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RESEARCH ARTICLE

Analysis Technical Efficiency of Rice Farming in Murung Raya Regency, Central Kalimantan, Indonesia

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ABSTRACT

Rice is a processed product from paddy, which is a very important food commodity in Indonesia. BPS (2022), Central Kalimantan is recorded to have a rice harvest area of 125,310.54 ha with a production of 400,444.04 tons. The productivity of Murung Raya Regency is the lowest compared to other districts in Central Kalimantan. The objectives of this study are: 1) to analyze what production factors affect the yield of rice farming products in rice fields; 2) to know the condition of agricultural technical efficiency; and 3) to know what factors affect technical inefficiency. The data collection method used was through a survey with a simple random sampling method, on 100 paddy rice farmers as respondents. The data analysis used is the cobb-douglas production function, the OLS approach, and the MLE approach to see efficiency. Through analysis and discussion, it is known that the production factors of land area, seeds, solid fertilizers, liquid fertilizers, pesticides and labor were found to have a real effect on rice production. The distribution of technical efficiency of rice farming is in the category of efficiency. Even though it is efficient, the production of rice paddy is still relatively low due to the impact of climate change and infertile soil. On average, rice farmers in the research area are technically efficient, and the variables that affect technical inefficiencies are age and farmer education.

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1. Introduction

Indonesia is a country that has a tropical climate that is suitable for agricultural activities and is supported by extensive and fertile land [1]–[3]. Agriculture is a sector that meets the needs of the population, especially for food needs such as rice [4]–[6]. GRDP at current prices according to business fields, the agricultural, forestry, and fisheries sectors managed to occupy the first position in 20 provinces in Indonesia and the top five positions in 12 other provinces [7]. Like other provinces, Central Kalimantan also relies on the agricultural sector for its economic activities [8].

Based on data from Central Kalimantan BPS [9], Central Kalimantan in 2020 recorded a rice harvest area of 125,310.54 ha, with production reaching 400,444.04 tons. The highest rice productivity is in Lamandau Regency, namely 40.45 quintals/ha. Apart from Lamandau Regency, West Kotawaringin and Kapuas Regency also have quite high productivity, namely 38.20 quintals/ha and 36.22 quintals/ha, respectively. Meanwhile, Murung Raya district has a productivity of 16.88 quintals/ha, and the productivity of Central Kalimantan province is 31.96 quintals/ha. The productivity of Murung Raya Regency is the lowest compared to other districts in Central Kalimantan. This low rice production is caused by the condition of rice fields in Murung Raya Regency, which tends to be less fertile/marginal land. According to information from extension workers and the Agriculture and Fisheries Service of Murung Raya Regency, it was explained that the soil pH condition in the rice fields in Murung Raya Regency was below normal pH. In fact, the soil pH needed for rice plants to grow optimally is between 5–6.5.

The lowland rice varieties cultivated in Murung Raya Regency consist of the Inpari 42, Ciputri, and Aromatic varieties. All of these varieties are superior rice varieties. If associated with the potential for superior variety production, paddy rice production from farming activities in Murung Raya Regency is still below the potential production of superior varieties of rice.

The function of the technical efficiency analysis of farming activities is to be able to measure actual production compared to the production of the potential limit of paddy field farming [10]–[13]. The technical efficiency of rice farming activities is carried out so that it can describe what production inputs affect production, what management variables affect the value of technical inefficiency, and whether farmers are operating at an efficient size or not.

The purpose of paddy rice farming is to get optimal production, so that high production will be obtained. In order for this goal to be achieved, the use of the right production inputs is very important, so that it can maximize the potential of available land, as well as use resources efficiently and effectively. This is considering that efforts to increase production through extensification programs will be more difficult to do [14] because the supply of productive agricultural land is increasingly limited. The way to increase the potential production of agricultural activities can be done through technical efficiency as an alternative [14], [15]. Through this background, it is necessary to conduct research with the following objectives: 1) to analyze what production factors affect the yield of rice farming products in rice fields; 2) to know the condition of agricultural technical efficiency; and 3) to know what factors affect the technical inefficiency.

