needs to be considered in order to achieve production efficiency, increase productivity and income.

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Coelli (2005) stated three sources of productivity growth, namely technological changes, increased technical efficiency and economies of scale. (Kumbakar 2002) examined the relationship between technical efficiency and productivity, namely that commodity production is affected by efficient input allocation, or the absence of technical inefficiency problems and agricultural production factors. Based on these problems, it is necessary to conduct research on the efficiency of cassava farming production in Lampung Province.

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So many research about production efficiency and income, but the research about the relation between production efficiency and income to farming sustainability has not been widely carried out. Therefore, this research objective is to analyze the efficiency of production, income, and sustainability of cassava farmers revenue in Lampung Tengah Regency, Lampung Province.

2. Research Method

This research was conducted in Bandar Agung Village of Terusan Nunyai sub-district of Lampung Tengah Regency, Lampung Province. The location of this study was determined purposively with the consideration that Lampung Province is the largest cassava producing province in Indonesia. The research time on July 2020. This study used a survey method at the location of cassava production centers in Lampung Province. The sample farmers were estimated to be 60 cassava farmers who were taken by *simple random sampling*. Analysis of the data used to answer the first objective of cassava farming used the production function *stochastic frontier* with the frontier 4.1 program using computer assistance. The *stochastic frontier* production function model for efficiency and technical inefficiency in cassava farming is as follows.

$$\text{Ln Y} = \ln b0 + b1lnX1 + b2lnX3 + \cdots + b9lnX9 + b1lnZ1 + b2lnZ2 + b3LnZ3 + b4ln + b5lnZ5 + b6lnZ6 + ei + \text{Ui} \text{..........................(1)}$$

Description:

Y = Cassava production (kg)
$b0$ = Intercept
$b1, b2 \ldots bn$ = Estimator variable parameter /regression coefficient
$X1$ = Land area (ha)
$X2$ = Seed (kg)
$X3$ = NPK fertilizer (kg)
$X4$ = Urea fertilizer (kg)
$X5$ = SP36 fertilizer (kg)
$X6$ = KCl fertilizer (kg)
$X7$ = Pesticides (gba)
$X8$ = Labor (HOK)
$Z1$ = Age of farmer (years)
$Z2$ = Formal education level
$Z3$ = Farming experience (years)
$Z4$ = Participation in counseling
$Z5$ = Number of dependents(person)
$Z6$ = Distance to factory (km)
ei = Errors due to random factors
Ui = Technical inefficiency factors

Farmer (years)

Passel et al (2006) describe factors affecting technical inefficiencies related to age, education, experience, credit and markets. Similar research also performed (Fauziyah 2010; Bare, 2012; Nahraini et al., 2013). Economic efficiency is obtained by using cost function parameter estimation. The variable used is the weighted price of each variable using the formula for the total cost of each input divided by the production of each farmer. The function of the overall economic efficiency estimation model can be written as follows :

Ln Ci= ln b0+b1 lnX1+b2 lnX2+b3 lnX3+…+ b8 lnX8 + Ui……………………………………….(2)

Description:

Ci = Total production cost (Rp)
$X1$ = Land rental price (Rp / ha)
$X2$ = Seed price (Rp / kg)
$X3$ = NPK fertilizer price (Rp / kg)
$X4$ = Urea fertilizer price (Rp / kg)
$X5$ = SP36 fertilizer price (Rp/ kg)
$X6$ = KCl fertilizer price (Rp/kg)
$X7$ = Pesticide price (Rp/kg)
$X8$ = Labor price (Rp/kg)
b = Regression coefficient
Ui = *error*

Results obtained from application *frontier* 4.1 with a cost function model is *Cost Efficiency* so that to get economic efficiency uses the formula:

$EE = \frac{1}{CE}$....…………………….......................(3)

Description:
EE = Economic efficiency
CE = *Cost efficiency*

Analysis of price efficiency or allocative efficiency is obtained from the calculation of economic efficiency divided by technical efficiency written with the formula:

$EH = \frac{EE}{ET}$ ………………………….................(4)

Description :
EH = Price efficiency
EE = Economic efficiency
ET = Technical efficiency

The income analysis is calculated to see how much the farmer's income is and the R/C value of cassava farming to see the feasibility of farming to calculate income using the following formula:

$\pi = TR - TC$..(5)

π = (Y.Py) - (X.Px).........……………..……..(6)

Description :
π = Farmer income
TR = Total revenue (Rp)
TC = Total *Cost* (Rp)
Y = Output (kg)
Py = Price of cassava (Rp)
X = Input (kg))
Px = Input Price (Rp)

The R / C formula used is:

$R/C = \frac{TR}{TC}$………..……………..................(7)

Description:
R / C = Ratio revenue and cost
TR = Total Revenue or total revenues (Rp)
TC = Total Cost (Rp)

3. Results And Discussion

3.1 Analysis of Cassava Production Efficiency

Based on Table 1 the variables that have a significant effect on production in Lampung Tengah Regency are the variable land area (X1), seeds (X2), NPK fertilizer (X3), KCL fertilizer (X6), pesticides. (X7), and labor (X8). The urea (X4) and SP36 (X5) fertilizer variables did not significantly affect production, meaning that the use of fertilizers was not efficient. The use of inefficient fertilizers needs to be paid attention to the dosage and time of fertilization. Based on the regression results in Table 1, the production function is *frontier* as follows:

Ln Y: 7,8280 + 0,3825 lnX1 + 0,2953 lnX2 + 0,0129 lnX3 + 0,0032 lnX4 +0,0029 lnX5 -0, 0065 lnX6 – 0,0230 lnX7 + 0,2972 lnX8 + Ui

Table 1. Estimation results of the production function of *stochastic frontier* cassava farming in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	Coefficient	*t-ratio*
Intercept	7,8280 ***	19,6829
Land area (X1)	0,3825 ***	5,4839
Seeds (X2)	0.2953 ***	4.2013
NPK Fertilizer (X3)	0.0129 ***	2.9858
Urea fertilizer (X4)	0.0032	1.4671
SP36 Fertilizer (X5)	0.0029	0.4637
KCl Fertilizer (X6)	-0.0065 ***	-3.8502
Pesticides (X7)	-0.0230 ***	-6.6436
Labor (X8)	0.2972 ***	18.0172
sigma-squared	0.6417 ***	8,1777
Gamma	1,0000***	3,5728
OLS Log Likelihood	-22,2586	
Log Likelihood MLE	-3.8368	

Source : Primary data, processed research results, 2020

Information: * = 90% confidence level (t-table = 1.6630)
** = 95% confidence level (t-table = 1.9833)
*** = 99 % (t-table = 2,6349)

The results of the *stochastic frontier* production test can produce the factors that affect the production of cassava farming and the level of technical efficiency of each farmer. The distribution of the technical efficiency of cassava farming in Lampung Tengah Regency in 2020 is presented in Table 2.

Table 2. The distribution of the efficiency level of cassava farming in Lampung Province.

Technical Efficiency	Lampung Tengah		Information
	Amount (people)	(%)	
<0,70	31	51,67	Not efficient
0,70 – 0,90	20	33,33	Quite efficient
> 0,90	9	15,00	Very efficient
Total	60	100.00	
Average	0,70		
Min	0,15		
Max	1,00		

Source: Primary data, processed research results, 2020

Based on Table 2, cassava farming in Lampung Tengah Regency is on average quite technically efficient with a value of 0,70. However, most of them are not efficient. The average efficiency level value of 0,70 means that farmers still have the opportunity to increase their efficiency by 30 percent. Similar research on technical efficiency, Fauziah (2010) on tobacco in Madura provides a technical efficiency index between 0,56 to 0,99 with an average of 0,78. Saptana et al., (2010) found that the average technical efficiency was 0,90 for Central Java red chili. A study by Banani et al., (2013) on shallots in Brebes found that technical efficiency levels ranged from 0,65 to 0,99, with an average of 0,80. Darmansyah et al., (2013) on Cabbage in Rejang Lebong Regency produces technical efficiency between 0,78 to 0.99, with an average value of 0,91. Meanwhile, Abiola and Daniel (2014) examined the technical efficiency of melons in Nigeria giving an index between 0,43 to 0,97, with an average of 0,84. A study conducted by Baree (2012) on onions in Bangladesh produced a technical efficiency index ranging from 0,58 to 0,99 with an average of 0,83. A study by Taiwo (2014) about the technical efficiency of cassava in Nigeria resulted in a technical efficiency level ranging from 0,42 to 0,97 with an average of 0,904. Kareem and Isgn (2016) regarding the technical efficiency of cassava in Ghana produced a technical efficiency level of between 9,1 to 99,6 with an average of 95,6. This efficiency value means that cassava farmers in Lampung Tengah can still improve technical efficiency by 30 percent.

