

TECHNICAL EFFICIENCY AND INPUT UTILIZATION IN LOWLAND RICE FARMING IN TANJUNG LAPANG VILLAGE NORTH KALIMANTAN INDONESIA



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ABSTRACT

This research seeks to outline the profile of farmers in Tanjung Lapang Village, determine the factors that shape the technical efficiency of rice farming, and assess the level of technical efficiency in rice cultivation (*Oryza sativa L.*) within the village in West Malinau District. The study is needed to measure the efficiency of input utilization and to determine the variables that shape productivity outcomes. This study focuses on examining the production factors involved in rice paddy farming and evaluating the technical effectiveness of the cultivation process. The study was conducted in the West Malinau subdistrict from January to February 2024. The method used was probability sampling, with 50 farmers selected as respondents. Information was obtained through interviews, observations, and recorded images, with questionnaires as the main instrument. The dataset was analyzed using descriptive methods, multivariate regression, and a production elasticity approach to determine how each input influences agricultural output. The results indicate that land size and chemical nutrient use are the most decisive factors in shaping rice production. In contrast, the combined contributions of land, seeds, chemical nutrients, Plant protection chemicals, and human resources account for 47.6% of yield variation, with the remainder influenced by external factors such as weather, soil conditions, water availability, and technology adoption. The elasticity value below one reflects diminishing proportional returns, where additional inputs yield increasingly smaller output gains. These findings provide a strategic basis for guiding farmers to optimize resource allocation and adopt targeted interventions, such as balanced chemical fertilization, improved cultivation practices, and better land and pest management, to enhance sustainable productivity.

Keywords: efficiency; production; rice; utilization.

INTRODUCTION

Rice cultivation in irrigated fields is a crucial component of the agricultural sector, supporting the nation's food security. As the primary staple for most Indonesians, rice holds significant strategic importance from both social and economic perspectives. However, increasing rice productivity still faces various obstacles, especially in rural areas far from technology centers and market access. Tanjung Lapang Village in West Malinau District, Malinau Regency, North Kalimantan, is one of the areas with potential for developing rice cultivation. The geographical conditions are relatively supportive, and data from the North Kalimantan BPS shows that the rice harvest area in Malinau Regency is relatively stable, increasing slightly from 1,520.93 hectares in 2022 to 1,537.51 hectares in 2023. However, despite the relatively stable harvest area, rice productivity in this region has fluctuated. This indicates that increasing yields does not solely depend on land availability but is also significantly influenced by the extent to which production inputs are utilized efficiently.

Several constraints continue to limit improvements in rice productivity in Malinau, including inconsistent and suboptimal use of production inputs such as planting materials, nutrient applications,



crop protection measures, and human resources. Restricted access to essential farming supplies, limited adoption of modern cultivation technologies, and external pressures such as climate variability and irrigation water availability also contribute to these productivity challenges (Rozci, 2024). Another major challenge is the increasing incidence of plant pests and diseases, along with the shrinking of rice fields due to the reorientation of land use from the agricultural sector to other sectors, which ultimately reduces the available production area (Ansari et al., 2023). Given rice's status as a strategic commodity, efforts to improve technical efficiency in rice cultivation in areas like Malinau are crucial not only for local food security but also for national food security.

An analysis focusing on efficiency in the paddy cultivation production process has been conducted in various regions of Indonesia and other countries. (Nurul C et al., 2018) Highlighting the urgency of managing production components more effectively, including cultivated field size, planting materials, nutrient applications, crop protection measures, and agricultural human resources, to increase crop yields while reducing unnecessary costs. On the other hand, several studies emphasize the influence of external factors. Rozci (2024) shows that climate change affects rainfall patterns and water availability, which greatly influence crop yields. (Ansari et al., 2023) even adds that climate change can reduce rice paddy production by up to 20% if not anticipated with adaptive technology.

Methodologically, many studies use econometric methods, such as probabilistic frontier analysis (Battese & Coelli, 1995), to measure technical efficiency levels. For example, Houma et al. (2021) examined the efficiency of rice farmers in Malaysia and found that farmers' education levels and access to extension services influenced efficiency. Research in Indonesia by Marwanti et al. (2023) measured the technical efficiency of rice at the regional and national scales and found regional variations in efficiency. Although these studies provide an important macro overview, they often fail to explore the dynamics at the local level. In fact, socio-economic factors, access to inputs, and environmental conditions vary significantly across regions, so generalizing the results at the national level may not be appropriate for a particular village.