2. Materials and Methods

2.1. Place and Time Research

The location of this research is in Murung Raya Regency, Central Kalimantan Province. Some of the stages of activities in this study include the preparation stage, data collection, analysis, and report. The time of this research starts from August 2023 to March 2024.

2.2. Data Type and Source

This study uses two types of data: primary data and secondary data. Primary data was collected through interviews with rice farmers with the help of a questionnaire containing a list of questions related to this study regarding the general performance of farming in Murung Raya Regency. Meanwhile, the data of agencies or agencies related to this study, such as the Agriculture and Fisheries Office of Murung Raya Regency, the Agriculture and Food Crops and Horticulture Office of Central Kalimantan Province, the District Extension Center and related institutions, as well as other literature, such as the BPS Murung Raya library, which is used as supporting or complementary data, are secondary data used to support research.

2.3. Sampling Methods

This study uses a method to collect data through the survey method. This method is assisted by using a questionnaire so that sampling in the field is more directed. The sub-district area where the research was conducted consisted of Murung Sub-district and Permata Intan Sub-district, with a population of 140 lowland rice farmers. These two sub-districts were chosen with consideration because the sub-districts have the largest rice harvest area in Murung Raya Regency. The number of lowland rice farmers in Murung District is spread across Beriwit Village, as many as 80 people, and Juking Pajang Village, as many as 20 people. Meanwhile, the number of lowland rice farmers in Permata Intan District is spread across Sungai Lobang Village as many as 40 people. The number of samples taken was 100 people in total rice farmers in Murung and Permata Intan Districts.

The sampling technique in this research used simple random sampling [16]–[18]. Determining the sampling unit to be selected for data collection in the field uses a random system. The names of the rice farmers were written down and then scrambled.

2.4. Data Analysis

This study uses an analysis using a stochastic frontier production function approach with the Cobb-Douglas model [19]. This production function has been frequently and widely used in research on efficiency, especially in developed and developing countries [20].

In the production function, the factors that directly affect the quality of the products produced are the production factors used. These factors are suspected to include land, seeds, solid fertilizers, liquid fertilizers, pesticides, and labor.

This study uses the Cobb-Douglas model, which uses six independent variables in the stochastic boundary equation. The production function model is written mathematically below:

$$\begin{aligned} LnYP \;=\; & \beta_0 + \beta_1 lnLL + \beta_2 lnBN + \beta_3 lnPD + \beta_4 lnPC \\ & + \beta_5 lnPS + \beta_6 lnTK + (v_i – u_i) \end{aligned}$$

where
YP – Rice Farming Production (kg)
LL – Rice Field Area (hectares)
BN – seeds used (kg)
PD – solid fertilizer (kg)
PC – liquid fertilizer (liters)
PS – pesticides (liters)
TK – Farmer-Employed Labor (HKO)
β_0 – intercept
β_j – estimator parameter coefficient
$v_i - u_i$ – error term

The expected coefficient values $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6 > 0$. The value of the coefficient is read as production elasticity. The value of the positive coefficient means that an increase in inputs in the form of land, seeds, solid fertilizers, liquid fertilizers, pesticides and the desired labor can provide an increase in rice production.

The technical efficiency of measuring it can be through the following mathematical model below:

$$TE_i = \frac{Y_i}{Y_i^*} = exp\,(-E\,[u_i|\varepsilon_i])\; 1 = 1, \ldots .., N$$

By $\frac{Y_i}{Y_i^*}$ is the technical efficiency of the farmer, $exp\,(-E\,[u_i|\varepsilon_i])$ that is, it is the value of expectation (*Mean*) from u_i with the condition ε_i, so that the technical efficiency value (TE_i) is between more than 0 and less than

1. The technical efficiency figure has the opposite relationship with the technical inefficiency effect number, and usually, its use is only for a certain number of outputs and also for certain inputs. Based on the technical efficiency figures, rice farming can be said to be quite efficient if the *TE* value is > 0.7, but if the *TE* value is ≤ 0.7, it is concluded that it is not efficient [21].