Technical efficiency can be increased by fostering ideal cropping patterns and cultivating seedlings. The majority of the cassava spacing applied by farmers in Lampung Tengah Regency was 50 cm x 50 cm and 30 cm x 40 cm. Based on the recommendation of cropping patterns in monocultures, the ideal can be done with a distance of 1 m x 1 m; 1 m x 0,8 m; 1 m x 0,75 m and 1 m x 0,7 m. Whereas for less fertile soils, dense spacing is used 1 m x 0,5 m, 0,8 m x 0,7 m. Multiple row spacing in an intercropping planting pattern that supports cassava plants planted at a spacing of 0,6 m x 0,7 m x 2,6 m (Sundari, 2010). Spacing that is too dense will affect the decline in production. Then to use the seeds must be in the form of stem cuttings from the bottom to the middle. To achieve the cropping pattern and superiority of a cassava seed, it is necessary to have an educational strategy for farmers to be able to add insight and knowledge, so that it can influence production results more optimally.

Table 3. Estimated parameters of technical inefficiency factors of cassava farmers in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	Coefficient	*t-ratio*
Intercept	7,8280 ***	19,6829
Age (Z1)	-0,1432	-0,3791
Level education (Z2)	0,0788	0,3305
Farming experience (Z3)	-0,1138	-0,5795
Number of dependents (Z4)	1,0187 ***	3,3586
Participating farmer (Z5)	-1,1454	-1, 6673
Distance to factory (Z6)	-0,7300 *	-1,9169
sigma-squared	0,6417 ***	2,7071
Gamma	1,0000 ***	1,5708
Log Likelihood OLS	-22,2586	
Log Likelihood MLE	-3,8368	

Source : Primary data, processed research results, 2020
Information: * = 90% confidence level (t-table = 1.6630)
** = 95% confidence level (t-table = 1.9833)

*** = 99 % (t-table = 2,6349)

These factors are technical inefficiency factors which are analyzed using the technical inefficiency model of the *stochastic frontier* production function. Estimated parameters of factors affecting the technical inefficiency of cassava farming are presented in Table 3. Based on the results in Table 3, the gamma value in Lampung Tengah Regency is 1,000, which means that 1,000 percent of the errors in the stochastic frontier production function are caused by technical inefficiency. The variables that affect the technical inefficiency factor in Lampung Tengah Regency are the number of dependents (Z4) and the distance to the factory (Z6).

The results of the calculation of Table 3 show that the variables that have a significant effect on cassava production are the number of dependents (Z4) and the distance to the factory (Z6), while other variables have no significant effect. The t-count value of the number of dependents (Z4) is greater than the t-table, which is 3,3586. These results indicate that the variable number of dependents of cassava farmer families in Lampung Tengah Regency has a significant effect on cassava production with a confidence level of 99 percent. This means that if the number of family dependents is increased by one percent, it will reduce the level of efficiency by 1,0187 percent.

Table 4. Estimation results of the production cost function of *stochastic frontier* cassava farming in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	coefficient	*t-ratio*
Intercept	14,9370 ***	12,0278
Land rental price / output (X1)	0,3222	1,0006
Seed / output price (X2)	-0,0632	-0,2635
Price of NPK fertilizer / output (X3)	0,0353 **	2,5965
Price of urea / output fertilizer (X4)	-0,0422	-1,3970
Price of fertilizer SP36 / output (X5)	0,0572 ***	4,6989
Price of KCl / output fertilizer (X6)	0,0335 *	1,9986
Pesticide price / output (X7)	0,0556 *	1,9425
Labor / output wage (X8)	-0,0393 **	-2,2494
sigma-squared	0,7254 ***	3,5001
Gamma	0,8890 ***	9,4821
Log Likelihood OLS	-49,8120	
Log Likelihood MLE	-48,1753	

Source : Primary data, processed research results, 2020.

Note: * = 90% confidence level (t-table = 1.6759)

** = 95% confidence level (t-table = 2.0086)

*** = confidence level 99% (t-table = 2.6778)

Based on Table 4, the variables that have a significant effect on the profits of cassava farming in Lampung Tengah are the price of NPK fertilizer/output (X3), the price of fertilizer SP36 / output (X5), the price of KCl/fertilizer output (X6), pesticide price / output (X7) and wages for labor / output (X8). Economic efficiency is obtained through an analysis of the cost of production inputs using weighted prices, namely by dividing the variable costs of inputs by the total production. Based on the results in Table 4, the frontier production cost function is as follows:

$$\text{Ln C: } 14{,}9370 + 0{,}3222 \ln X1 - 0{,}0632 \ln X2 + 0{,}0353 \ln X3 - 0{,}0422 \ln X4 + 0{,}0572 \ln X5 + 0{,}0335 \ln X6 + 0{,}0556 \ln X7 - 0{,}0393 \ln X8 + Ui.$$

The results of the analysis show that the constant in the model that affects the economic efficiency factor is 14,9370 with the t-count value greater than the t-table, meaning that the variable value of land rental price/kg, the price of seeds/kg, the price of NPK/kg, the price of urea/kg, the price of SP36/kg, the price of KCl/ kg, the price of pesticides/kg, and the price of labor / kg are equal to zero then the value of farming profits cassava amounted to 14,9370 percent. The results of the estimation of the production cost function of *stochastic frontier* cassava farming in Lampung Tengah Regency are presented in Table 5.

Table 5. Distribution of the economic efficiency of cassava farming in Lampung Tengah Regency in 2020.

Economic Efficiency of	Lampung Tengah		Information
	Amount (person)	(%)	
<0,70	44	73,34	Not efficient
0,70 – 0,90	16	26,66	Quite efficient
> 0,90	0	0,00	Very efficient
Total	60	100,00	
Average	0,46		
Min	0,14		
max	0,88		

Source : Primary data, processed research results, 2020

After obtaining the results of the factors that affect the benefits of cassava farming, it will be obtained the value of economic efficiency. Based on Table 5, the average cassava farming is not economically efficient (0,46). This is because farmers are less able to allocate inputs properly so that they are not able to equalize input prices with marginal products. Although allocatively (price) it is efficient. The distribution of price efficiency in Lampung Tengah Regency is presented in Table 6.

Table 6. Distribution of the efficiency of cassava farming prices in Lampung Tengah Regency in 2020.

Price efficiency	Lampung Tengah		Information
	Amount (people)	(%)	
<0.70	21	35, 00	Not efficient
0.70 - 0.90	15	25.00	Quite efficient
> 0.90	24	40.00	Very efficient
Total	60	100.00	
Average	0.96		
Min	0.15		
Max	1.00		

Source: Primary data, processed research results, 2020.

Based on the results of research the efficiency distribution of cassava farming prices in Lampung Tengah Regency, it was obtained 35 percent with an average of 0,96 in Lampung Tengah Regency. This means that cassava farming is included in the very efficient category in terms of price.

3.2 Cassava Farming Income

In this research, apart from discussing production efficiency, it also discusses the income of cassava farming in Lampung Tengah Regency, Lampung Province. Income is measured as revenue minus production costs. Analysis of cassava farming income is presented in Table 7.

Table 7. Revenue, costs, income and R / C farming of cassava in Lampung Tengah 2020.

Description	Unit	Price (Rp)	Lampung Tengah Farming per 1 ha	
			Amount	Value (Rp / yr)
Revenue				
Production	kg	957,25	22.270,99	21.318.907,44
Production Costs				
I. Cash Cost				
NPK fertilizer	kg	2.959,01	327,77	969.865,67
Urea fertilizer	kg	2.376,31	366,13	870.049,62
TSP /SP36 fertilizer	kg	5.114,65	170,31	871.075,29
KCl Fertilizer	kg	5.694,69	200,97	1.144.439,18
Pesticides	HOK	65.681,82	79,89	5.247.442,46
TKLK	Rp			1.240.776,08
Cost transportation	Rp			69.615,14
PBB				10.911.498,72
Cash Cost Amount				
II. Cost Calculated				
Seedlings	kg	6.318,06	407,25	2.573.040,18
Land rent	Rp			6.172.391,86
TKDK	HOK	65.681,82	9,68	635.718,11
Depreciation of Equipment	Rp			151.038,92
Cost Calculated Amount				9.532.189,07
III. Cost Amount				20.443.687,79
Income				
I. Income on Cash Costs				10.407.408,72
II. Income on Costs Amount				875.219,65
R/C on Cash Costs				**1,95**
R/C on Cost Amount				**1,04**

Source: Primary data, research processed results, 2020

Based on Table 7, it can be seen that the largest use of input costs is the cost of labor outside the family (TKLK). This is because in cassava farming, the process of cultivating the land, planting, and harvesting usually uses workers outside the family (TKLK). Cassava production in Lampung Tengah Regency is low (22,270 tons / ha), whereas the potential for cassava farming can reach 40 tons/ha. The low production of cassava in Lampung Tengah Regency is due to: the use of spacing and the use of fertilizers that are not in accordance with the recommendations and the use of seeds from the harvest (not native seeds-F1). Cassava farming income from cash costs in Lampung Tengah Regency is

Rp10. 407.408,72/ha with an R/C of 1,95, which means that the cost of one rupiah spent by the farmer for cassava farming in Lampung Tengah Regency will get a profit of Rp1,95.

