# A Comparison of Economic Efficiency of Monoculture and Multiple Cropping Patterns: The Case of Cassava Farming in Ende, Indonesia

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## Abstract

Nuabosi cassava is an alternative carbohydrate source for the community, which is expected to be a substitute for rice. This commodity has the potential to be developed, but is limited in resources, so it requires technological breakthroughs. This study aims at analyzing the level of technical, allocative and economic efficiency between the cassava cropping pattern and the factors that affect the efficiency. The research was conducted in Randotonda Village, from November 2019 to January 2020 and the samples consisted of 61 monoculture farmers and 46 multiple cropping farmers. Data analysis was performed using the Cobb-Douglass stochastic frontier production function. The allocative and economic efficiency was examined with the stochastic frontier cost function approach. The results of stochastic frontier estimation show that all variables have a positive effect on the production variable. The variables having a positive effect on the total cost include the price of cassava cuttings, the price of fertilizer, production and the dummy cropping pattern. The average level of economic efficiency of monoculture farmers is lower than that of multiple cropping farmers. Factors that affect economic efficiency are age, length of time to cultivate, frequency of obtaining information, dummy of farmer group membership and dummy of cropping patterns. In short, the level of technical, allocative and economic efficiency of monoculture farmers is lower than that of multiple cropping farmers. Farmers are expected to pay attention to the types of plants that are suitable in implementing the multiple cropping pattern.

**Keywords:** cassava multiple cropping; economic efficiency; frontier production function

## INTRODUCTION

Human civilization is currently faced with serious food scarcity. The global food stock base of cereals has experienced a crisis due to climate change in recent years. However, the lifestyle of modern society prefers food from cereals and seeds (FAO, IFAD and WFP, 2013). The wealth of biodiversity must be preserved and used optimally to fulfill the need of food for present and future generations. Food is not only based on cereals and seeds but also takes form of root crops, especially cassava. This plant has wide adaptability to tropical areas and the main food source for ancient civilizations (Widodo, 2018).

The productivity of cassava in India in 2013 reached 35 tons ha$^{-1}$ (FAO, IFAD and WFP, 2013). In Indonesia, it only reached 22.48 tons ha$^{-1}$ in 2017 and 24.4 tons ha$^{-1}$ in 2018 (Widodo, 2018). The productivity of cassava in the 2015-2018 period fluctuated quite a bit with a downward trend. This was indicated by a decrease in the harvested areas each year with an average annual growth of 3.36% (BPS, 2018). The problems of low productivity were quite diverse,

namely, the utilization of less superior varieties, late fertilizing, the amount of fertilizers given and limited irrigation facilities.

The contribution of cassava to the Gross Regional Domestic Product (GRDP) of Ende Regency in the food crop sub-sector ranks at the first place. This commodity is expected to be an alternative source for the community; however, the productivity of cassava in Ende is relatively lower, with 12 tons ha$^{-1}$ in 2016 (BPS - Statistics of Ende Regency, 2016), when compared to the national productivity. This was allegedly due to the use of production technology and the price received, which was not as an incentive for farmers to continue planting cassava. This phenomenon was also found in Randotonda Village. The interviews with field extension officers and the head of the village have revealed that the productivity of Nuabosi cassava in 2020 only reached 17.50 tons ha$^{-1}$, which was due to reduced land area and relatively low selling price of IDR 7,000 kg$^{-1}$ at the farmer level. Cultivation technology was also carried out conventionally without fertilization. Chepng'etich et al. (2015) argues that small-scale agricultural systems are usually characterized by limited resources. Improving technical efficiency in resource-limited small-scale agricultural systems is key to increase household food availability (Itam et al., 2015).

Nuabosi cassava is the district's leading commodity because it has several advantages, which among others are productivity and high quality, delicious taste, soft texture and low levels of hydrogen cyanide (HCN). Based on these advantages, the cassava is necessary to be developed by applying the technology of multiple cropping with peanuts, where planting is carried out at the same time. Nyi et al. (2014) suggest that planting cassava together with peanuts can increase productivity and profit. Ajieh et al. (2014) also assert that technology adoption will increase production and affect income.

