Agro Bali : Agricultural Journal
Vol. 7 No. 2: 307-318, July 2024

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

Technical Efficiency of Indonesian Potato Farming during Rainy and Dry Seasons: Evidence from Merangin District, Indonesia

Yusnina[1♥], Yusman Syaukat[2], Sri Hartoyo[2], Anna Fariyanti[3]

[1]Agricultural Economics Science Study Program, Faculty of Economics and Management, IPB University, Bogor, Indonesia
[2]Department of Resource and Environmental Economics, Faculty of Economics and Management, IPB University, Bogor, Indonesia
[3]Agribusiness, Faculty of Economics and Management, IPB University, Bogor, Indonesia
♥Corresponding author email: ninabakar2@gmail.com

Article history: submitted: December 5, 2023; accepted: July 18, 2024; available online: July 26, 2024

Abstract. Potatoes are among the vegetables highly susceptible to climate change, and its consequences can significantly affect technical efficiency.However, the production of potato relatively fluctuated due to some factors influencing it. The study aims to analyze the factors affecting potato production, measure the level of technical efficiency in potato farming, and identify the socio-economic factors that influence technical inefficiency in potato farming, both in the rainy and dry seasons. The study was conducted in Merangin Regency, Jambi Province. A purposive sampling method was used to select the research area and collect data from 102 potato farmers. The data were analyzed using the Stochastic Frontier Cobb-Douglas production function model with a maximum likelihood estimation (MLE) approach. The research results show that land and seed variables significantly influence potato production, both in the rainy and dry seasons. Meanwhile, fertilizer P and labor only significantly influence the dry season. The average level of technical efficiency in the dry season (0.89) is higher than in the rainy season (0.73). The results of the average difference test (t-test) show that in the dry season, the level of technical efficiency has a higher value than in the rainy season, with a significance of 1%. The significant socio-economic variables influencing technical efficiency are membership in farmer groups.

Keywords*:* dry season; potato farming; rainy season; technical efficiency

INTRODUCTION

The demand for food in Indonesia is increasing rapidly due to population growth, the food industry, purchasing power and changing preferences. However, competition for land use, extreme climate change, agricultural resource degradation, and lack of infrastructure hinder the national food production capacity. These obstacles significantly affect efforts to improve farmer efficiency. Therefore, it is essential to understand the concept of efficiency and find ways to increase agricultural productivity (Saptana, 2012). Technological advancements, improved technological efficiency, and business expansion are sources of productivity growth (Coelli et al., 2005).

Extreme climate changes, such as an increase in global temperature, unexpected rainfall, and changing seasons, can harm the technical efficiency of agriculture. These changes can increase the risk of crop failure, harvest damage, and decreased productivity and quality of land, water, and agricultural infrastructure (Arora, 2019). The La Niña climate phenomenon disrupts plant productivity in Indonesia, resulting in a 35.75% decrease in fruit production and a 20.25% decrease in vegetable production compared to average climatic conditions (Sarvina, 2019).

Potatoes are among the vegetables highly susceptible to climate change, and its consequences can significantly affect technical efficiency. Climate change can lead to decreased productivity, increased risks of pests and diseases, and altered planting times, reducing potato yields and quality (Sarvina, 2019). According to Salan et al., (2022), the lengthy rainy season's decreased rainfall intensity and altered rainfall patterns could negatively effect on potato production. The study used Bayesian Hierarchical Spatial-Temporal modeling to examine the impact of climate change on potato production. According to the study, farmers must use adaptive strategies to lessen the effects of climate change on potato output because it can have a significant influence. Potato

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

growers with access to information and resources are more likely to be motivated to adapt to climate change in agriculture and other sectors (Purwanti et al., 2022).

Potatoes are strategically supporting food diversification programs, food security, industrial raw materials, and exports. Additionally, potatoes can be a source of income for farmers of all scales, from small to large (Mulyono et al., 2017 ; Fatchullah, 2016). In 2022, Indonesia produced 1,504 million tons of potatoes from 76,728 hectares of planting land, with a productivity rate of 19.60 tons per hectare (Kementerian Pertanian, 2022). However, this amount still needs to be increased to meet the need for 3,167 kg of food per person annually. Indonesia's potato demand is estimated to reach 6.16 million tons annually due to its high preference among the Indonesian population.