The equation used to analyze the effect of technical inefficiencies on management variables uses a mathematical model developed by Coelli *et al*. [22]. Assumptions for the u_j variable as the variable used in measuring the effect of technical inefficiency is free and normally distributed with N (μ_{it}, σ^2).

The mathematical model of the effect of technical inefficiency in this study is:

$$\mu_{it} = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + W_{it}$$

where
μ_{it} – effect of technical inefficiency of paddy fields
Z_1 – respondent's age
Z_2 – respondent's education
Z_3 – total dependents of the respondent's household members
Z_4 – Length of farming
Z_5 – non-formal education
Z_6 – participation in a group
Z_7 – active participation in counseling
δ_0 – constant

FRONT 4.1 is used as software to estimate the parameters of the production functions that are arranged as well as the functions of the effects of technical inefficiencies that are carried out simultaneously. The parameters of the production function and *inefficiency function* were tested in two stages, namely: (1) testing the production function by the OLS method, (2) testing all parameters β_0, β_j, variance u_i, and v_i using the *Maximum Likelihood method* at the real test level of 5 % (α = 0.05).

The FRONT 4.1 software processing produces an approximate number of variance in the form of the following parameterization:

$$\sigma 2 = \sigma_v^2 + \sigma_u^2$$

$$r = \frac{\sigma_v^2}{\sigma_u^2}$$

The *r* value, which is the result of FRONT 4.1 software processing, ranges from 0 to 1. The figure illustrates the role of technical efficiency in the residual effect.

3. Results and Discussion

3.1. The Influence of Factors on Lowland Rice Production

The model used in looking at the influence of production inputs on rice paddy production itself uses the *Cobb-Douglas* model with the OLS or Ordinary Least Square approach. This model will be able to explain the average role of rice production process activities with the use of current technology. The initial production function with the OLS method aims to see the production inputs that have a real influence on the production of the rice paddies. The production factors as independent variables are land, seeds, solid fertilizers, liquid fertilizers, pesticides, and labor, while the dependent variable is rice production.

The R^2 value, also known as the determination coefficient, is a way to see the accuracy of the *Cobb-Douglas* model with the OLS approach used in this study. The R^2 function is one of the good tests of the model in providing predictions for rice farming production. The R^2 value ranges from 0 to 1; the closer the R^2 value is to 1, the more the model used in this study is said to be feasible because it can predict production more accurately. The R^2 value of the production function produced through the analysis of the OLS method is 0.991. This means that the ability of the unbound variable (production input) to explain the bound variable (production) is 99.1%. The remaining 0.09% cannot be explained by the model because other influences that are not included in the variable are not bound to the model.

The results of the analysis through the OLS method with the conjecture of the Cobb Douglas production model of paddy rice farming, which explains the influence of unbound variables consisting of rice farming land variables, the use of rice seeds, solid fertilizers used, liquid fertilizers, pesticides to overcome plant pest organisms and labor on the bound variables, namely the production results from farming are presented in Table I. If the independent variable (production factor) has a probability value of Sig. that is smaller than the actual test level (α), then the production factor is stated to have a significant effect on the dependent variable (production). The results of the alleged Cobb Douglass production model of paddy rice farming using the OLS method are presented in Table I.

Based on the data processing in Table I, it can be seen that production inputs together have a real influence on the production of rice farming in Murung Raya Regency. This statement is supported by the F $\text{value}_{\text{calculation}}$ generated from the OLS method showing a value greater than the F_{table}. The F value is calculated as 1637.795, while the F $\text{value}_{\text{table}}$ is only 2.1977 when db1 = k-1 = 7-1 = 6, db2 = n-(k-1) = 100 – (7-1) = 93, $\alpha = 5\%$. So it can be said that the model from this research analysis is said to be feasible to provide a prediction of the influence of production inputs on rice production in Murung Raya Regency.

Meanwhile, in order to find out the influence of each input from farming activities on the physical results of suspected rice farming products, a test called the t-test (partial test) was. Through partial test analysis of the regression coefficient of each input from rice farming activities, it was found that there was a real influence on the physical results of paddy farming products. The regression coefficient of each variable has a positive value, meaning that it is in accordance with the expected sign of the value of the coefficient.