Based on this literature, several *research gaps* can be identified. First, most studies focus solely on technical efficiency from a quantitative perspective and rarely relate it to farmers' local socio-economic conditions (Sularso & Sutanto, 2020). Second, studies on technical efficiency in the Kalimantan region, particularly in Malinau Regency, remain limited. However, this region has geographical and social characteristics that differ from those of other regions, such as difficult transportation access, limited distribution of chemical nutrients and Plant protection chemicals, and relatively high human resource costs. Third, there is still little research linking the results of technical efficiency analysis to practical recommendations that farmers and local governments can directly apply (Haryanto et al., 2015). In other words, although there is already a considerable amount of literature on the technical efficiency of rice paddies, its contribution to decision-making at the local level is still minimal.

The distinctive contribution of this research lies in its analytical design, which integrates a quantitative approach employing an input-elasticity-based production function model with an in-depth examination of contextual factors influencing agricultural conditions in Tanjung Lapang Village. This combination of methods offers a more comprehensive perspective for understanding the dynamics of efficiency and productivity at the farm level. Unlike regional or national studies, which tend to be general in nature, this study focuses on the local conditions of farmers in West Malinau. This study also highlights the phenomenon of *decreasing returns to scale* in rice cultivation, in which an increase in inputs does not always result in a proportional increase in output. These research findings have rarely been addressed in previous studies and are therefore expected to make a new contribution to the literature on production performance in the agricultural sector. In addition, by emphasizing socio-economic aspects and local constraints, this study not only enriches academic understanding but also offers more applicable recommendations for increasing farmer productivity in Malinau.

In line with the identification of these problems and research gaps, this research seeks to: (1) identify the profile of rice producers in Tanjung Lapang Village; (2) identify the production factors that affect technical efficiency; and (3) examine how effectively paddy producers in Tanjung Lapang Village utilize their production inputs. Through this analytical framework, the research is anticipated to offer conceptual insights that enrich studies on production performance, while also providing practical value for initiatives aimed at strengthening food resilience in Indonesia's frontier areas.

MATERIALS AND METHODS

The study area is in Tanjung Lapang rural community, West Malinau District, Malinau Regency, North Kalimantan Province. This location was chosen deliberately (*purposively*) as it has the potential and relevant challenges in improving the technical efficiency of rice cultivation. Malinau

Regency shows a relatively stable harvest area compared to other regions in North Kalimantan, with a slight increase from 1,520.93 hectares in 2022 to 1,537.51 hectares in 2023, reflecting the resilience of its agricultural system. In addition, rice productivity in Malinau, which reached 34.94 quintals per hectare in 2023, is at a competitive level of efficiency, despite a slight decline from the previous year. These findings indicate that the use of agricultural inputs, ranging from high-quality seeds and chemical nutrient application to effective irrigation management and human resource allocation, still has room for improvement to enhance production efficiency and achieve better output.

Furthermore, Tanjung Lapang Village exemplifies the region's agricultural characteristics, with cropping patterns and access to technology that can still be improved, enabling this study to provide applicable recommendations for local farmers. Among the areas in West Malinau, Tanjung Lapang Village has the highest number of residents and is the second largest rice producer in Malinau Regency. The research adopted a Cluster Sampling approach within a probability sampling framework, selecting 50 farmers out of 481 who were accessible to researchers. Information for the study was obtained through four activities: observation, interviews, questionnaire distribution, and documentation (Mandey & Waney, 2019).