Between 2018 and 2022, the average growth rate of potato consumption in Indonesia was 8.9%, while potato production only increased by about 6.9%. The productivity of potatoes in Indonesia is still relatively low and unstable, with production reaching 1.21 million tons in 2016 and 1.36 million tons in 2021. The development of high-quality potato seeds is limited, and most farmers use next-generation potato tubers from the harvest as seeds for initial planting. This high consumption rate can lead to issues. Consequently, potato production must be increased to meet the potato consumption needs in Indonesia (Rosdiana et al., 2023 ; Pusdatin, 2022).

However, it is essential to note that the growth in Indonesian consumption is outpacing potato production, indicating the necessity for increased production (Nugraheni et al., 2022). In addition to relying on domestic production, Indonesia imported 72,300 tons of potatoes in 2022 from countries such as Belgium, the United States, and the Netherlands. Although the import volume is relatively small, domestic production cannot meet the demand (BPS, 2022). Increasing productivity through efficiency improvement is one way to overcome the condition. Since there is a significant difference between agricultural and non-agricultural land, increasing production through efficiency improvement is a better alternative. According to (Ulum et al., 2018; Wassihun et al., 2019) the technical efficiency of potato farming is still low, with a range of 0.59 and 0.46.

Jambi Province, one of the largest potato-producing regions on Sumatra Island, had the fourth-highest potato production in Indonesia in 2023, with 186,038 tons. Jambi contributed 14.9 percent to the national potato production. From 2021 to 2023, the average potato cultivation area was 8726 hectares, with an annual production yield of 166,698 tons and a productivity rate of 19 ton ha^{-1}. Nevertheless, this province's cultivated area, production, and productivity only increased by 14.9 percent per year, 16.8 percent, and 6.2 percent, respectively (BPS 2024)

Merangin Regency is one of the potato-producing areas in the Province of Jambi, with a cultivated area of 262 hectares and an annual potato production of 4816 tons. In 2023, potato production was the highest among seasonal crops, accounting for 21.2% of seasonal crop production and being the main commodity (BPS, 2023), but its productivity is low, at 18.4 tons ha^{-1}.

Several factors influence potato production in the Merangin Regency. These factors include limited land area, high costs associated with seeds, pesticides, fertilizers, and labor, as well as a shortage of labor and capital resources (Damayanti & Saputra 2019). The optimal utilization of production factors such as seeds, pesticides, fertilizers, and labor has yet to be achieved. According to (Sahara et al., 2023), the proportion of input used to produce potatoes is significant and needs to follow recommendations. Extensive research has been conducted regarding the technical efficiency of potato cultivation.

The proportion of inputs used in potato production is significant and should align

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

with recommended practices. Extensive research has been conducted on the technical efficiency of potato cultivation."

The rainy season's impact on potato farming's technical efficiency needs to be studied because the season affects the use of production factors and potato productivity, become our novelty in this study. The involvement of climate variable relatively rare in previous research. Therefore, this study has three main objectives: (1) analyze the factors influencing potato farming production, (2) assess and compare the levels of technical efficiency in potato farming during the rainy and dry seasons, and (3) identify the socio-economic factors that contribute to technical inefficiencies in potato farming.

METHODS

The study was intentionally carried out in the Merangin Regency due to the consideration that the Merangin Regency holds the potential for developing potato farming in Jambi Province. Based on Nainggolan et al., (2022), Merangin could be considered as one of biggest potato farming in Indonesia. On the other hand, the production is still fluctuating in this location. The research was executed from October to December 2022. The study utilized primary data from cross-sectional data obtained through direct interviews with potato respondents using questionnaires .