The application of multiple cropping pattern is an inevitable option in a sustainable agricultural system, which is oriented towards three sustainable dimensions, namely natural ecology, economic enterprises and human social life (Rivai and Anugrah, 2011). Multiple cropping of cassava and peanuts can minimize the use of inorganic fertilizers. Farmers can use peanut waste as organic fertilizer. Cassava and peanut multiple cropping can improve soil quality by increasing the nitrogen content in the soil (Tang et al., 2020). With this pattern, the economic benefits for farmers are higher, for they get income from both cassava and peanuts (Hongxin et al., 2016).

One way to increase food crop production is by practicing multiple cropping pattern (Sasmita et al., 2014). Combining cassava and peanuts can help control weeds (Amosun and Aduramigha-Modupe, 2016). Multiple cropping can increase per-unit farmland productivity through a resource-efficient utilization (Chen et al., 2019). Multiple cropping of corn and peanuts can provide benefits and increase land productivity (Li et al., 2019). Some of the studies above show that multiple cropping patterns support sustainable agricultural systems in the tropics.

Increasing production through technical, allocative and economic efficiency is very important because it can multiply the potential output of farmers and reduce farming costs (Kusnadi et al., 2011). Efficiency can improve output without having to add input and the level of efficiency is influenced by socio-economic factors (Ogundari and Brümmer, 2011). Studies on efficiency have received much attention, including from Khan and Saeed (2011); Adem and Gebregziabher (2014); Latruffe and Nauges (2014) and Galluzzo (2017), with some variations in methodology, data type, model specification and location. These studies are very helpful in analyzing the level of efficiency between the planting patterns of Nuabosi's cassava commodities in small farmers, who have mutual cooperation with local wisdom, with increasingly limited land areas, so a technological breakthrough is needed. The present study provides an answer to the idea of food diversification in East Nusa Tenggara Province, because cassava is one of the main food substitutes for rice. The study examines the level of technical, allocative and economic efficiency between the cassava cropping pattern and the factors that affect the efficiency.

## MATERIALS AND METHOD

The research was conducted in Randotonda Village, Ende Sub-district, Ende Regency, in East Nusa Tenggara Province of Indonesia, from November 2019 to January 2020. The research location was determined with the following considerations: (a) it is a Nuabosi cassava

cultivation center and (b) there are many farmers practicing multiple cropping pattern of cassava and peanuts. The population in this study were all of the Nuabosi cassava farmers in Randotonda Village, amounting to 210 people. A total of 119 applied monoculture farming and 99 farmers practiced multiple cropping of cassava and peanuts. Cluster sampling was employed to gather the samples. The calculation of sample size resulted a total of 107 farmers as respondents, comprising 61 monoculture farmers and 46 multiple cropping farmers. The sample size was calculated using the following formula (Parel et al., 1973).

$$n = \frac{NZ^2\sigma^2}{Nd^2 + Z^2\sigma^2}$$

Note:
n = Sample size
N = Population size
D = Tolerable minimum deviation = 0.05
Z = 95% confidence level = 1.96 according to Z distribution table
$\sigma^2$ = Population variance in the V of cassava farming land

The analytical method used in this research was production function analysis of Cobb-Douglass stochastic frontier. The frontier production model was estimated using MLE (maximum likelihood estimation) and Frontier Version 4.1 software. The production functions were as follows:

$$LnY = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3$$
$$+\beta_4 LnX_4 + \beta_5 LnX_5 + E_j D_j (V_i - u_i)$$

Note:
Y = Production
$X_1$ = Area of land (ha)
$X_2$ = Cassava seed (cutting)
$X_3$ = Fertilizer (kg)
$X_4$ = Labor (workers' day)
$X_5$ = Pesticide (kg)
$E_j$ = Dummy variable coefficient
$D_j$ = Cropping pattern dummy variable (D = 1 multiple cropping method, D = 0 monoculture)
Bi = Regression coefficient (i = 0,1,2, .... 5)

Measurement of technical efficiency of farming production for the $i^{th}$ farmer was estimated using the following formula:

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{exp(x_i\beta + V_i - u_i)}{exp(x_i\beta + v_i)} = exp(-u_i)$$