To answer the first objective, descriptive analysis was used. The study considered factors such as the respondents' age, sex, educational background, household size, and agricultural experience. This descriptive analysis aimed to summarize the livelihood-related background of the farmers involved, serving as a basis for understanding production performance. The second objective was analyzed using multivariate linear regression to determine the impact of different production inputs on rice field production output. Before performing the regression analysis, classical assumption tests were conducted, including tests for normality, multicollinearity, and heteroscedasticity, to assess the validity of the regression model. The analysis was performed using SPSS version 25. The multiple linear regression method was used to model the relationship between a single dependent variable and two or more independent variables. The aim was to understand how the impact on the predicted variable is evaluated when only one explanatory variable is adjusted while others are held constant. The Multiple Linear Regression function is:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + e \quad (1)$$

Explanation: Y: Rice yield volume (kg), X1: Field Size (ha), X2: Seeds (kg), X3: Chemical Nutrients (ml), X4: Plant protection chemical (ml), X5: Human Resources (HOK), e: Residual

Next, model validation was performed using individual-variable significance (t-tests) and collective model validity (F-tests). The t-test in the context of multivariate linear regression was employed to test the significance of regression coefficients for each explanatory variable, individually, against the predicted variable (Irawati & Mukaramah, 2024). The primary purpose of the individual variable significance is to determine whether an explanatory variable significantly affects the predicted variable or not. Individual variable significance (t-tests) was used to determine whether the predicted variable, in this research, production yield (Y), is correlated with the explanatory variables, namely field size (X1), seeds (X2), chemical nutrients (X3), Plant protection chemical (X4), and human resources (X5). The hypotheses are as follows (H₀): If the regression coefficient of an independent variable equals zero ($\beta_i = 0$), it implies that the variable has no meaningful effect on the predicted variable. (H₁) If an independent variable has a regression coefficient that is not equal to zero ($\beta_i \neq 0$), it indicates that the variable has a meaningful effect on the outcome variable.

Next, a collective model validity test determines whether there is a significant overall linear relationship between the explanatory variables and the predicted variable. This test differs from the t-test, which evaluates the effect of each independent variable individually. The hypothesis examined through the F-test is formulated as follows (H₀) If all regression coefficients for the independent variables equal zero ($\beta_1 = \beta_2 = \dots = \beta_k = 0$), then none of the predictors significantly influence the predicted variable as a group. (H₁): If the regression coefficients of the explanatory variables are not zero ($\beta_i \neq 0$), it signifies that the predictors have a meaningful impact on the outcome variable.

The final objective employs a classic production function approach, a mathematical tool in economic analysis that links the quantity of inputs to the resulting production level (Teftae et al., 2022). All variables are measured in standard agricultural units, such as kilograms for seeds and chemical nutrients, liters for Plant protection chemicals, hectares for land, and person-days (MD) for human resources. A classic production function approach is also employed to calculate production elasticity, analyze *returns to scale*, and identify inefficiently used inputs (Wahab et al., 2021). This function is widely used because of its simplicity and ability to reflect substitution between inputs. The equation model applied is listed below:

$$\text{Ln Prod} = \alpha + \beta_1 \text{Ln X1} + \beta_2 \text{Ln X2} + \beta_3 \text{Ln X3} + \beta_4 \text{Ln X4} + \beta_5 \text{Ln X5} \quad (2)$$

Explanation: Ln Pro: Production output (kg), Ln X1: Field Size (ha), Ln X2: Seeds (kg), Ln X3: Chemical Nutrients (ml), Ln X4: Plant protection chemical (ml), Ln X5: Human Resources (HOK)

In this study, the predicted variable used was rice paddy production, measured in kilograms (kg) as the total harvest during one planting season. The independent variables include: field size (hectares), seeds (kg), chemical nutrients (kg), Plant protection chemicals (liters), and human resources (person-days/HOK). Field size refers to the total area of rice fields used by farmers, while seeds refer to the number of rice seedlings planted. Chemical nutrients and Plant protection chemicals reflect the amount of chemical inputs used to support plant growth and control pests/diseases. Meanwhile, human resources includes all the working hours spent in the rice cultivation process. All these variables are measured using quantitative data collected from respondent farmers via structured questionnaires.

RESULTS AND INTERPRETATION

Respondent Profile

To understand the socio-economic conditions of the participants, the first identified profile of rice farmers in Tanjung Lapang Village, West Malinau District, Malinau Regency. These characteristics included years of life, sex, educational background, family dependents, and length of time engaged in farming. Information about farmer characteristics is essential because it can influence how farmers make decisions regarding the use of input factors, the level of agricultural technology application, and their ability to achieve technical efficiency. An overview of the respondent profile in this study is shown in Table 1.