The sample selection was done using purposive sampling, a non-probability sampling method. The purposive sampling method involves intentionally selecting individual samples based on specific criteria, namely potato monoculture farming production during the last rainy and dry seasons in the past year when the research was conducted. The total number of respondents in the study was 102. The data analysis uses a stochastic frontier production model because it considers the uncertainty of results caused by errors. These errors can come from noise (vi) and other random factors, such as weather and natural disasters, that farmers cannot control. In addition, errors come from inefficiency effects (ui) that describe technical inefficiency.

The data analysis uses a stochastic frontier production model, which is chosen because it considers the uncertainty of results caused by errors. These errors can come from noise (vi) and other random factors, such as weather and natural disasters, that farmers cannot control. In addition, errors come from inefficiency effects (ui) that describe technical inefficiency. The production function for potato farming is assumed to have a Cobb-Douglas form transformed into a natural logarithmic linear form. The assumptions used according to (Debertin, 2012) are: (1) it must be homogeneous, which can reduce the dual cost function of the production function; (2) the form must be simpler; (3) it can be made in linear additive form, and (4) rarely causes problems. This study begins by determining the frontier production factors through the OLS method. In the second stage, estimation uses the Maximum Likelihood Estimator (MLE) method.

The production function for potato farming assumes that the factors that are suspected to affect production are land, seeds, fertilizers, pesticides, and labor. Previously, fertilizers were assessed by physical weight. However, given that many farmers do not use fertilizers completely, the types of fertilizers are grouped based on the active substances that contain Nitrogen (N), Phosphorus (P), and Potassium (K). The stochastic frontier Cobb-Douglas production function model for potato farming is as follows :

$$LnY = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \ldots + \beta_{10} \ln X_{10} + (vi - ui) \quad \ldots(1)$$

Where:

Y	=	potato production (kg)
X_1	=	land area (ha)
X_2	=	seeds (kg)
X_3	=	N fertilizer (kg)
X_4	=	P fertilizer (kg)
X_5	=	K fertilizer (kg)
X_6	=	solid pesticides (kg)

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

X_7 = liquid pesticides (liters)
X_8 = family labor (Man-Hour Work)
X_9 = hired labor (Man-Hour Work)
X10 = Seasonal dummy (0 = rainy season; 1 = dry season)
β0 = intersep
Bi = estimated parameters (i = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
(vi-ui) = error term (vi is the noise effect. ui is the technical inefficiency effect in the model

The expected signs and magnitudes of the parameters areβ1, β2, β3, β4, β5, β6, β7, β8, β9, β10>0. Positive coefficient values mean that an increase in input usage is expected to increase potato production.

Stochastic frontier analysis can produce three estimations simultaneously. The results of testing factors influencing production (output), the level of technical efficiency, and the factors causing technical inefficiency are used to measure the technical efficiency of potatoes during the dry and rainy seasons. The analysis of technical efficiency used here refers to (Coelli et al., 2005) as follows:

$$TE_i = \exp\left(-E\left[ui \mid \varepsilon i\right]\right), i = 1, 2, 3, ..., n \quad (2)$$

Where:
TE_i = technical efficiency of farmer i
$\exp\left(-E\left[ui \mid \varepsilon i\right]\right)$ = the expected value (mean) of u_i subject to ε_i.
Technical efficiency values 0≤ Tei ≤1. are inversely related to the value of technical inefficiency effect. The higher the value of ui, the greater the impact of technical inefficiency, or in other words, farm efficiency becomes lower. According to the model developed by (Coelli et al., 2005), the value of technical inefficiency can be calculated by computing the parameter values of the distribution (ui) in the Stochastic Frontier production function. The equation model used is as follows:

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + v_i ....(3)$$

Informaton :
u_i = technical inefficiency effect
Z_1 = farmer's age (years)
Z_2 = farmer's formal education (years)
Z_3 = farming experience (years)
Z_4 = agricultural income other than
Z_5 = potatoes (Rp)
distance from home to farmland (km)
Z_6 = *Farmer organization or Gapoktan membership dummy (0 = not a member, 1 = member)*
Z_7 = *credit access dummy (0 = no, 1 = yes)*
Z_8 = *participation in extension programs dummy (0 = no, 1 = yes)*
vi = random variables

The expected sign for δ1 is greater than 0, while for the others, it is less than 0.