Where $Y_i$ was the actual production of the observation and $Y_i^*$ was the frontier production estimation obtained from stochastic frontier production function. Allocative and economic efficiency was analyzed using stochastic frontier cost function approach. The analysis was performed with Frontier Version 4.1 software. The empirical model of Cobb-Douglas stochastic frontier cost function was on the following equation:

$$Ln\ C_i = \alpha_0 + \alpha_1 Ln\ Px_{1i} + \alpha_2 Ln\ Px_{2i}$$
$$+\alpha_3 Ln\ Px_{3i} + \alpha_4 Ln\ Y_i + E_j D_j$$
$$+(V_i + U_i)$$

Note:
C = Production cost (IDR)
$X_1$ = Cassava cutting price (IDR $kg^{-1}$)
$X_2$ = Fertilizer price (IDR $kg^{-1}$)
$X_3$ = Labor wage (IDR workers' $day^{-1}$)
$Y_i$ = Total output (kg)
$E_j$ = Dummy variable coefficient
$D_j$ = Cropping pattern dummy variable: D = 1 multiple cropping; D = 2 monoculture
$V_i + U_i$ = Error term component
$V_i$ = Random variable assumed to be independently and identically distributed as μ (0, $\sigma^2 v$) and independent of $U_i$s; that represent the stochastic effect outside the farmer's control
$U_i$ = One sided (Ui ≥ 0) efficiency component that represents economic inefficiency in production, which is assumed to be independently and identically distributed as truncation (at zero) of the normal distribution with mean, Ki σ and variance
α = Estimated parameter

Cost inefficiency ($CE_i$) wa defined as the ratio between total actual cost (C) and estimated total minimum cost (C*), so that $CEi_i$ value ranged between one and infinity. Thus, the inverse of $CE_i$ was the cost efficiency level. Cost efficiency was defined as allocative efficiency (EA). The EA was formulated as follows: $AE_i = 1 / CE_i$. The value of EA obtained ranged between 0 and 1.

$$CE_i = \frac{C}{C^*} = \frac{E(C|ui, Yi, \ Pi)}{E(C_i|ui = 0, Yi, Pi)} = exp(-ui)$$

To measure the economic efficiency (EE) per individual farmer, the formula of $EE_i = ET_i \cdot EA_i$. was used. Factors affecting the level of technical efficiency, EA and EE were estimated simultaneously with the frontier production function using Ordinary Least Square (OLS) method of multiple linear regression model. Linear regression model factors affecting the technical efficiency, EA, EE were formulated as follows:

$$U_i = \delta_0 + \delta_0 Z_1 + \delta_0 Z_2 + \delta_0 Z_3 + \delta_0 Z_4 + \delta_0 Z_5$$

Note:
$U_i$ = Technical/allocative/economic efficiency
$Z_1$ = Age
$Z_2$ = Length of farming
$Z_3$ = Frequency of getting information
$Z_4$ = Dummy of farmer group membership
$Z_5$ = Cropping pattern dummy

## RESULTS AND DISCUSSION

### Distribution of technical efficiency level

The production process is technically efficient if the value of TE = 1 (full efficiency) (Coelli et al., 2005). In Table 1, the average level of technical efficiency of farmers with a monoculture cropping pattern is 78% and it is assumed that there are obstacles in increasing productivity. The average value of technical efficiency means that the average Nuabosi cassava farmers with a monoculture cropping pattern can reach a minimum of 78% of the production potential obtained from the combination of production inputs used. This finding is in line with that reported by Kitila and Alemu (2014), where the TE value $< 1 = 66$. If cassava farming with a monoculture cropping pattern per farmer is managed using the best cultivation technology through weed cleaning, using fertilizers and spacing, the production will increase by 8.5 tons. The average actual production is 30 tons $ha^{-1}$, where the potential production per hectare = (100 : 78) x 30 tons $ha^{-1}$ = 38.5 tons $ha^{-1}$.