Table 1. Respondent profile

Attribute	Category	Number (People)	%
Age (Years)	20	1	2
	31-40	4	8
	41-50	11	22
	51-60	25	50
	61-70	7	14
	71-80	2	4
Gender	Male	34	68
	Female	16	32
Education Background	Did not finish	9	18
	Elementary School	11	22
	Lower Secondary School	15	30
	Upper Secondary School	15	30
Number of Family Dependents (Persons)	1-5	29	58
	6-10	20	40
	11-15	1	2
Farming Experience (Years)	10-20	13	26
	21-30	17	34
	31-40	13	26
	41-50	6	12
	51-60	1	2

Source: Primary Data Processed, 2024

One aspect of the respondents' profile examined in this research was their age, because farmers' age can influence how they manage their farms, including in terms of technology application, decision-making, and productivity levels (Setiyowati et al., 2022). Most participants were in the 51–60 age range, namely 25 people, or 50% of the total respondents. The 41–50 age group accounted for 22%, while the rest were spread across younger and older age groups, with relatively small proportions in each. These data show that most rice farmers in Tanjung Lapang Village are approaching old age and generally have extensive experience in farm management. Advanced age may positively affect production effectiveness by fostering the accumulation of knowledge and skills (Gitosaputro & Irawan, 2024). On the other hand, physical limitations and the possibility of low

adoption of new technologies among the elderly can also pose challenges to sustainably improving efficiency and productivity.

Gender is an important social characteristic to analyze in the context of farming, as it can influence roles, responsibilities, and access to agricultural resources. In rice farming activities, the division of roles between men and women often follows its own dynamics, both in decision-making and in field implementation (Riantini et al., 2020). Most respondents in this study were male (34, or 68% of the total), while female respondents numbered 16 (32%). This male dominance shows that men still hold the leading role in managing rice farming in Tanjung Lapang Village. This reflects a typical pattern in rural areas, where men are more involved in large-scale agricultural production, while women tend to play supporting or administrative roles (Hanum, 2024). Nevertheless, women's involvement remains significant and can contribute to the efficiency of farming, especially in post-harvest management and household financial record-keeping.

The farmer's education level plays an important role in shaping how farmers manage their farms, particularly in terms of innovation acceptance, technology use, and decision-making related to production efficiency. Farmers with advanced levels of education are more likely to exhibit superior skills and efficiency in managing agricultural resources, resulting in improved productivity. Abilities in accessing information, understanding modern farming methods, and implementing more efficient farming practices (Setiyowati et al., 2022). A large portion of the study's participants reported having lower school and upper school, with 15 people, or 30% of the total respondents, in each group. Meanwhile, 22% of respondents had only an elementary education, and 18% did not complete formal education. These findings indicate that the majority of farmers in Tanjung Lapang Village have a lower-middle education background. This relatively low level of education can affect the effectiveness of agricultural technology implementation and of information-based decision-making. Even so, the experience and local wisdom of farmers remain important assets for efficiently running farming activities (Soedarto & Ainiyah, 2022).

A farmer's family members can influence decisions in managing farm operations. The more dependents there are, the greater the economic needs that must be met, which in turn can affect how farmers allocate resources, take risks, and determine the scale of their business (Mandang et al., 2020). The majority of respondents had between 1 and 5 dependents, namely 29 people or 58% of the total respondents. A total of 20 respondents (40%) had 6-10 dependents, while only one respondent (2%) had more than 10. These data show that most farmer households in Tanjung Lapang Village have a moderate to high number of dependents. A large number of dependents can increase household economic pressure, which in turn can influence farm management decisions, such as the efficient use of inputs and diversification of income sources (Ulma et al., 2024).

Experience in farming is an important factor that can influence farmers' skills in managing land, selecting production inputs, and mitigating agricultural risks (Khairunnisa et al., 2021). The longer the farming experience, the better the farmers' ability to make efficient, adaptive decisions in response to changes in environmental and market conditions. Therefore, analyzing respondents' farming experience is relevant to understanding its contribution to technical efficiency. Most respondents had considerable experience in rice farming, with 34% having 21-30 years of experience. The groups with 10–20 and 31–40 years of experience each accounted for 26% of respondents, while the remaining respondents had more than 40 years of experience. Analysis of the data reveals that a large proportion of respondents in Tanjung Lapang Village have been farming for 2 decades or more, which is expected to contribute positively to technical efficiency through mastery of local practices and wisdom. This extensive experience enables farmers to be more adaptable and effective in managing resources and addressing production challenges (Zahara, 2024).