3.3 The Sustainability of Cassava in Lampung Tengah Regency

Keberlanjutan dari usaha tani teknis dapat dilihat dari efisiensi produksi dan pendapatan. Berdasarkan hasil analisis usaha tani singkong di Lampung Tengah tidak efisien secara teknis dan ekonomis sehingga produksi yang dihasilkan rendah dan belum maksimal. Kurang optimalnya produksi yang dihasilkan disebabkan oleh penggunaan jarak tanam, bibit dan umur panen. Jarak tanam yang digunakan oleh petani berkisar diantara 0,5 x 0,5 dan 0,3 x 0,4 m tidak sesuai dengan rekomendasi dan tidak memberikan hasil yang optimal. Rekomendasi dari Indonesian Agency for Agricultural Research and Development (IAARD) (2016) yaitu 1 x 1 m, 1 x 0,8 m, 1 x 0,75 m dan 1 x 0,7 m yang disesuaikan dengan tingkat kesuburan tanah. Bibit yang digunakan oleh petani merupakan bibit yang berasal dari pohon tanaman panen sebelumnya sehingga dapat menurunkan produktivitas ubi kayu karena itu petani seharusnya menggunakan bibit yang murni baru atau asli (F1). Sebagian besar petani memanen ubi kayu pada saat umur 6 bulan sehingga harga yang diterima oleh petani rendah. Menurut IAARD (2016) petani memiliki kecendrungan untuk memanen ubi kayu sesuai dengan harga jual yang terbentuk, sehingga ketika harga ubi kayu baik petani akan memanen lebih awal. Padahal kadar air dan kadar pati ubi kayu ditentukan oleh umur panen. Semakin tua umur panen maka kadar air akan semakin berkurang dan kadar pati ubi kayu meningkat. Umur panen yang direkomendasikan oleh IAARD adalah berkisar pada 7-10 bulan.
The sustainability of cassava farming and increasing production efficiency and farmer income, education–is needed to farmers through strategies in the short term that can be taken through restructuring the use of production factors.

4. Conclusion

Cassava farming in Lampung Tengah Regency is mostly not technically efficient nor economically efficient. However, cassava farming in Lampung Tengah Regency is still worthy of being cultivated.

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Comment [Kn9]: The conclusion answers the research objectives and discusses the sustainability aspects of Cassava in Lampung Tengah regency

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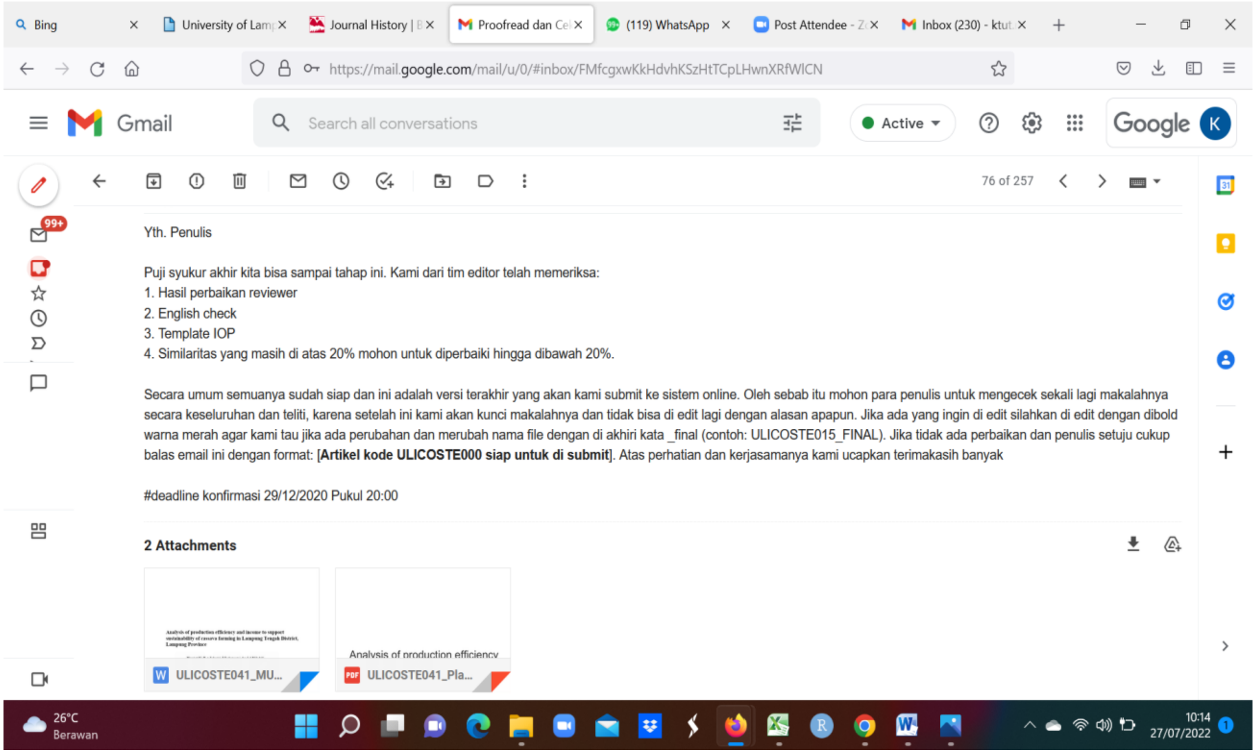

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Analysis of production efficiency and income to support sustainability of cassava farming in Lampung Tengah District, Lampung Province

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Word count: 4089
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Analysis of production efficiency and income to support sustainability of cassava farming in Lampung Tengah District, Lampung Province

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Abstract. This study aims to analyze the efficiency of production, income, and sustainability of cassava farmers revenue in Lampung Tengah Regency, Lampung Province. Lampung Tengah Regency was chosen as the research location with the consideration that the district is a center for cassava production in Lampung Province. The number of respondents was 60 respondents who were taken using *simple random sampling*. Data collection was carried out in July 2020. The data used in this study are primary and secondary data. Data analysis used the production function *stochastic frontier* with the *Frontie*r 4.1 program, income analysis, and R/C ratio to know sustainability of cassava farming. The result showed that cassava farming in Lampung Tengah Regency on average, is not efficient both technically and economically but was profitable with R/C > 1 it means the cassava farming in Lampung Tengah district still sustain to cultivate.

1. Introduction

food crop sub sector has a very important role in realizing national food security, absorption of labor, providers of industrial raw materials and food [1–3] stated that the food crop sub sector has a very important role in realizing national food security, absorption of labor, providers of industrial raw materials and food. One of the important commodities in the food plant group is cassava. Pusat Data dan Sistem Informasi Pertanian showed that Indonesia is the fourth largest producer of cassava after Thailand in the world [4]. It's just that Indonesian cassava is mostly consumed domestically [5].

The harvested area for cassava in Indonesia in 2015 was 0,95 million hectares and the production reached was 21,80 million tons with a productivity of 22,95 tons /ha. In 2016, the harvested area for cassava is projected to be 1,11 million hectares with a productivity of 20,23 tons/ha, so the national cassava production is expected to reach 25 million tons [4]. The opportunity for cassava development is very wide, given the availability of quite extensive land, based on data from BPS in 2005, it shows that there is a potential dry land area of 25.955.901 hectares consisting of 10.775.051 hectares of tegal land, 3.839.093 hectares and temporary undeveloped land for an area of 11.341.757 ha. These lands are available potential for the development of cassava cultivation/ farming areas [4].