The estimation of the inefficiency model coefficients is done simultaneously with the estimation of the production function and technical efficiency. Furthermore, to test for the presence of inefficiency effects in the model, a Likelihood Ratio (LR-test) is conducted. To estimate the value of gamma (γ), the variance of the error components vi and ui is used. The value of γ has a distribution of 0 ≤ γ ≤ 1, which describes the contribution of technical efficiency to the total residual. The smaller the value of γ (approaching 0), the more dominant the random error (noise) component is in the variation of the output produced. Conversely, if the value of γ approaches 1, it means that the technical inefficiency effect is more dominant.

RESULTS AND DISCUSSION

Production Function Analysis

The initial stage is to determine the components that influence potato farming production using the Cobb-Douglas model. The analysis carried out consists of three production functions, namely potato farming in the rainy season, dry season, and combined with a planting season dummy. The stochastic frontier method is used to estimate the production function in two stages. The first and second stages respectively use Ordinary Least Square (OLS) and Maximum Likelihood Estimator (MLE). Tests of statistical and econometric assumptions on the data were carried out through OLS analysis which included normality, multicollinearity and heteroscedasticity tests.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

Furthermore, after the production function model passes the classic assumption tests, it is then analyzed using the Maximum Likelihood Estimator (MLE) method. This method differs from the previous one because it can demonstrate the best performance that farmers can achieve during the production process. Additionally, the level of technical efficiency in potato farming can be measured simultaneously using MLE. **Table 1** displays the production function estimation results using the OLS method.

Table 1. Estimation Results of Potato Farming Frontier Production Function in Merangin Regency Using the OLS Method

Variables		Rainy Season			Dry Season			Combined		
		Coef.	t-ratio	VIF	Coef.	t-ratio	VIF	Coef.	t-ratio	VIF
Constant		7.538	4.60		6.59	8.69		6.63	9.39	
X_1	land area	0.96 [a]	4.10	7.09	0.64 [a]	4.66	4.84	0.73 [a]	6.75	4.22
X_2	seeds	0.43 [b]	2.07	5.40	0.40 [a]	4.67	2.92	0.39 [a]	4.49	3.34
X_3	N fertilizer	-0.27 [a]	-2.73	3.46	-0.27 [a]	-3.42	3.41	-0.23 [a]	-3.85	3.20
X_4	P fertilizer	0.16 [b]	2.25	1.99	0.14 [b]	2.14	2.37	0.16 [a]	3.67	1.91
X_5	K fertilizer	0.09	1.05	2.35	0.08	0.88	5.17	0.06	0.99	2.85
X_6	solid pest	-0.02	-0.32	1.59	-0.06	-0.98	2.06	-0.06	-1.27	1.74
X_7	liquid pest	-0.02	-0.23	1.58	0.003	0.04	1.98	0.01	0.20	2.08
X_8	family labor	0.01	0.12	1.82	0.001	0.01	1.44	0.11 [b]	1.73	1.23
X_9	Hired labor	-0.16 [c]	-1.56	1.96	0.11 [c]	1.62	1.63	0.004	0.08	1.41
X_{10}	Seasonal dummy (0 = rainy season; 1 = dry season)							0.10 [c]	1.46	1.51
Adj.R^2			0.781			0.839			0.809	
F-Sig			0.00			0.00			0.00	
Kolmogorov-Smirnov			>0.15			>0.15			>0.15	
Shapiro-Wilk			>0.1			>0.1			>0.1	

Source: Primary Data, 2022
Information: [a] significant at the α 0.01 level. [b] significant at the α 0.05 level. [c] significant at the α 0.1 level.

The estimation results of the production function using the OLS method indicate a coefficient of determination (Adj-R^2) of 0.781, 0.839, and 0.809, respectively. This suggests that the variation in the dependent variable in each production function can be explained by the independent variables to the extent of 78.1%, 83.9%, and 80.9%, while the remainder is explained by other factors not included in the model. Among the other variables mentioned are climate, pest and disease attacks, or other environmental factors.