The average level of technical efficiency of farmers with multiple cropping was 86%. This value exemplifies that the average cassava farmers practicing multiple cropping could reach at least 86% of the potential production from the combination of production inputs. The actual average production was 42 tons $ha^{-1}$, with potential production per hectare = (100 : 86) x 42 tons $ha^{-1}$ = 49 tons $ha^{-1}$. If Nuabosi's cassava farming with a multiple cropping pattern is managed properly, through the use of plant sereza as organic fertilizer, cleaning weeds and arranging proper spacing, the production can be increased to 7 tons $ha^{-1}$. The technical efficiency level of farmers with monoculture was lower than that of famers with multiple cropping, due to differences in their knowledge and technical skills of cultivation. The findings of studies by Orewa (2012); Adewuyi et al. (2013); Nkang and Ele (2014) on technical efficiency of cassava showed the average values of technical efficiency level by 77%, 68% and 70% respectively, which were lower than Nuabosi cassava farming with multiple cropping and monoculture methods in Randotonda Village.

Table 1. Distribution of technical efficiency level of Nuabosi cassava farmers practicing multiple cropping and monoculture

| Range of technical efficiency level | Farmers with monoculture | | Farmers with multiple cropping | |
|---|---|---|---|---|
| | Frequency | Relative frequency (%) | Frequency | Relative frequency (%) |
| Up to 0.70 | - | - | - | - |
| 0.71 - 0.80 | 39 | 64 | 5 | 11 |
| 0.81 - 0.90 | 22 | 36 | 40 | 87 |
| 0.91 - 1.00 | - | - | 1 | 2 |
| Total | 61 | 100 | 46 | 100 |
| Average efficiency level | 0.7882 | | 0.8639 | |
| Standard deviation | 0.0750 | | 0.0400 | |
| Maximum | 0.8994 | | 0.9094 | |
| Minimum | 0.7084 | | 0.7794 | |

**Factors affecting the technical efficiency of Nuabosi cassava farming**

The estimation results presented in Table 2 show that the F-statistic value (25.460) is significant at α 1%. $F_{count} > F_{table}$ (25.460 > 3.51) means that all the variables included in the model simultaneously affect the level of technical efficiency. The age variable has a significant and negative sign. The findings in the field show that 70% of farmers are at productive age. Maganga (2012); Mussa et al. (2012);

Nahraeni (2012); Okoye et al. (2016) said that with increasing age of farmers, the enthusiasm to be creative and apply new technologies and innovations decreases. Mango et al. (2015) also found that older farmers tend to be technically inefficient because age affects productivity. However, this study is different from the research by Tabe-Ojong and Molua (2017); Tenaye (2020), which conclude that age has a significant effect on technical efficiency and is positive.

Table 2. Factors affecting the technical efficiency of Nuabosi cassava farming with monoculture and multiple cropping methods

| Variable | Coefficient | Standard error | t-ratio |
|---|---|---|---|
| Constanta ($Z_0$) | 0.771***) | 0.038 | 20.191 |
| Age ($Z_1$) | -0.001***) | 0.001 | -2.429 |
| Length of farming ($Z_2$) | 0.003*) | 0.002 | 1.542 |
| Frequency of getting information ($Z_3$) | 0.003**) | 0.001 | 1.782 |
| Dummy of farmer group membership ($Z_4$) | 0.051***) | 0.014 | 3.701 |
| Cropping pattern dummy ($Z_5$) | 0.049***) | 0.010 | 5.092 |
| $R^2$ = 0.747, F-statistics = 25.460 | | | |

Note: 1. Dependent variable of technical efficiency
2. F table (α = 0.01, df 1 = 4, df2 = 103) = 3.51
3. T table α 0.01 = (0.01, df 99) = 2.36        ***) Significant on α by 1%
   T table α 0.05 = (0.05, df 95) = 1.66         **) Significant on α by 5%
   T table α 0.10 = (0.10, df 90) = 1.29          *) Significant on α by 10%

The length of farming is positive and significant, in which the longer the farmers run farming activities, the more technically efficient they are in using production inputs. The results disclose that 85% of the farmers had experience in cassava farming for over 10 years. Abdulai et al. (2013) and Itam et al. (2015) noticed that experience in farming contributes to the technical efficiency and leads to high productivity.