Factors Affecting Technical Efficiency

A. Fundamental Assumption Analysis

a. Distribution Normality Assessment

Data normality was assessed using the nonparametric Kolmogorov-Smirnov test. The results indicate that the dataset follows a normal distribution. Specifically, when the significance level (P-value) exceeds 0.05, the alternative hypothesis (H1) is accepted, confirming normality. Table 2 presents the detailed outcomes of the Kolmogorov-Smirnov normality evaluation.

Table 2. Fundamental assumption analysis

	Standardized Residual
N	50
P-Value (2-tailed)	0.200

Source: Analyzed Original Data, 2024

The P-value (2-tailed) of 0.200 is greater than 0.05, indicating statistical non-significance, as indicated by the normality test conducted in the SPSS program shown in the table above. This result indicates that the data follow a normal distribution, ensuring that the core prerequisites for the normality test are met and that the null hypothesis (H_0) is not rejected. Thus, the alternative assumption (H_1), that the data deviate from normality, is rejected. This aligns with the view that a dataset is normally distributed when the Kolmogorov-Smirnov test yields a p-value exceeding 0.05. Ensuring that the normality assumption is met is essential to maintain the reliability of subsequent statistical analyses, especially when employing parametric techniques.

b. Collinearity Test

The analysis of the VIF (Variance Inflation Factor) outputs for detecting multicollinearity shows that when multicollinearity is high, it can cause problems in model estimation, such as unstable regression coefficients, high standard errors, and results that are difficult to interpret. The indicator used is a VIF value not exceeding 10, as shown in the table below.

Table 3. Multicollinearity test results

Independent Variables	Tolerance Value	VIF	Description
Field Size	0.706	1.417	No Multicollinearity
Seeds	0.728	1.374	No Multicollinearity
Chemical Nutrients	0.818	1.222	No Multicollinearity
Plant Protection Chemical	0.764	1.309	No Multicollinearity
Human Resources	0.866	1.155	No Multicollinearity

Source: Processed Primary Data, 2024

The evaluation reveals that all independent variables have VIF values below 10, indicating that the dataset is not affected by collinearity. Furthermore, multicollinearity can be assessed using the tolerance indicator, in which a tolerance value greater than 0.1 indicates no collinearity problem (Kambono & Marpaung, 2020).

c. Heteroscedasticity Test

A diagnostic test for heteroscedasticity is applied to regression analysis to identify whether there are differences in the variance of residuals (error terms) at various levels of the independent variable (Mardiatmoko, 2020). In OLS, the approach assumes that the residuals' variability is constant, thereby satisfying the homoscedasticity requirement. If the residual variance changes (i.e., is not constant), this is called heteroscedasticity, which can cause inefficient estimation results (Risma & Sahrman, 2020). The method used in the heteroscedasticity examination is a graphical test of the residual vs. prediction plot, as shown in the figure below.

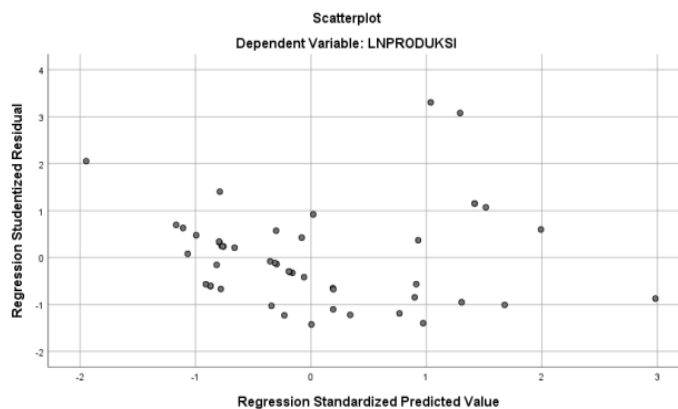


Figure 1. Analysis of variance homogeneity

Considering the results, the regression model does not indicate heteroscedasticity, as the distribution of points is erratic, lying on both sides of the Y-axis origin. If the points in a scatter plot are randomly distributed and do not form a specific structure, that indicates there's no heteroscedasticity (Jamaluddin et al., 2021). The residual variance is relatively constant across the range of independent variable values (homoscedasticity). This is the ideal condition in regression, which means that the OLS assumption is satisfied.