Land variables are one of the production inputs that have a significant influence on the physical yield of paddy rice farming products in Murung Raya Regency. This is

TABLE I: OLS Method Production Model

Variable input	Coefficient	Standard error	T count	Sig.
Constant	5.210	0.377	13.801	0.000
Land (LL)	0.411	0.105	3.918	0.000**
Seed (BN)	0.289	0.063	4.625	0.000**
Solid fertilizer (PD)	0.107	0.050	2.147	0.034*
Liquid fertilizer (PC)	0.030	0.013	2.386	0.019*
Pesticides (PS)	0.383	0.106	3.603	0.001**
Labor (TK)	0.119	0.053	2.251	0.027*
R-Square	0.991			
F-Count	1637.795			

Note: ***real at α = 1%, **real at α = 5%, $F_{0,05}$ (6, 93) = 2,1977, $t_{0,05}$ (93) = 1,9858.

supported by a larger t-count value compared to the t-table. The t-value calculated in this study is 3.918, while the t-value of the table is 1.9858 when db = 93, α = 5%, or compared with the sig value. 0.000 which is smaller than the significant level of α of 0.05. The coefficient of the variable land area as production elasticity is 0.411, this means that an additional 1% of land will provide an increase in the physical yield of paddy rice products of 0.411%.

The variable of the number of seeds used significantly has an influence on the yield of rice farming products in Murung Raya Regency. This is supported by a larger t-count value compared to the t-table. The calculated t value in this study was 4.625, while the table t value was 1.9858 when db = 93, α = 5%, or compared with the sig value. 0.000, which is smaller than the significant level of α of 0.05. The coefficient of the variable of seed use as production elasticity is 0.289, which means that an increase in seed use of 1% will provide an increase in the physical yield of paddy rice products by 0.289%.

The variable of the amount of solid fertilizer used significantly had an influence on the yield of paddy rice farming products in Murung Raya Regency. This is supported by a larger t-count value compared to the t-table. The t-value calculated in this study is 2.147, while the t-value of the table is 1.9858 when db = 93, α = 5%, or compared with the sig value. 0.034, which is smaller than the significant level of α of 0.05. The coefficient of the variable of the use of the amount of solid fertilizer as production elasticity is 0.107; this means that an increase in the use of the amount of solid fertilizer by 1% will provide an increase in the physical yield of paddy rice products by 0.107%.

The variable of the amount of liquid fertilizer used significantly has an influence on the yield of paddy rice farming products in Murung Raya Regency. This is supported by a larger t-count value compared to the t-table. The t-value calculated in this study was 2.386, while the t-value of the table was 1.9858 when db = 93, α = 5%, or compared with the sig value. 0.019 which is smaller than the significant level of α of 0.05. The coefficient of the variable of the use of liquid fertilizer as production elasticity is 0.030, which means that an increase in the use of liquid fertilizer by 1% will increase the physical yield of paddy rice products by 0.030%.

The variable of the amount of pesticide use significantly has an influence on the yield of rice farming products in Murung Raya Regency. This is supported by a larger t-count value compared to the t-table. The calculated t value in this study is 3.603, while the table t value is 1.9858 when db = 93, α = 5%, or compared with the sig value. 0.001, which is smaller than the significant level of α of 0.05. The coefficient of the variable of the use of the number of pesticides as production elasticity is 0.383; this means that an increase in the use of the number of pesticides by 1% will give an increase in the physical yield of paddy rice products by 0.383%.

The variable of labor use has a significant influence on the yield of rice farming products in Murung Raya Regency. This is supported by a larger t-count value compared to the t-table. The t-value calculated in this study was 2.251, while the t-value of the table was 1.9858 when db = 93, α = 5%, or compared with the sig value. 0.027, which is smaller than the significant level of α of 0.05. The coefficient of the variable of using labor as production elasticity is 0.119, which means that an increase in labor of 1% will provide an increase in the physical yield of paddy rice products by 0.119%.

3.2. Technical Efficiency

The technical efficiency approach used in this study is an approach through the stochastic frontier model seen from the output side. Farming is said to achieve perfect technical efficiency if the efficiency value is 1. So, perfect efficiency will be achieved if the tennis efficiency value reaches 1. The following presents the distribution of farmers based on the level of technical efficiency.