The frequency of obtaining information has a significant effect and is positive, denoting that by intensifying the information received by farmers from field extension officers, the technical efficiency increases. Cohen and Lemma (2011) confirmed that information dissemination influences farmers to adopt better agricultural practices. However, this fact is different from the finding of the research conducted by Ragasa et al. (2013), where visits and information from field extension workers do not affect productivity because they have many limitations.

Dummy variable of farmer group membership has a significant and positive sign. This means

that farmer membership in farmer groups will increase technical efficiency. Fadwiwati et al. (2014); Nkang and Ele (2014), concluded that access to extension services in farmer groups rises agricultural production. Findings in the field indicate that 75% of the farmers are already members of farmer groups.

The dummy variable of the cropping pattern has a significant effect and is positive. This shows that farmers practicing multiple cropping are technically more efficient than farmers implementing monoculture. Abebe (2014) reinforced that the practice of multiple cropping has a positive effect on technical efficiency. Farmers who practice multiple cropping gain higher yields because of better conservation of soil resources. The results of the study also depict that 95% of the formal education of the intercropping farmers graduated from high school, while only 16% of monoculture farmers were high-school graduates. Educated farmers are able to take advantage of farmers' social information and communication networks, are able to take advantage of new technologies and combine inputs optimally

(Kitila and Alemu, 2014). The results of this study are different from those of Okoye et al. (2016) who found that uneducated farmers are technically more efficient than educated farmers and this fact is because educated farmers tend to consider farming as the side job, in which they practice it when they have spare time.

**Effect of monoculture and multiple cropping on EA**

The result of stochastic frontier estimation using MLE method is better than that using OLS method due to the higher sigma-squared value and log likelihood function value. The gamma coefficient value ($\Upsilon$) was 0.4450, exemplifying that the variation of the confounding error was more dominant due to cost efficiency of 44.50% or the difference between actual costs and the possibility of minimum costs was caused more by the differences in cost efficiency. The value of likelihood ratio test (LR test) = 1.2502 < $X^2$ (chi-square) = 143.94 denotes that the allocative efficiency of Nuabosi cassava farming was still low.

The estimation of cost function demonstrated in Table 3 illustrates that the price of cassava cuttings has a significant effect on the 99% significance level and is positive. This means that an increase in the price of cassava (*Ceteris paribus*) cutting by 1% will increase production cost by 2.1015. Fertilizer price has a significant effect at 99% significance level and is positive, signifying that multiplying the fertilizer price of cassava by 1% will increase cost by 1.1394. Labor wage does not have significant effect on production cost and is positive. This is because the allocation of labor is efficient. It is also found that farmer groups are accustomed to mutual cooperation in working on agricultural land, from preparation to harvest. Production variable has a significant effect with the significance level of 99% and if there is an increase in production, it will have a vital contribution to the addition of production cost. The dummy variable of cropping pattern has a significant effect on the significance level of 99% and is positive. This describes that the production cost of farmers with multiple cropping is higher than that of farmers with monoculture.

Table 3. Results of cost function estimation in Nuabosi cassava farmers applying monoculture and multiple cropping methods

| Variable | Parameter | Coefficient | Standard error | t-ratio |
|---|---|---|---|---|
| Interception | $\beta_0$ | -9.5169***) | 2.3140 | -5.5169 |
| P X$_1$ (cutting price) | $\beta_1$ | 2.1015***) | 0.4933 | 4.2593 |
| P X$_2$ (fertilizer price) | $\beta_2$ | 1.1394***) | 3.4963 | 3.2590 |
| P X$_3$ (labor wage) | $\beta_3$ | 1.0677 | 3.4963 | 1.2352 |
| Y (production) | $\beta_4$ | 0.8085***) | 8.9972 | 8.9871 |
| Cropping pattern dummy | $\beta_6$ | 2.6243***) | 3.2302 | 2.6243 |
| Sigma squared | $\sigma^2$ | 0.4360 | | 4.4607 |
| Gamma | $\Upsilon$ | 0.4450 | | 3.2200 |
| Log likelihood function | | 13.4931 | | |
| LR test = 1.2502 | | | | |
| $X^2$ = 143.94 | | | | |