B. Multiple Linear Regression

The individual parameter evaluation (t-test) in the regression framework determines the statistical significance of each predictor's coefficient: field size, seeds, chemical nutrients, plant protection chemical, and human resources. The aim is to explore whether each explanatory variable has a meaningful effect on the predicted variable (production quantity) separately (Sukestiyarno & Agoestanto, 2017), under the premise that the other explanatory variables remain stable. The table presents the results of the T-test conducted.

Table 4. The regression model's multivariate findings

Model	Unscaled Coefficient B	Coefficients Std. Error	Unstandardized Coefficients Beta	t	Sig
1 (Constant)	325.037	272.417		1,193	0.239
Field Size	494,099	207,527	0.326	2,381	0.022
Seeds	-1,615	6,497	-0.037	-0.249	0.805
Chemical Nutrients	71,647	18,551	0.495	3,862	0.000
Plant Protection Chemical	35,065	67,353	0.061	0.521	0.605
Human Resources	-10,602	10,058	-0.115	-1,054	0.298
F	7,996				0.000
R Square	0.476				

Source: Processed Primary Data, 2024

The regression analysis results show that field size and chemical nutrient use have a meaningful effect on rice production, with significance values of 0.022 and 0.000, respectively (below 0.05). The positive coefficients for land (494.099) and chemical nutrients (71.647) indicate that an increase in these inputs contributes to a substantial improvement in production levels. Meanwhile, the variables of seeds, plant protection chemicals, and human resources don't have a meaningful effect on production, as indicated by significance values of 0.805, 0.605, and 0.298 (all above 0.05), respectively. In fact, human resources has a negative coefficient (-10.602), suggesting that a rise in human resources input may diminish production efficiency.

The constant value of 325.037 indicates that if all production variables, namely field size, seeds, chemical nutrients, plant protection chemicals, and human resources, are zero, production (Y) will still increase by 325.037. This can be interpreted as the basic production potential that remains even if no input factors are used, which may reflect soil conditions or environmental factors that support rice growth in Tanjung Lapang Village, West Malinau District.

The effect of field size on production is significant, with a significance value (sig) of 0.022, which is lower than 0.05. This means that the larger the area of land used, the greater the rice production. This factor is supported by local farmers' practice of using private land without renting, which gives them complete control over its management. The average land ownership of one to two hectares also contributes to production efficiency, as farmers can implement more optimal agricultural practices. A study by Saputro & Sari (2024) shows that larger landholdings are often associated with higher productivity due to economies of scale in the use of agricultural inputs.

Meanwhile, seeds have an insignificant effect on production, with a meaningful value of 0.805, which exceeds 0.05. This is due to the dominance of superior, stable varieties among local farmers, which generally already have sufficient resistance and productivity. Although some farmers still use local varieties such as Pari 32, the broadcast method used reduces production variability caused by seed quality. The broadcast method uses more seeds than the row planting method, which should increase seed use efficiency (Sembiring et al., 2019). However, in this case, excessive seed use may fail to have a substantial impact on production, partly due to external factors such as land fertility and cultivation practices.

Chemical Nutrients show a significant effect on production (p-value = 0.000). Farmers in Tanjung Lapang Village generally use only one or two types of chemical nutrients, such as urea and NPK, which are appropriate for the number of seeds planted and the available field size. The efficient use of these chemical nutrients allows farmers to achieve optimal yields. According to research by Cassman et al. (2002), the balance between chemical nutrient dosage and plant requirements is a key factor in increasing crop yields without causing soil degradation due to excessive chemical nutrient use.