The potential productivity of cassava is high in aggregate but is not balanced with the actual productivity of the farmers. The difference in the use of production factors and the managerial ability of farmers causes differences in the productivity of cassava. The use of production factors need to be considered to increase farmers income and will provide maximum profit and production efficiency. Land area is the variable most responsive to the production (frontier) of cassava farming [6]. The low price of cassava can lead to low farmer income because the cost of farming production is not proportional to the income earned. Based on the survey on the field the ability of farmers to detect farming problems is still low, while the success of farming is determined by the decisions taken. The allocation of the use of production factors needs to be considered in order to achieve production efficiency, increase productivity and income.

Coelli [7] stated three sources of productivity growth, namely technological changes, increased technical efficiency and economies of scale. Kumbhakar [8] examined the relationship between technical efficiency and productivity, namely that commodity production is affected by efficient input allocation, or the absence of technical inefficiency problems and agricultural production factors. Based on these problems, it is necessary to conduct research on the efficiency of cassava farming production in Lampung Province.

So many research about production efficiency and income, but the research about the relation between production efficiency and income to farming sustainability has not been widely carried out. Therefore, the research objective is to analyze the efficiency of production, income, and sustainability of cassava farmers revenue in Lampung Tengah Regency, Lampung Province.

Research Method

This research was conducted in Bandar Agung Village of Terusan Nunyai sub-district of Lampung Tengah Regency, Lampung Province. The location of this study was determined purposively with the consideration that Lampung Province is the largest cassava producing province in Indonesia. The research time on July 2020. This study used a survey method at the location of cassava production centers in Lampung Province. The sample farmers were estimated to be 60 cassava farmers who were taken by *simple random sampling*. Analysis of the data used to answer the first objective of cassava farming used the production function *stochastic frontier* with the frontier 4.1 program using computer assistance. The *stochastic frontier* production function model for efficiency and technical inefficiency in cassava farming is as follows.

$$\text{Ln Y} = \ln b0 + b1lnX1 + b2lnX3 + \cdots + b9lnX9 + b1lnZ1 + b2lnZ2 + b3LnZ3 + b4ln + b5lnZ5 + b6lnZ6 + ei + \text{Ui} \quad \ldots\ldots\ldots\ldots(1)$$

Description:

Y	= Cassava production (kg)	$Z3$	= Farming experience (years)
$b0$	= Intercept	$Z4$	= Participation in counseling
$b1, b2 \ldots bn$	= Estimator variable parameter /regression coefficient	$Z5$	= Number of dependents(person)
$X1$	= Land area (ha)	$Z6$	= Distance to factory (km)
$X2$	= Seed (kg)	ei	= Errors due to random factors
$X3$	= NPK fertilizer (kg)	Ui	= Technical inefficiency factors
$X4$	= Urea fertilizer (kg)		
$X5$	= SP36 fertilizer (kg)		
$X6$	= KCl fertilizer (kg)		
$X7$	= Pesticides (gba)		
$X8$	= Labor (HOK)		
$Z1$	= Age of farmer (years)		
$Z2$	= Formal education level Farmer (years)		

Van Passel et al [9] describe factors affecting technical inefficiencies related to age, education, experience, credit and markets. Similar research also performed by Fauziyah, Baree, and Nahraeni et al [10]; [11]; [12]. Economic efficiency is obtained by using cost function parameter estimation. The variable used is the weighted price of each variable using the formula for the total cost of each input

divided by the production of each farmer. The function of the overall economic efficiency estimation model can be written as follows :

$$\text{Ln } Ci = \ln b0 + b1 \ln X1 + b2 \ln X2 + b3 \ln X3 + \ldots + b8 \ln X8 + Ui \quad \ldots\ldots (2)$$

Description:

Ci = Total production cost (Rp)
$X1$ = Land rental price (Rp / ha)
$X2$ = Seed price (Rp / kg)
$X3$ = NPK fertilizer price (Rp / kg)
$X4$ = Urea fertilizer price (Rp / kg)
$X5$ = SP36 fertilizer price (Rp/ kg)
$X6$ = KCl fertilizer price (Rp/kg)
$X7$ = Pesticide price (Rp/kg)
$X8$ = Labor price (Rp/kg)
b = Regression coefficient
Ui = *error*

Results obtained from application *frontier* 4.1 with a cost function model is *Cost Efficiency* so that to get economic efficiency uses the formula:

$$EE = \frac{1}{CE} \quad \ldots\ldots (3)$$

Description:
EE = Economic efficiency
CE = *Cost efficiency*

Analysis of price efficiency or allocative efficiency is obtained from the calculation of economic efficiency divided by technical efficiency written with the formula:

$$EH = \frac{EE}{ET} \quad \ldots\ldots (4)$$

Description :
EH = Price efficiency
EE = Economic efficiency
ET = Technical efficiency

The income analysis is calculated to see how much the farmer's income is and the R/C value of cassava farming to see the feasibility of farming to calculate income using the following formula:

$$\pi = TR - TC \quad \ldots\ldots (5)$$

$$\pi = (Y.Py) - (X.Px) \quad \ldots\ldots (6)$$

Description :
π = Farmer income
TR = Total revenue (Rp)
TC = Total *Cost* (Rp)
Y = Output (kg)
Py = Price of cassava (Rp)
X = Input (kg))
Px = Input Price (Rp)

The R / C formula used is:

$$R/C = \frac{TR}{TC} \quad \ldots\ldots (7)$$

Description:
R / C = Ratio revenue and cost
TR = Total Revenue or total revenues (Rp)
TC = Total Cost (Rp)

3. Results And Discussion

3.1. Analysis of Cassava Production Efficiency

Based on Table 1 the variables that have a significant effect on production in Lampung Tengah Regency are the variable land area (X1), seeds (X2), NPK fertilizer (X3), KCL fertilizer (X6), pesticides. (X7), and labor (X8). The urea (X4) and SP36 (X5) fertilizer variables did not significantly affect production, meaning that the use of fertilizers was not efficient. The use of inefficient fertilizers needs to be paid attention to the dosage and time of fertilization. Based on the regression results in Table 1, the production function is *frontier* as follows:

$$\text{Ln } Y: 7{,}8280 + 0{,}3825 \ln X1 + 0{,}2953 \ln X2 + 0{,}0129 \ln X3 + 0{,}0032 \ln X4 + 0{,}0029 \ln X5 - 0{,}0065 \ln X6 - 0{,}0230 \ln X7 + 0{,}2972 \ln X8 + Ui$$

Table 1. Estimation results of the production function of *stochastic frontier* cassava farming in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	Coefficient	*t-ratio*
Intercept	7,8280 ***	19,6829
Land area (X1)	0,3825 ***	5,4839
Seeds (X2)	0.2953 ***	4.2013
NPK Fertilizer (X3)	0.0129 ***	2.9858
Urea fertilizer (X4)	0.0032	1.4671
SP36 Fertilizer (X5)	0.0029	0.4637
KCl Fertilizer (X6)	-0.0065 ***	-3.8502
Pesticides (X7)	-0.0230 ***	-6.6436
Labor (X8)	0.2972 ***	18.0172
sigma-squared	0.6417 ***	8,1777
Gamma	1,0000***	3,5728
OLS Log Likelihood	-22,2586	
Log Likelihood MLE	-3.8368	

Source : Primary data, processed research results, 2020
Information: * = 90% confidence level (t-table = 1.6630)
** = 95% confidence level (t-table = 1.9833)
*** = 99 % (t-table = 2,6349)

The results of the *stochastic frontier* production test can produce the factors that affect the production of cassava farming and the level of technical efficiency of each farmer. The distribution of the technical efficiency of cassava farming in Lampung Tengah Regency in 2020 is presented in Table 2.

Table 2. The distribution of the efficiency level of cassava farming in Lampung Province.