Note:  1.  Dependent variable Ln total cost
2.  T table α 0.01 = (0.01, df 99) = 2.36          ***) Significant on α by 1%
T table α 0.05 = (0.05, df 95) = 1.66           **) Significant on α by 5%
T table α 0.10 = (0.10, df 90) = 1.29            *) Significant on α by 10%

**EA level distribution**

The data in Table 4 highlight that the average value of EA in farmers with multiple cropping was 0.8259. This value was greater than the average value of farmers with monoculture that was 0.7909. A value of 0.8259 represents that the average minimum cost level achieved by farmers with multiple cropping was around 82.59% of the limit cost (frontier). If multiple cropping farmers can achieve the most efficient cost level, the additional profit for the farmer will be 9%, [1- (0.82/0.90)]. For the most inefficient farmers, the possibility of additional benefit is 11%, (1- (0.80/0.90).

Table 4. Distribution of EA level of Nuabosi cassava farmers practicing multiple cropping and monoculture methods

| Range of EA | Farmers practicing monoculture | | Farmers practicing multiple cropping | |
|---|---|---|---|---|
| | Frequency | Relative frequency (%) | Frequency | Relative frequency (%) |
| 0.30 – 0.39 | - | - | - | - |
| 0.40 – 0.49 | - | - | - | - |
| 0.50 – 0.59 | - | - | - | - |
| 0.60 – 0.69 | - | - | - | - |
| 0.70 – 0.79 | 29 | 48 | - | - |
| 0.80 – 0.89 | 32 | 52 | 42 | 91 |
| 0.90 – 0.99 | - | - | 4 | 9 |
| Total | 61 | 100 | 46 | 100 |
| Average efficiency level | 0.7909 | | 0.8259 | |
| Standard deviation | 0.0638 | | 0.0365 | |
| Maximum | 0.8921 | | 0.9042 | |
| Minimum | 0.7001 | | 0.8001 | |

The average value of EA of farmers with monoculture was 0.7909. This value implies that the average minimum cost level achieved by farmers was 79.09% of the limit cost. If farmers with Nuabosi cassava monoculture are able to achieve the most efficient cost level, they can get an additional profit of 11% [1- (0.79/0.89)]. The most inefficient farmers are possible to increase profit by 21%, [1- (0.70/0.89)], with the hope that these farmers can combine a number of inputs at the input price and the amount of output such as farmers with the highest cost efficiency.

Maurice et al. (2015); Onubuogu and Esiobu (2019) reported that the study on food crop and cassava farmers in Nigeria showed the average EA of 0.84 and 0.86. These EA values were greater than that found in the research in Randotonda Village, for both farmers with monoculture system and the multiple cropping of cassava and peanuts. The difference in EA between farmers applying multiple cropping and monoculture is due to the fact that intercropping farmers have easier access to information on prices for agricultural inputs and outputs, are active in farmer groups and have vehicles to facilitate the transportation of agricultural inputs and products.

**Factors affecting the EA of Nuabosi cassava farming**

The data presented in Table 5 highlight the F-statistics value of 18.075, value of $F_{count} > F_{table}$ (18.075 > 3.51). It means that all variables included in the model simultaneously affect the EA level. The regression coefficient for the age variable has a significant effect and is negative. This suggests that the older the farmer is, the lower the EA will be. Older farmers rely more on experience but are slow to adapt to newer and more efficient practices. This study differs from the research conducted by Girei et al. (2016), which found that with increasing age, EA increases and older farmers tend to have more experience in farming. The length of the farming, which is called experience, has a significant effect and is positive. It is said that the longer the farmer experience in farming is, the more efficient he is in using production inputs. This supports the findings of the studies by Haile (2015) and Mokgalabone (2015), where experienced farmers have higher efficiency since they have a better knowledge of the market situation.