The effect of the plant protection chemical on production is insignificant, with a meaningful score of 0.605 that exceeds 0.05. This can be explained by the diversity of pests and diseases farmers face, including weeds, stink bugs, snails, and other pests. To overcome this problem, farmers

use various types of Plant protection chemicals, such as basmilang, dermason, and ragen. However, the effectiveness of Plant protection chemicals in increasing crop yields is highly dependent on the method of application, frequency of use, and the level of pest resistance to the Plant protection chemical. A study by Onibala & Sondakh (2017) shows that excessive or inappropriate use of Plant protection chemicals can cause pest resistance, which, in the long term, can reduce their effectiveness in supporting agricultural production.

Human resources also does not exert a meaningful influence on production; it exerts a considerable value of 0.298. The relatively high cost of human resources, which is around Rp150,000 per day, is one of the main factors causing farmers' dependence on human resources to remain low. This aligns with the trend of agricultural mechanization, which aims to reduce dependence on manual labor and increase operational efficiency (Fuglie, 2018). Therefore, policies that encourage the adoption of agricultural technology, such as the use of planting and harvesting machines, can facilitate reductions in production costs for farmers and strengthen the efficiency of their operations (Tey & Brindal, 2012). From the results of this analysis, several policy implications can be considered, namely, through increased access to land, given that land size demonstrates a meaningful impact on production outcomes, policies that encourage redistribution or access to wider land ownership for farmers can help increase rice production. Second, through the optimization of chemical nutrient use, where, according to the t-test findings, chemical nutrient has a meaningful effect on production, the government can provide more targeted chemical nutrient subsidies, as well as training programs for farmers on the optimal dosage and type of chemical nutrients. The final policy implication is the adoption of agricultural mechanization. Given the high human resources costs, policies that encourage agricultural mechanization, such as providing subsidies for agricultural tools or training in machine operation, can help increase production efficiency.

The simultaneous assessment using the F-test aims to determine whether the independent variables, when considered together, influence the dependent variable. A significance level below 0.05 indicates that the group of predictors jointly affects the outcome variable. In this study, the null hypothesis (H_0) posits that the independent variables, field size (X_1), seeds (X_2), chemical nutrients (X_3), Plant protection chemical (X_4), and human resources (X_5) do not meaningfully influence the predicted variable, namely rice production (Y). Conversely, the alternative hypothesis (H_1) asserts that these predictors collectively have a meaningful effect on the predicted variable.

The findings of the F-test presented in Table 4 indicate an F-statistic of 7.996 and a significance level of 0.000. Given this result, H_0 is rejected, and H_1 is accepted. This outcome indicates that the set of independent variables, when assessed simultaneously, has a statistically meaningful impact on the dependent variable. The R^2 coefficient shows how much of the variation in the variable is explained by the model. From the analysis, the R-Square value is 0.476, meaning that about 47% of the variation in rice production is accounted for by the independent variables in the model.

Technical Efficiency Level of Rice Farming

A. Cobb-Douglas Production Function Analysis

The Cobb-Douglas production function describes the relationship between inputs and outputs to measure the scale of efficiency in an economy (Colther & Doussoulin, 1928), in this case, the efficiency of rice farming. The following presents the results of the analysis, logarithmized using the Cobb-Douglas production function.

Table 5. Cobb-Douglas parameter estimation approach

Model	Unstandardized Coefficient B	Coefficient Std. Error	Unstandardized Coefficient Beta	t	Sig
1 (Constant)	5.733	0.558		9.751	0.000
LnX1	0.270	0.146	0.236	1.852	0.071
LnX2	0.325	0.147	0.285	2.210	0.032
LnX3	0.213	0.085	0.309	2.504	0.016
LnX4	0.112	0.093	0.141	1.210	0.223
LnX5	-0.133	0.120	-0.127	-1.114	0.271

Source: Analyzed Original Data, 2024

The findings indicate that the production model using the Cobb-Douglas framework can be expressed as:

$$\ln Y = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5. \quad (3)$$

In this formulation, field size (X_1), seed use (X_2), chemical nutrient input (X_3), Plant protection chemical application (X_4), and human resources (X_5) are the explanatory variables for rice output (Y). Based on the estimation results, the production equation generated from the model is:

$$\ln Y = 5.733 + 0.270 \ln X_1 + 0.325 \ln X_2 + 0.213 \ln X_3 + 0.112 \ln X_4 - 0.133 \ln X_5. \quad (4)$$

This specification reflects how each input contributes to changes in production after being transformed into logarithmic form.