Technical Efficiency	Lampung Tengah		Information
	Amount (people)	(%)	
<0,70	31	51,67	Not efficient
0,70 – 0,90	20	33,33	Quite efficient
> 0,90	9	15,00	Very efficient
Total	60	100.00	
Average	0,70		
Min	0,15		
Max	1,00		

Source: Primary data, processed research results, 2020

Based on Table 2, cassava farming in Lampung Tengah Regency is on average quite technically efficient with a value of 0,70. However, most of them are not efficient. The average efficiency level value of 0,70 means that farmers still have the opportunity to increase their efficiency by 30 percent.Similar research on technical efficiency, Fauziyah [10] on tobacco in Madura provides a technical efficiency index between 0,56 to 0,99 with an average of 0,78. Saptana, Daryanto, Daryanto and Kuntjoro [13] found that the average technical efficiency was 0,80 for Central Java red chili. A study by Banani and Koestiono [14] on shallots in Brebes found that technical efficiency levels ranged from 0,65 to 0,99, with an average of 0,80. Darmansyah, Sukiyono and Sugiarti [15] on Cabbage in Rejang Lebong Regency produces technical efficiency between 0,78 to 0.99, with an average value of 0,91. Meanwhile, Abiola and Daniel (2014) examined the technical efficiency of melons in Nigeria giving an index between 0,43 to 0,97, with an average of 0,84. A study conducted by Baree [11] on onions in Bangladesh produced a technical efficiency index ranging from 0,58 to 0,99 with an average of 0,83. A study by Taiwo, Dayo and K. O B [16] about the technical efficiency of cassava in Nigeria resulted in a technical efficiency level ranging from 0,42 to 0,97 with an average of 0,904. Kareem and Isgn [17] regarding the technical efficiency of cassava in Ghana produced a technical efficiency level of between 9,1 to 99,6 with an average of 95,6. This efficiency value means that cassava farmers in Lampung Tengah can still improve technical efficiency by 30 percent.

Technical efficiency can be increased by fostering ideal cropping patterns and cultivating seedlings. The majority of the cassava spacing applied by farmers in Lampung Tengah Regency was 50 cm x 50 cm and 30 cm x 40 cm. Based on the recommendation of cropping patterns in monocultures, the ideal can be done with a distance of 1 m x 1 m; 1 m x 0,8 m; 1 m x 0,75 m and 1 m x 0,7 m. Whereas for less fertile soils, dense spacing is used 1 m x 0,5 m, 0,8 m x 0,7 m. Multiple row spacing in an intercropping planting pattern that supports cassava plants planted at a spacing of 0,6 m x 0,7 m x 2,6 m [18]. Spacing that is too dense will affect the decline in production. Then to use the seeds must be in the form of stem cuttings from the bottom to the middle. To achieve the cropping pattern and superiority of a cassava seed, it is necessary to have an educational strategy for farmers to be able to add insight and knowledge, so that it can influence production results more optimally.

Table 3. Estimated parameters of technical inefficiency factors of cassava farmers in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	Coefficient	*t-ratio*
Intercept	7,8280 ***	19,6829
Age (Z1)	-0,1432	-0,3791
Level education (Z2)	0,0788	0,3305
Farming experience (Z3)	-0,1138	-0,5795
Number of dependents (Z4)	1,0187 ***	3,3586
Participating farmer (Z5)	-1,1454	-1, 6673
Distance to factory (Z6)	-0,7300 *	-1,9169
sigma-squared	0,6417 ***	2,7071
Gamma	1,0000 ***	1,5708
Log Likelihood OLS	-22,2586	
Log Likelihood MLE	-3,8368	

Source : Primary data, processed research results, 2020
Information: * = 90% confidence level (t-table = 1.6630)
** = 95% confidence level (t-table = 1.9833)
*** = 99 % (t-table = 2,6349)

These factors are technical inefficiency factors which are analyzed using the technical inefficiency model of the *stochastic frontier* production function. Estimated parameters of factors affecting the technical inefficiency of cassava farming are presented in Table 3. Based on the results of Table 3, the gamma value in Lampung Tengah Regency is 1,000, which means that 1,000 percent of the errors in the stochastic frontier production function are caused by technical inefficiency. The variables that affect the technical inefficiency factor in Lampung Tengah Regency are the number of dependents (Z4) and the distance to the factory (Z6).

The results of the calculation of Table 3 show that the variables that have a significant effect on cassava production are the number of dependents (Z4) and the distance to the factory (Z6), while other variables have no significant effect. The t-count value of the number of dependents (Z4) is greater than the t-table, which is 3,3586. These results indicate that the variable number of dependents of cassava farmer families in Lampung Tengah Regency has a significant effect on cassava production with a confidence level of 99 percent. This means that if the number of family dependents is increased by one percent, it will reduce the level of efficiency by 1,0187 percent.

Table 4. Estimation results of the production cost function of *stochastic frontier* cassava farming in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	coefficient	*t-ratio*
Intercept	14,9370 ***	12,0278
Land rental price / output (X1)	0,3222	1,0006
Seed / output price (X2)	-0,0632	-0,2635
Price of NPK fertilizer / output (X3)	0,0353 **	2,5965
Price of urea / output fertilizer (X4)	-0,0422	-1,3970
Price of fertilizer SP36 / output (X5)	0,0572 ***	4,6989
Price of KCl / output fertilizer (X6)	0,0335 *	1,9986
Pesticide price / output (X7)	0,0556 *	1,9425
Labor / output wage (X8)	-0,0393 **	-2,2494
sigma-squared	0,7254 ***	3,5001
Gamma	0,8890 ***	9,4821
Log Likelihood OLS	-49,8120	
Log Likelihood MLE	-48,1753	

Source : Primary data, processed research results, 2020.
Note: * = 90% confidence level (t-table = 1.6759)
** = 95% confidence level (t-table = 2.0086)
*** = confidence level 99% (t-table = 2.6778)

Based on Table 4, the variables that have a significant effect on the profits of cassava farming in Lampung Tengah are the price of NPK fertilizer/output (X3), the price of fertilizer SP36 / output (X5), the price of KCl/fertilizer output (X6), pesticide price / output (X7) and wages for labor / output (X8). Economic efficiency is obtained through an analysis of the cost of production inputs using weighted prices, namely by dividing the variable costs of inputs by the total production. Based on the results in Table 4, the frontier production cost function is as follows:

Ln C: 14,9370 + 0,3222 lnX1 – 0,0632 lnX2 + 0,0353 lnX3 – 0,0422 lnX4 + 0,0572 lnX5 + 0,0335 lnX6 + 0,0556 lnX7 – 0,0393 lnX8 + Ui.

Table 5. Distribution of the economic efficiency of cassava farming in Lampung Tengah Regency in 2020.

Economic Efficiency of	Lampung Tengah		Information
	Amount (person)	(%)	
<0,70	44	73,34	Not efficient
0,70 – 0,90	16	26,66	Quite efficient
> 0,90	0	0,00	Very efficient
Total	60	100,00	
Average	0,46		
Min	0,14		
max	0,88		

Source : Primary data, processed research results, 2020

The results of the analysis show that the constant in the model that affects the economic efficiency factor is 14,9370 with the t-count value greater than the t-table, meaning that the variable value of land rental price/kg, the price of seeds/kg, the price of NPK/kg, the price of urea/kg, the price of SP36/kg, the price of KCl/ kg, the price of pesticides/kg, and the price of labor / kg are equal to zero then the value of farming profits cassava amounted to 14,9370 percent. The results of the estimation of the production cost function of *stochastic frontier* cassava farming in Lampung Tengah Regency are presented in Table 5.

After obtaining the results of the factors that affect the benefits of cassava farming, it will be obtained the value of economic efficiency. Based on Table 5, the average cassava farming is not economically efficient (0,46). This is because farmers are less able to allocate inputs properly so that they are not able to equalize input prices with marginal products. Although allocatively (price) it is efficient. The distribution of price efficiency in Lampung Tengah Regency is presented in Table 6.

Table 6. Distribution of the efficiency of cassava farming prices in Lampung Tengah Regency in 2020.

Price efficiency	Lampung Tengah		Information
	Amount (people)	(%)	
<0.70	21	35,00	Not efficient
0.70 - 0.90	15	25.00	Quite efficient
> 0.90	24	40.00	Very efficient
Total	60	100.00	
Average	0.96		
Min	0.15		
Max	1.00		

Source: Primary data, processed research results, 2020.

Based on the results of research the efficiency distribution of cassava farming prices in Lampung Tengah Regency, it was obtained 35 percent with an average of 0,96 in Lampung Tengah Regency. This means that cassava farming is included in the very efficient category in terms of price.

3.2. Cassava Farming Income

In this research, apart from discussing production efficiency, it also discusses the income of cassava farming in Lampung Tengah Regency, Lampung Province. Income is measured as revenue minus production costs. Analysis of cassava farming income is presented in Table 7.

Table 7. Revenue, costs, income and R / C farming of cassava in Lampung Tengah 2020.