The average value of technical efficiency presented in Table II is 0.906. The lowest technical efficiency value is 0.798, while the highest technical efficiency value is 0.999. Based on the average value of efficiency in the model, it can be interpreted that, on average, the respondent farmers still have the opportunity to obtain production at a higher level, in which condition farmers can apply the most efficient farmer cultivation skills and techniques. Opportunities to obtain potential yields that can be done by farmers, such as the use of lime to increase soil pH so that it is able to bind good nutrients for plants [23]. In addition, it is also necessary to set the right planting calendar considering the current conditions with the impact of climate change [24], so that it is able to make better growth of paddy rice plants in the vegetative and generative period.

Based on the data presented in Table II, the position of farmers in the study area is in a condition that achieves technical efficiency because all farmers are at a level of technical efficiency of farming above 0.70. If you look at

TABLE II: Technical Efficiency

Technical efficiency	Number of respondents	Percentage (%)
>0.7 ≤ 0.8	1	1.00
>0.8 ≤ 0.9	47	47.00
>0.9 ≤ 1.0	52	52.00
Total	100	100.00
Rate-rate	0.90569	
Minimum	0.79818	
Maximum	0.99996	

Source: Primary Data Processing, 2024

the average production of paddy rice farming in Murung Raya Regency based on the results of the study, it shows that the average paddy rice production ranges from 1,697 tons/farming or 4.24 tons/ha GKP. Even though it is efficient, the production of rice paddy is still relatively low. The production in previous years was even larger than the data at around 5.2 tons/ha GKP (Murung Raya Regency Agriculture Office, 2022). The low productivity in Murung Raya Regency is due to the impact of climate change, which causes an impact on farming activities both from planting time to harvest and crop yields; this is in line with research conducted by Pramono *et al*. [24] which states that climate change influence on paddy rice productivity. In addition, the soil condition in Murung Raya Regency is less fertile with low soil pH conditions based on measurements made by the Murung Raya Regency Agriculture Office, namely the soil pH in this district is below 5, while farmers mostly do not use lime to overcome the low soil pH. In fact, based on research by Krisnawati *et al*. [23], the application of lime will increase the productivity of paddy rice farming.

3.3. *Sources of Technical Inefficiency*

The factors that affect technical inefficiency are seen based on the model of the effect of technical inefficiency on the production function itself. Measurement of variables that affect technical inefficiency through the OLS method. The management variables that were measured for their influence on the effect of technical inefficiency consisted of the age of the farmer respondents, formal education from the farmer respondents, the number of family dependents, the length of farming (experience), education obtained through non-formal channels, participation in farmer groups, and activity in counseling, while the non-independent variable was the effect of the technical inefficiency of farming itself. The calculation value of the influence of the source of technical inefficiency is shown in the following Table III.

Based on the results of the alleged effects of technical inefficiency with the OLS method in Table III, one way to see the model can be said to be able to explain the dependent variable through an independent variable seen from the value of the determination coefficient (R^2). The R^2 value of the technical inefficiency effect model obtained is 0.161. This means that 16.1% of the variation in the effect of technical inefficiency can be explained by management variables, which include variations in the age of farmers, formal education obtained by farmers, the number of dependents of farmers' families, length of farming, education obtained through informal channels, participation in farmer groups, and activeness in counseling, while the remaining 83.9% is explained by other variables that are not included in the model. The R^2 value of the technical inefficiency effect model is still relatively low. To increase the R^2 value can actually be done by adding other independent variables that are outside the model; this can be done in other further research.

Based on the estimation of the effect model of technical inefficiency with the OLS method in Table III, the influence of the independent variables together can be seen from the F-count value if the F-count value is greater than the F-table value so that the results provide an understanding that all management variables simultaneously have a real influence on the effect of technical inefficiency of rice farming. The value of the F-count test obtained is 2.518, while the value of the F-table is 2.1108 at db1 = k-1 = 8-1 = 7; db2 = n-k-1 = 100-7-1 = 92; $\alpha = 5\%$, then it can be interpreted that this model is feasible to predict the influence of independent variables on the effect of technical inefficiencies in paddy fields in Murung Raya Regency.