Table 6. Returns to scale

Variables and Constants	Parameter/Coefficient Values	t Calculated	Nature
Field size	0.270	1.852	Inefficient
Seeds	0.325	2.210	Inefficient
Chemical nutrient	0.213	2,504	Inefficient
Plant protection chemical	0.112	1.210	Inefficient
Human resources	-0.133	-1.114	Inefficient
Constant	5.733		
Adj R ²	0.476		
F Calculate	7,996		

Source: Analyzed Original Data, 2024

It shows that all production variables exhibit inefficiency or yields less than 1, indicating diminishing returns to scale, where an increase in input factors does not yield optimal increases in output (Septiadi & Nursan, 2021). An adjusted R² score of 0.476 indicates that approximately 47.6% of production variation is explained by the model's factors, while the remaining variation stems from influences outside the model framework. The F-statistic of 7.996 indicates that the regression model remains valid. However, the inefficiency of all variables indicates decreasing returns to scale (DRS), where the addition of production factors actually causes efficiency to decline rather than increasing production proportionally (Puspitasari, 2017).

Field size contributes to production with a coefficient of 0.270 and a t-value of 1.852, but it is not significant enough to optimally increase yields. This indicates that, even though field size has been expanded, land-use efficiency remains a constraint, possibly due to suboptimal cultivation practices or poor soil fertility management. Seeds have the highest coefficient (0.325), indicating that their effect on production is relatively greater than that of other variables. However, the inefficient status suggests that farmers may be using excessive amounts of seeds or choosing varieties that are less suitable for the land and climate conditions. Additionally, inefficiency may occur due to excessive seed use and disregard for recommended planting techniques, as farmers in the study location use very close planting distances (Cahyati & Hasan, 2021). The coefficient suggests that chemical nutrients contribute substantially to the outcome, with a coefficient of 0.213 and a T statistic of 2.504, but it is still categorized as inefficient. This indicates that higher chemical nutrient use does not always correlate with increased production. Imbalances in the type and dosage of chemical nutrients used may be the leading cause. The effect of Plant protection chemicals on production is relatively small. This may occur due to excessive use of plant protection chemicals or inappropriate use for the type of pest present, thereby reducing their effectiveness. Plant protection chemical use also needs to be reduced to achieve production optimization, not only because excessive use is harmful to plants, but also because it will decrease the value of the production factor (Situmorang et al., 2021). The negative value of the human resources coefficient (- 0.133) indicates that adding human resources actually reduces production. This could be due to high human resources costs that are not proportional to the increase in yield, or due to inefficient work practices.

The findings indicate that while specific production inputs contribute to yield outcomes, all variables are inefficient, suggesting decreasing returns to scale (Adnan et al., 2021). To improve agricultural efficiency and productivity, there is a need to enhance the utilization of land, seeds, chemical nutrients, Plant protection chemicals, and human resources through a more effective approach to technology and resource management. Implementing policies focused on farmer education, agricultural equipment subsidies, and diversification of cultivation methods can help overcome inefficiencies and increase yields sustainably.

CONCLUSIONS

The analysis indicates that the majority of rice farmers in Tanjung Lapang Village fall within the productive age range of 51–60 years, with most being male. Educational attainment is primarily at the junior and senior high school levels, while the number of family dependents typically ranges from 1 to 5. Regarding farming experience, most farmers have been engaged in agriculture for 21 to 30 years. Among the factors affecting production, field size and chemical nutrient usage are the most influential. Collectively, the variables of field size, seeds, chemical nutrients, Plant protection chemicals, and human resources account for 47.6% of the variation in rice production, leaving 52.4% unexplained by other factors not examined in this study. A total coefficient value below 1 indicates decreasing returns to scale, implying that increases in input usage yield proportionally smaller gains in production. Based on these findings, it is recommended that farmers in Tanjung Lapang Village enhance the efficiency of land and chemical nutrient utilization, for instance, by implementing modern cultivation techniques and practicing balanced chemical nutrient management. In addition, it is important to increase farmers' capacity through training and assistance in farm management to improve technical efficiency. The government or relevant institutions are also advised to support farmers' access to agricultural innovations, capital, and appropriate production facilities to increase productivity sustainably despite limitations in business scale.

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