Description	Unit	Price (Rp)	Lampung Tengah	
			Farming per 1 ha	
			Amount	Value (Rp / yr)
Revenue				
Production	kg	957,25	22.270,99	21.318.907,44
Production Costs				
I.Cash Cost				
NPK fertilizer	kg	2.959,01	327,77	969.865,67
Urea fertilizer	kg	2.376,31	366,13	870.049,62
TSP /SP36 fertilizer	kg	5.114,65	170,31	871.075,29
KCl Fertilizer	kg	5.694,69	200,97	1.144.439,18
Pesticides	HOK	65.681,82	79,89	5.247.442,46
TKLK	Rp			1.240.776,08

Cost transportation	Rp			69.615,14
PBB				10.911.498,72
Cash Cost Amount				
II. Cost Calculated				
Seedlings	kg	6.318,06	407,25	2.573.040,18
Land rent	Rp			6.172.391,86
TKDK	HOK	65.681,82	9,68	635.718,11
Depreciation of Equipment	Rp			151.038,92
Cost Calculated Amount				9.532.189,07
III. Cost Amount				20.443.687,79
Income				
I. Income on Cash Costs				10.407.408,72
II. Income on Costs Amount				875.219,65
R/C on Cash Costs				**1,95**
R/C on Cost Amount				**1,04**

Source: Primary data, research processed results, 2020

Based on Table 7, it can be seen that the largest use of input costs is the cost of labor outside the family (TKLK). This is because in cassava farming, the process of cultivating the land, planting, and harvesting usually uses workers outside the family (TKLK). Cassava production in Lampung Tengah Regency is low (22,270 tons / ha), whereas the potential for cassava farming can reach 40 tons/ha. The low production of cassava in Lampung Tengah Regency is due to: the use of spacing and the use of fertilizers that are not in accordance with the recommendations and the use of seeds from the harvest (not native seeds-F1). Cassava farming income from cash costs in Lampung Tengah Regency is Rp10.407.408,72/ha with an R/C of 1,95, which means that the cost of one rupiah spent by the farmer for cassava farming in Lampung Tengah Regency will get a profit of Rp1,95.

3.3. The sustainability of cassava in Lampung Tengah Regency

The sustainability of technical farming can be seen from the efficiency of production and income. Based on the analysis results, cassava farming in Central Lampung is technically and economically inefficient, so the production is low and not optimal. The less of optimal production was caused by the use of spacing, seeds, and harvest age. The spacing used by the farmers, ranging from 0.5 x 0.5 and 0.3 x 0.4 m, was not following the recommendations and did not provide an optimal result. Recommendations from the Agricultural Research and Development Agency (IAARD) [19] are 1 x 1 m, 1 x 0.8 m, 1 x 0.75 m, and 1 x 0.7 m, adjusted to soil fertility level. The seeds used by farmers are seeds that come from previously harvested trees will reduce cassava productivity. In order to optimize productivity, farmers have to use new or original seeds (F1). Most of the farmers harvest the cassava at the age of 6 months, so the farmers' price is low. According to the Agricultural Research and Development Agency (2016), farmers tend to harvest cassava following the regular selling price. When cassava's price is high, farmers will harvest early even though the harvest age determines the water content and starch content of cassava. The older harvest age the less water content and more starch content. The harvest age recommendation by the IAARD is around 7-10 months [19]. The sustainability of cassava farming and increasing production efficiency and farmer income, educationis needed to farmers through strategies in the short term that can be taken through restructuring the use of production factors.

4. Conclusion

Cassava farming in Lampung Tengah Regency is mostly not technically efficient nor economically efficient. However, cassava farming in Lampung Tengah Regency is still worthy of being cultivated. In order to improve the sustainability of cassava farming in Lampung Tengah regency, the farmers need to get education about short term strategies and following the recommendations of cassava cultivation.

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Analysis of production efficiency and income to support sustainability of cassava farming in Lampung Tengah District, Lampung Province

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Abstract. This study aims to analyze the efficiency of production, income, and sustainability of cassava farmers revenue in Lampung Tengah Regency, Lampung Province. Lampung Tengah Regency was chosen as the research location with the consideration that the district is a center for cassava production in Lampung Province. The number of respondents was 60 respondents who were taken using *simple random sampling.* Data collection was carried out in July 2020. The data used in this study are primary and secondary data. Data analysis used the production function *stochastic frontier* with the *Frontie*r 4.1 program, income analysis, and R/C ratio to know sustainability of cassava farming. The result showed that cassava farming in Lampung Tengah Regency on average, is not efficient both technically and economically but was profitable with R/C > 1 it means the cassava farming in Lampung Tengah district still sustain to cultivate.

1. Introduction

food crop sub sector has a very important role in realizing national food security, absorption of labor, providers of industrial raw materials and food [1–3] stated that the food crop sub sector has a very important role in realizing national food security, absorption of labor, providers of industrial raw materials and food. One of the important commodities in the food plant group is cassava. Pusat Data dan Sistem Informasi Pertanian showed that Indonesia is the fourth largest producer of cassava after Thailand in the world [4]. It's just that Indonesian cassava is mostly consumed domestically [5].

The harvested area for cassava in Indonesia in 2015 was 0,95 million hectares and the production reached was 21,80 million tons with a productivity of 22,95 tons /ha. In 2016, the harvested area for cassava is projected to be 1,11 million hectares with a productivity of 20,23 tons/ha, so the national cassava production is expected to reach 25 million tons [4]. The opportunity for cassava development is very wide, given the availability of quite extensive land, based on data from BPS in 2005, it shows that there is a potential dry land area of 25.955.901 hectares consisting of 10.775.051 hectares of tegal land, 3.839.093 hectares and temporary undeveloped land for an area of 11.341.757 ha. These lands are available potential for the development of cassava cultivation/ farming areas [4].

The potential productivity of cassava is high in aggregate but is not balanced with the actual productivity of the farmers. The difference in the use of production factors and the managerial ability of farmers causes differences in the productivity of cassava. The use of production factors need to be considered to increase farmers income and will provide maximum profit and production efficiency. Land area is the variable most responsive to the production (frontier) of cassava farming [6]. The low price of cassava can lead to low farmer income because the cost of farming production is not proportional to the income earned. Based on the survey on the field the ability of farmers to detect farming problems is still low, while the success of farming is determined by the decisions taken. The allocation of the use of production factors needs to be considered in order to achieve production efficiency, increase productivity and income.

Coelli [7] stated three sources of productivity growth, namely technological changes, increased technical efficiency and economies of scale. Kumbhakar [8] examined the relationship between technical efficiency and productivity, namely that commodity production is affected by efficient input allocation, or the absence of technical inefficiency problems and agricultural production factors. Based on these problems, it is necessary to conduct research on the efficiency of cassava farming production in Lampung Province.

So many research about production efficiency and income, but the research about the relation between production efficiency and income to farming sustainability has not been widely carried out. Therefore, this research objective is to analyze the efficiency of production, income, and sustainability of cassava farmers revenue in Lampung Tengah Regency, Lampung Province.

2. Research Method

This research was conducted in Bandar Agung Village of Terusan Nunyai sub-district of Lampung Tengah Regency, Lampung Province. The location of this study was determined purposively with the consideration that Lampung Province is the largest cassava producing province in Indonesia. The research time on July 2020. This study used a survey method at the location of cassava production centers in Lampung Province. The sample farmers were estimated to be 60 cassava farmers who were taken by *simple random sampling*. Analysis of the data used to answer the first objective of cassava farming used the production function *stochastic frontier* with the frontier 4.1 program using computer assistance. The *stochastic frontier* production function model for efficiency and technical inefficiency in cassava farming is as follows.

$$\text{Ln Y} = \ln b0 + b1lnX1 + b2lnX3 + \cdots + b9lnX9 + b1lnZ1 + b2lnZ2 + b3LnZ3 + b4ln + b5lnZ5 + b6lnZ6 + ei + \text{Ui} \quad (1)$$

Description:

Y	= Cassava production (kg)
$b0$	= Intercept
$b1, b2 \ldots bn$	= Estimator variable parameter /regression coefficient
$X1$	= Land area (ha)
$X2$	= Seed (kg)
$X3$	= NPK fertilizer (kg)
$X4$	= Urea fertilizer (kg)
$X5$	= SP36 fertilizer (kg)
$X6$	= KCl fertilizer (kg)
$X7$	= Pesticides (gba)
$X8$	= Labor (HOK)
$Z1$	= Age of farmer (years)
$Z2$	= Formal education level Farmer (years)
$Z3$	= Farming experience (years)
$Z4$	= Participation in counseling
$Z5$	= Number of dependents(person)
$Z6$	= Distance to factory (km)
ei	= Errors due to random factors
Ui	= Technical inefficiency factors

Van Passel et al [9] describe factors affecting technical inefficiencies related to age, education, experience, credit and markets. Similar research also performed by Fauziyah, Baree, and Nahraeni et al [10]; [11]; [12]. Economic efficiency is obtained by using cost function parameter estimation. The variable used is the weighted price of each variable using the formula for the total cost of each input

divided by the production of each farmer. The function of the overall economic efficiency estimation model can be written as follows :

$$\text{Ln } C_i = \ln b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + \ldots + b_8 \ln X_8 + U_i \quad \ldots\ldots(2)$$