Meanwhile, to assess the impact of each independent variable on the effect of suspected technical inefficiency, through partial testing, namely the t-test. According to the partial test analysis, it is explained that the coefficient of the partial regression model, which includes the age and formal education of farmers, on the effect of technical inefficiency of paddy rice farming in the study area, has a significant influence. Meanwhile, the variables of farmer family dependents, length of farming, education taken through non-formal channels, participation in farmer groups, and activeness in extension did not have a real effect on the effect of technical inefficiency.

The age factor is included in the effect of inefficiency with the suspicion of having a negative effect on technical inefficiency in the activities carried out by rice farmers in rice farming. The results in Table III show that real life affects technical inefficiencies at a rate of α 5 percent. In this study, age has a negative impact on technical inefficiency, meaning that the older the age, the more efficient it is. The value of the age coefficient is −0.003, this shows that if the farmer's age increases by 1%, the hasl makes a decrease in the technical inefficiency value of 0.003%. This is in accordance with the average age of the respondents in this study, who are farmers and are included in the productive age group category. The average age of farmers in this study was 44.61 years. Most of them were in the age group between 30–40 years old (39%) and the age group of 41–50 years (38%).

TABLE III: Effects of Technical Inefficiency

Variable	Coefficient	Standard error	T count	Sig.
Constant	1.119	0.099	11.275	0.000
Farmer age (Z_1)	−0.003	0.002	−2.039	0.044*
Farmer formal education (Z_2)	−0.007	0.002	−2.898	0.005**
Number of family dependents (Z_3)	0.004	0.010	0.358	0.721
Length of farming (Z_4)	−0.003	0.003	−0.902	0.370
Non-formal education (Z_5)	−0.013	0.018	−0.745	0.458
Participation in farmer groups (Z_6)	−0.015	0.019	−0.788	0.433
Activeness in counseling (Z_7)	−0.001	0.012	−0.096	0.924
R-Square	0.161		Sig. = 0.020	
F-Count	2.518			

Note: ** real at $\alpha = 1\%$, * real at $\alpha = 5\%$, $F_{0.05}$ (7. 92) = 2.1108, $t_{0.05}$ (92) = 1.9860.
Source: Primary Data Processing, 2024.

Based on the data presented in Table III, it shows that formal education has a real effect on the level of farmer inefficiency at $\alpha = 5\%$. This is in line with the research of Askalani *et al*. [25], which shows that formal education has a significant influence on the technical inefficiency of farming. In this study, it was found that if there is an increase in formal education by 1 year, it will provide a decrease in technical inefficiency by 0.007%, meaning that farmers experience an increase in technical efficiency.

Other variables such as family dependents, length of farming, education taken through non-formal channels, participation in farmer groups, and activeness in extension have variable data on each distribution of technical inefficiencies. This is estimated to be the cause of the ineffectual variable.

4. Conclusion

Through this study, it is known that the use of production inputs in the form of rice fields in units of area (LL), production inputs in the form of seed use (BN), production inputs in the form of solid fertilizer (PD), production inputs in the form of liquid fertilizers (PC), production inputs in the form of pesticides for rice plant pest organisms (PS), and production inputs in the form of labor (TK), have a significant influence on the physical results of rice field production (YP) in Murung Raya Regency With positive signs as expected, increased production and extensification can still be done by utilizing land that is still not cultivated.

The distribution of technical efficiency of rice farming is in the category that is already efficient because all farmers are in the category above 0.70. Even though it is efficient, the production of rice paddy is still relatively low. The low productivity in Murung Raya Regency is due to the effects of climate change, as well as infertile soil.

The average rice farmer in Murung Raya Regency is already in the efficient category from a technical point of view. The variables that affect technical inefficiency are the age and education variables of farmers, while the dependents of the farmer's family, the length of farming, education taken through non-formal channels, participation in groups, and the activeness of farmers to participate in counseling are variables that do not have a significant effect.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

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