The frequency of getting information has significant effect and is positive, which means that information obtained by the farmers can increase the EA. The information deals with the availability as well as price and quality of agricultural inputs. The variable of farmer group membership has a significant effect and is positive, suggesting that when more farmers become the farmer group members, the EA will increase. This outcome is in line with that found by Audu et al. (2013), but differs from that of Dogba et al. (2020), where EA can be reduced when a farmer wants to be a member of a farmer group. This occurs due to the poor management of the farmer group because the members who want to obtain various information must pay the other group members.

Table 5. Factors affecting the EA of Nuabosi cassava farming practicing monoculture and multiple cropping methods

| Variable | Coefficient | Standard error | t-ratio |
|---|---|---|---|
| Constanta ($Z_0$) | 0.722[***] | 0.039 | 18.652 |
| Age ($Z_1$) | -0.001[**] | 0.001 | -1.711 |
| Length of farming ($Z_2$) | 0.003[**] | 0.002 | 1.825 |
| Frequency of getting information ($Z_3$) | 0.003[**] | 0.002 | 1.683 |
| Dummy of farmer group membership ($Z_4$) | 0.067[***] | 0.015 | 4.552 |
| Cropping pattern dummy ($Z_5$) | 0.026[***] | 0.011 | 2.436 |
| $R^2 = 0.687$, F-statistics = 18.075 | | | |

Note: 1. Dependent variable of technical efficiency
2. F table ($\alpha = 0.01$, df 1 = 4, df2 = 103) = 3.51
3. T table $\alpha$ 0.01 = (0.01, df 99) = 2.36          ***) Significant on $\alpha$ by 1%
   T table $\alpha$ 0.05 = (0.05, df 95) = 1.66          **) Significant on $\alpha$ by 5%
   T table $\alpha$ 0.10 = (0.10, df 90) = 1.29           *) Significant on $\alpha$ by 10%

The dummy variable of cropping pattern has a significant effect and positive sign. It highlights that multiple cropping farmers are more efficient in managing their farming and are also better in combining their inputs at minimum cost if a price reduction occurs. One of the underlying factors is the educational background as it was found that 95% of multiple cropping farmers were high school graduates, while only 16% monoculture farmers had the same education level. The research of Asadullah and Rahman (2011) discovered that education has a significant positive effect on efficiency, where educated farmers usually have better access to information on input and output prices and have a higher tendency to use modern methods more optimally and efficiently. This research differs from the research of Mutoko et al. (2015), which figured out that farmers who get higher education tend to leave the agriculture to non-agricultural activities to earn higher income.

**Effect of monoculture and multiple cropping on economic efficiency**

The data in Table 6 uncover that the average level of economic efficiency of monoculture farmers was 0.6233, which was lower than the efficiency of farmers implementing multiple cropping patterns, with 0.7133. This difference is due to the implementation of multiple cropping technology so that the soil becomes fertile, the attack of pests is reduced and most multiple cropping farmers have access to input and output markets.

Table 6. Distribution of economic efficiency level of Nuabosi cassava farmers practicing multiple cropping and monoculture methods

| Range of EA | Farmers practicing monoculture | | Farmers practicing multiple cropping | |
|---|---|---|---|---|
| | Frequency | Relative frequency (%) | Frequency | Relative frequency (%) |
| 0.30 – 0.39 | - | - | - | - |
| 0.40 – 0.49 | 1 | 2 | - | - |
| 0.50 – 0.59 | 19 | 31 | - | - |
| 0.60 – 0.69 | 33 | 54 | 16 | 35 |
| 0.70 – 0.79 | 8 | 13 | 27 | 59 |
| 0.80 – 0.89 | - | - | 3 | 6 |
| 0.90 – 0.99 | - | - | - | - |
| Total | 61 | 100 | 46 | 100 |
| Average efficiency level | 0.6233 | | 0.7133 | |
| Standard deviation | 0.0674 | | 0.0417 | |
| Maximum | 0.7979 | | 0.8073 | |
| Minimum | 0.4967 | | 0.6260 | |

The economic efficiency estimated in this study is greater than that measured in the examination conducted by Akpan et al. (2013) on cassava farmers in Nigeria, where the average

level of economic efficiency obtained is 0.5801, but smaller than the finding of research by Nwike et al. (2017) on cassava in Southeast Nigeria, amounting to 0.76. If the average monoculture farmers are able to achieve the highest level of economic efficiency, they can save cost by 22%, [1- (0.6233/0.7979)] and the most inefficient farmer will be able to save cost by 38% [1-(0.4967/0.7979)], with the hope that the farmers can achieve the highest economic efficiency level. Farmers applying multiple cropping patterns can save cost by 12%, [(1- (0.7133/0.8073)], if they achieve the highest economic efficiency level. Meanwhile, the least efficient farmers are able to save cost by 22%, [1- (0.6260/0.8073)].