Description:

Ci = Total production cost (Rp)
$X1$ = Land rental price (Rp / ha)
$X2$ = Seed price (Rp / kg)
$X3$ = NPK fertilizer price (Rp / kg)
$X4$ = Urea fertilizer price (Rp / kg)
$X5$ = SP36 fertilizer price (Rp/ kg)
$X6$ = KCl fertilizer price (Rp/kg)
$X7$ = Pesticide price (Rp/kg)
$X8$ = Labor price (Rp/kg)
b = Regression coefficient
Ui = *error*

Results obtained from application *frontier* 4.1 with a cost function model is *Cost Efficiency* so that to get economic efficiency uses the formula:

$$EE = \frac{1}{CE} \quad \ldots\ldots(3)$$

Description:
EE = Economic efficiency
CE = *Cost efficiency*

Analysis of price efficiency or allocative efficiency is obtained from the calculation of economic efficiency divided by technical efficiency written with the formula:

$$EH = \frac{EE}{ET} \quad \ldots\ldots(4)$$

Description :
EH = Price efficiency
EE = Economic efficiency
ET = Technical efficiency

The income analysis is calculated to see how much the farmer's income is and the R/C value of cassava farming to see the feasibility of farming to calculate income using the following formula:

$$\pi = TR - TC \quad \ldots\ldots(5)$$

$$\pi = (Y.Py) - (X.Px) \quad \ldots\ldots(6)$$

Description :
π = Farmer income
TR = Total revenue (Rp)
TC = Total *Cost* (Rp)
Y = Output (kg)
Py = Price of cassava (Rp)
X = Input (kg))
Px = Input Price (Rp)

The R / C formula used is:

$$R/C = \frac{TR}{TC} \quad \ldots\ldots(7)$$

Description:
R / C = Ratio revenue and cost
TR = Total Revenue or total revenues (Rp)
TC = Total Cost (Rp)

3. Results And Discussion

3.1. Analysis of Cassava Production Efficiency

Based on Table 1 the variables that have a significant effect on production in Lampung Tengah Regency are the variable land area (X1), seeds (X2), NPK fertilizer (X3), KCL fertilizer (X6), pesticides. (X7), and labor (X8). The urea (X4) and SP36 (X5) fertilizer variables did not significantly affect production, meaning that the use of fertilizers was not efficient. The use of inefficient fertilizers needs to be paid attention to the dosage and time of fertilization. Based on the regression results in Table 1, the production function is *frontier* as follows:

Ln Y: 7,8280 + 0,3825 lnX1 + 0,2953 lnX2 + 0,0129 lnX3 + 0,0032 lnX4 +0,0029 lnX5 -0, 0065 lnX6 – 0,0230 lnX7 + 0,2972 lnX8 + Ui

Table 1. Estimation results of the production function of *stochastic frontier* cassava farming in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	Coefficient	*t-ratio*
Intercept	7,8280 ***	19,6829
Land area (X1)	0,3825 ***	5,4839
Seeds (X2)	0.2953 ***	4.2013
NPK Fertilizer (X3)	0.0129 ***	2.9858
Urea fertilizer (X4)	0.0032	1.4671
SP36 Fertilizer (X5)	0.0029	0.4637
KCl Fertilizer (X6)	-0.0065 ***	-3.8502
Pesticides (X7)	-0.0230 ***	-6.6436
Labor (X8)	0.2972 ***	18.0172
sigma-squared	0.6417 ***	8,1777
Gamma	1,0000***	3,5728
OLS Log Likelihood	-22,2586	
Log Likelihood MLE	-3.8368	

Source : Primary data, processed research results, 2020
Information: * = 90% confidence level (t-table = 1.6630)
** = 95% confidence level (t-table = 1.9833)
*** = 99 % (t-table = 2,6349)

The results of the *stochastic frontier* production test can produce the factors that affect the production of cassava farming and the level of technical efficiency of each farmer. The distribution of the technical efficiency of cassava farming in Lampung Tengah Regency in 2020 is presented in Table 2.

Table 2. The distribution of the efficiency level of cassava farming in Lampung Province.

Technical Efficiency	Lampung Tengah		Information
	Amount (people)	(%)	
<0,70	31	51,67	Not efficient
0,70 – 0,90	20	33,33	Quite efficient
> 0,90	9	15,00	Very efficient
Total	60	100.00	
Average	0,70		
Min	0,15		
Max	1,00		

Source: Primary data, processed research results, 2020

Based on Table 2, cassava farming in Lampung Tengah Regency is on average quite technically efficient with a value of 0,70. However, most of them are not efficient. The average efficiency level value of 0,70 means that farmers still have the opportunity to increase their efficiency by 30 percent.Similar research on technical efficiency, Fauziyah [10] on tobacco in Madura provides a technical efficiency index between 0,56 to 0,99 with an average of 0,78. Saptana, Daryanto, Daryanto and Kuntjoro [13] found that the average technical efficiency was 0,90 for Central Java red chili. A study by Banani and Koestiono [14] on shallots in Brebes found that technical efficiency levels ranged from 0,65 to 0,99, with an average of 0,80. Darmansyah, Sukiyono and Sugiarti [15] on Cabbage in Rejang Lebong Regency produces technical efficiency between 0,78 to 0.99, with an average value of 0,91. Meanwhile, Abiola and Daniel (2014) examined the technical efficiency of melons in Nigeria giving an index between 0,43 to 0,97, with an average of 0,84. A study conducted by Baree [11] on onions in Bangladesh produced a technical efficiency index ranging from 0,58 to 0,99 with an average of 0,83. A study by Taiwo, Dayo and K. O B [16] about the technical efficiency of cassava in Nigeria resulted in a technical efficiency level ranging from 0,42 to 0,97 with an average of 0,904. Kareem and Isgn [17] regarding the technical efficiency of cassava in Ghana produced a technical efficiency level of between 9,1 to 99,6 with an average of 95,6. This efficiency value means that cassava farmers in Lampung Tengah can still improve technical efficiency by 30 percent.

Technical efficiency can be increased by fostering ideal cropping patterns and cultivating seedlings. The majority of the cassava spacing applied by farmers in Lampung Tengah Regency was 50 cm x 50 cm and 30 cm x 40 cm. Based on the recommendation of cropping patterns in monocultures, the ideal can be done with a distance of 1 m x 1 m; 1 m x 0,8 m; 1 m x 0,75 m and 1 m x 0,7 m. Whereas for less fertile soils, dense spacing is used 1 m x 0,5 m, 0,8 m x 0,7 m. Multiple row spacing in an intercropping planting pattern that supports cassava plants planted at a spacing of 0,6 m x 0,7 m x 2,6 m [18]. Spacing that is too dense will affect the decline in production. Then to use the seeds must be in the form of stem cuttings from the bottom to the middle. To achieve the cropping pattern and superiority of a cassava seed, it is necessary to have an educational strategy for farmers to be able to add insight and knowledge, so that it can influence production results more optimally.

Table 3. Estimated parameters of technical inefficiency factors of cassava farmers in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	Coefficient	*t-ratio*
Intercept	7,8280 ***	19,6829
Age (Z1)	-0,1432	-0,3791
Level education (Z2)	0,0788	0,3305
Farming experience (Z3)	-0,1138	-0,5795
Number of dependents (Z4)	1,0187 ***	3,3586
Participating farmer (Z5)	-1,1454	-1, 6673
Distance to factory (Z6)	-0,7300 *	-1,9169
sigma-squared	0,6417 ***	2,7071
Gamma	1,0000 ***	1,5708
Log Likelihood OLS	-22,2586	
Log Likelihood MLE	-3,8368	

Source : Primary data, processed research results, 2020

Information: * = 90% confidence level (t-table = 1.6630)
** = 95% confidence level (t-table = 1.9833)
*** = 99 % (t-table = 2,6349)

These factors are technical inefficiency factors which are analyzed using the technical inefficiency model of the *stochastic frontier* production function. Estimated parameters of factors affecting the technical inefficiency of cassava farming are presented in Table 3. Based on the results in Table 3, the gamma value in Lampung Tengah Regency is 1,000, which means that 1,000 percent of the errors in the stochastic frontier production function are caused by technical inefficiency. The variables that affect the technical inefficiency factor in Lampung Tengah Regency are the number of dependents (Z4) and the distance to the factory (Z6).

The results of the calculation of Table 3 show that the variables that have a significant effect on cassava production are the number of dependents (Z4) and the distance to the factory (Z6), while other variables have no significant effect. The t-count value of the number of dependents (Z4) is greater than the t-table, which is 3,3586. These results indicate that the variable number of dependents of cassava farmer families in Lampung Tengah Regency has a significant effect on cassava production with a confidence level of 99 percent. This means that if the number of family dependents is increased by one percent, it will reduce the level of efficiency by 1,0187 percent.

Table 4. Estimation results of the production cost function of *stochastic frontier* cassava farming in Lampung Tengah Regency in 2020.

Variable	Lampung Tengah	
	coefficient	*t-ratio*
Intercept	14,9370 ***	12,0278
Land rental price / output (X1)	0,3222	1,0006
Seed / output price (X2)	-0,0632	-0,2635
Price of NPK fertilizer / output (X3)	0,0353 **	2,5965
Price of urea / output fertilizer (X4)	-0,0422	-1,3970
Price of fertilizer SP36 / output (X5)	0,0572 ***	4,6989
Price of KCl / output fertilizer (X6)	0,0335 *	1,9986
Pesticide price / output (X7)	0,0556 *	1,9425
Labor / output wage (X8)	-0,0393 **	-2,2494
sigma-squared	0,7254 ***	3,5001
Gamma	0,8890 ***	9,4821
Log Likelihood OLS	-49,8120	
Log Likelihood MLE	-48,1753	

Source : Primary data, processed research results, 2020.

Note: * = 90% confidence level (t-table = 1.6759)

** = 95% confidence level (t-table = 2.0086)

*** = confidence level 99% (t-table = 2.6778)

Based on Table 4, the variables that have a significant effect on the profits of cassava farming in Lampung Tengah are the price of NPK fertilizer/output (X3), the price of fertilizer SP36 / output (X5), the price of KCl/fertilizer output (X6), pesticide price / output (X7) and wages for labor / output (X8). Economic efficiency is obtained through an analysis of the cost of production inputs using weighted prices, namely by dividing the variable costs of inputs by the total production. Based on the results in Table 4, the frontier production cost function is as follows:

Ln C: 14,9370 + 0,3222 lnX1 – 0,0632 lnX2 + 0,0353 lnX3 – 0,0422 lnX4 + 0,0572 lnX5 + 0,0335 lnX6 + 0,0556 lnX7 – 0,0393 lnX8 + Ui.

Table 5. Distribution of the economic efficiency of cassava farming in Lampung Tengah Regency in 2020.

Economic Efficiency of	Lampung Tengah		Information
	Amount (person)	(%)	
<0,70	44	73,34	Not efficient
0,70 – 0,90	16	26,66	Quite efficient
> 0,90	0	0,00	Very efficient
Total	60	100,00	
Average	0,46		
Min	0,14		
max	0,88		

Source : Primary data, processed research results, 2020

The results of the analysis show that the constant in the model that affects the economic efficiency factor is 14,9370 with the t-count value greater than the t-table, meaning that the variable value of land rental price/kg, the price of seeds/kg, the price of NPK/kg, the price of urea/kg, the price of SP36/kg, the price of KCl/ kg, the price of pesticides/kg, and the price of labor / kg are equal to zero then the value of farming profits cassava amounted to 14,9370 percent. The results of the estimation of the production cost function of *stochastic frontier* cassava farming in Lampung Tengah Regency are presented in Table 5.

After obtaining the results of the factors that affect the benefits of cassava farming, it will be obtained the value of economic efficiency. Based on Table 5, the average cassava farming is not economically efficient (0,46). This is because farmers are less able to allocate inputs properly so that they are not able to equalize input prices with marginal products. Although allocatively (price) it is efficient. The distribution of price efficiency in Lampung Tengah Regency is presented in Table 6.

Table 6. Distribution of the efficiency of cassava farming prices in Lampung Tengah Regency in 2020.

Price efficiency	Lampung Tengah		Information
	Amount (people)	(%)	
<0.70	21	35, 00	Not efficient
0.70 - 0.90	15	25.00	Quite efficient
> 0.90	24	40.00	Very efficient
Total	60	100.00	
Average	0.96		
Min	0.15		
Max	1.00		

Source: Primary data, processed research results, 2020.

Based on the results of research the efficiency distribution of cassava farming prices in Lampung Tengah Regency, it was obtained 35 percent with an average of 0,96 in Lampung Tengah Regency. This means that cassava farming is included in the very efficient category in terms of price.

3.2. Cassava Farming Income

In this research, apart from discussing production efficiency, it also discusses the income of cassava farming in Lampung Tengah Regency, Lampung Province. Income is measured as revenue minus production costs. Analysis of cassava farming income is presented in Table 7.

Table 7. Revenue, costs, income and R / C farming of cassava in Lampung Tengah 2020.

Description	Unit	Price (Rp)	Lampung Tengah Farming per 1 ha	
			Amount	Value (Rp / yr)
Revenue				
Production	kg	957,25	22.270,99	21.318.907,44
Production Costs				
I. Cash Cost				
NPK fertilizer	kg	2.959,01	327,77	969.865,67
Urea fertilizer	kg	2.376,31	366,13	870.049,62
TSP /SP36 fertilizer	kg	5.114,65	170,31	871.075,29
KCl Fertilizer	kg	5.694,69	200,97	1.144.439,18
Pesticides	HOK	65.681,82	79,89	5.247.442,46
TKLK	Rp			1.240.776,08

Cost transportation	Rp			69.615,14
PBB				10.911.498,72
Cash Cost Amount				
II. Cost Calculated				
Seedlings	kg	6.318,06	407,25	2.573.040,18
Land rent	Rp			6.172.391,86
TKDK	HOK	65.681,82	9,68	635.718,11
Depreciation of Equipment	Rp			151.038,92
Cost Calculated Amount				9.532.189,07
III. Cost Amount				20.443.687,79
Income				
I. Income on Cash Costs				10.407.408,72
II. Income on Costs Amount				875.219,65
R/C on Cash Costs				**1,95**
R/C on Cost Amount				**1,04**

Source: Primary data, research processed results, 2020

Based on Table 7, it can be seen that the largest use of input costs is the cost of labor outside the family (TKLK). This is because in cassava farming, the process of cultivating the land, planting, and harvesting usually uses workers outside the family (TKLK). Cassava production in Lampung Tengah Regency is low (22,270 tons / ha), whereas the potential for cassava farming can reach 40 tons/ha. The low production of cassava in Lampung Tengah Regency is due to: the use of spacing and the use of fertilizers that are not in accordance with the recommendations and the use of seeds from the harvest (not native seeds-F1). Cassava farming income from cash costs in Lampung Tengah Regency is Rp10.407.408,72/ha with an R/C of 1,95, which means that the cost of one rupiah spent by the farmer for cassava farming in Lampung Tengah Regency will get a profit of Rp1,95.

3.3. The sustainability of cassava in Lampung Tengah Regency

The sustainability of technical farming can be seen from the efficiency of production and income. Based on the analysis results, cassava farming in Central Lampung is technically and economically inefficient, so the production is low and not optimal. The less of optimal production was caused by the use of spacing, seeds, and harvest age. The spacing used by the farmers, ranging from 0.5 x 0.5 and 0.3 x 0.4 m, was not following the recommendations and did not provide an optimal result. Recommendations from the Agricultural Research and Development Agency (IAARD) [19] are 1 x 1 m, 1 x 0.8 m, 1 x 0.75 m, and 1 x 0.7 m, adjusted to soil fertility level. The seeds used by farmers are seeds that come from previously harvested trees will reduce cassava productivity. In order to optimize productivity, farmers have to use new or original seeds (F1). Most of the farmers harvest the cassava at the age of 6 months, so the farmers' price is low. According to the Agricultural Research and Development Agency (2016), farmers tend to harvest cassava following the regular selling price. When cassava's price is high, farmers will harvest early even though the harvest age determines the water content and starch content of cassava. The older harvest age the less water content and more starch content. The harvest age recommendation by the IAARD is around 7-10 months [19]. The sustainability of cassava farming and increasing production efficiency and farmer income, educationis needed to farmers through strategies in the short term that can be taken through restructuring the use of production factors.

4. Conclusion

Cassava farming in Lampung Tengah Regency is mostly not technically efficient nor economically efficient. However, cassava farming in Lampung Tengah Regency is still worthy of being cultivated. In order to improve the sustainability of cassava farming in Lampung Tengah regency, the farmers need to get education about short term strategies and following the recommendations of cassava cultivation.

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