**Factors affecting economic efficiency of Nuabosi cassava farming**

The data in Table 7 demonstrate that the F-statistic value was 23.112, significant at α 1%, with the value of $F_{count} > F_{table}$ (23.112 > 3.51). It can be interpreted that all variables comprised in the model together affect the economic efficiency level. The regression coefficient of age variable has a significant effect on economic efficiency and is negative, meaning that as the farmers get older, the efficiency level decreases. This fact is consistent with a research conducted by Ayodele et al. (2012), where older farmers are less likely to adopt better practices. The length of farming has a significant effect and has a positive relationship, where the farmer's experience in

running farming activities is longer, the economic efficiency is increasing. Adeyemo et al. (2010); Ogunleye et al. (2014); Abdul-kareem and Şahinli (2018) said that farming experience increases the efficiency and profitability of cassava.

The frequency of getting information positively influences the economic efficiency. If the quality of information obtained by farmers, in terms of cassava cultivation technology, input and output prices is better, the economic efficiency of each farmer will increase. The dummy variable of farmer group membership has a significant effect and is positive. This means that by becoming a farmer group member, the economic efficiency per farmer increases. Lema (2013) and Mutoko et al. (2015) found that by becoming a farmer group member, farmers obtains information from the field extension officers about distributors, prices, as well as agricultural inputs and outputs. This finding differs from that in the research by Lanamana (2019), where farmer group membership does not put effect on the economic efficiency, due to the fact that many respondent farmers are not yet farmer group members. The dummy variable of cropping pattern has a significant effect and a positive relationship characteristic and this fact illustrates that multiple cropping farmers are economically more efficient in managing cassava farming when compared to monoculture farmers. Nyi et al. (2014) found that cassava planted at the same time as peanuts has increased the net profit.

Table 7. Factors affecting the economic efficiency of Nuabosi cassava farming with monoculture and multiple cropping methods

| Variable | Coefficient | Standard error | t-ratio |
|---|---|---|---|
| Constanta ($Z_0$) | 0.631[***] | 0.041 | 15.328 |
| Age ($Z_1$) | -0.002[***] | 0.001 | -2.758 |
| Length of farming ($Z_2$) | 0.003[**] | 0.002 | 1.764 |
| Frequency of getting information ($Z_3$) | 0.003[**] | 0.002 | 1.751 |
| Dummy of farmer group membership ($Z_4$) | 0.033[**] | 0.016 | 2.063 |
| Cropping pattern dummy ($Z_5$) | 0.001[***] | 0.012 | 5.231 |
| $R^2 = 0.730$, F-statistics = 23.112 | | | |

Note: 1. Dependent variable of technical efficiency
2. F table (α = 0.01, df 1 = 4, df2 = 103) = 3.51
3. T table α 0.01 = (0.01, df 99) = 2.36          ***) Significant on α by 1%
   T table α 0.05 = (0.05, df 95) = 1.66          **) Significant on α by 5%
   T table α 0.10 = (0.10, df 90) = 1.29           *) Significant on α by 10%

**CONCLUSIONS**

The average levels of technical, allocative and economic efficiency of farmers with monoculture

cropping patterns is 78%, 79% and 62%, respectively. These percentages are lower than those of farmers practicing multiple cropping patterns, the average percentage of 86%, 82% and

71% for each efficiency level, correspondingly. The results show that the factors, which have a positive effect on technical, allocative and economic efficiency, are age, length of farming, frequency of getting information, dummy of farmer group membership and cropping patterns dummy. Nuabosi's cassava farmers require assistance from field extension officers in multiple cropping patterns and use of agricultural waste as organic fertilizer.

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