The research results (Syawaluddin et al., 2023) indicate a positive correlation and weak rainfall's influence on potato productivity. High rainfall can lead to waterlogging and reduce soil aeration, which is detrimental to potato growth. The F-test results for the three production functions show significant values. In this research, the model has passed the classical assumption tests, including normality, heteroscedasticity, and multicollinearity. Therefore, the next step is to estimate the production. function using the MLE method. The results of the production function estimation (**Table 2**) indicate that all three production functions used have higher Maximum Likelihood Estimation (MLE) log-likelihood values compared to the Ordinary Least Squares (OLS) log-likelihood values. Therefore, the production function estimated using the MLE method is considered a more suitable model for the field conditions.The signs of all coefficient variables in the production function during the rainy season, dry season, and planting season dummy were not consistent with the proposed hypothesis and theory. All predictor variables were expected

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

to produce positive coefficients. Of the nine variables significant to potato production during the rainy season, they were land area, seeds, and external labor. Meanwhile, during the dry season, the significant variables were land area, seeds, N fertilizer, P fertilizer, and external labor. In the production function combined with the planting season dummy, the significant variables were land area, seeds, N fertilizer, P fertilizer, solid pesticides, internal labor, and the season dummy.

The land area variable had a significant effect on potato production with a value of 0.88, 0.78, and 0.78 for the rainy season, dry season, and combined season, respectively, at the level of α = 0.01. These values indicate that increasing the land area (while keeping other inputs constant) can still increase potato production. This finding is consistent with previous studies that state that land area has a positive and significant effect on potato production.(Lubis et al., 2021; Setiawan & Inayati, 2020 ; Agatha & Wulandari, 2018; Fianda et al., 2016; Kabeakan et al., 2021). The land variable is the most responsive compared to other variables because it has the largest coefficient of 0.73. The average land use in the research location was 0.73 hectares, with a minimum land area of 0.25 hectares and a maximum of 2 hectares. There is still room for land expansion because the land area is still small (Adawiyah et al., 2022). The coefficients or the sensitivity of the seed variable were determined to have a noteworthy influence on potato production, with values of 0.37, 0.40, and 0.40. These values were also statistically significant at the α = 0.05 and 0.01 significance levels. This implies that a 1 percent increase in seed usage, while keeping other factors constant, can result in a 0.37 percent increase in potato production during the rainy season and a 0.40 percent increase during the dry season.

Tabel 2. Estimation Results of Potato Farming Production Frontier Function in Merangin Regency Using the Maximum Likelihood Estimation (MLE) Method

Variables		Rainy Season		Dry Season		Combined	
		Coef.	t-ratio	Coef.	t-ratio	Coef.	t-ratio
Constant		8.01	6.19	7.41	9.64	7.31	8.70
X_1	land area	0.88 [a]	4.36	0.78 [a]	5.84	0.78 [a]	6.64
X_2	seeds	0.37 [b]	2.37	0.40 [a]	4.97	0.40 [a]	4.36
X_3	N fertilizer	-0.10	-1.01	-0.3 [a]	-4.08	-0.21 [a]	-2.98
X_4	P fertilizer	0.06	0.88	0.15 [b]	2.33	0.12 [b]	2.23
X_5	K fertilizer	-0.003	-0.04	-0.04	-0.46	-0.02	-0.26
X_6	solid pest	-0.07	-1.12	-0.09 [c]	-1.43	-0.11 [b]	-2.14
X_7	liquid pest	0.03	0.39	-0.02	-0.30	0.04	0.80
X_8	family labor	0.12	1.08	-0.11	-1.05	0.11 [c]	1.62
X_9	Hired labor	-0.14 [c]	-1.49	0.21 [b]	2.80	0.02	0.43
X_{10}	Seasonal dummy (0 = rainy season; 1 = dry season)					0.1 [c]	1.37
Log Likelihood OLS		-10.48		4.43		-12.87	
Log Likelihood MLE		-4.04		10.19		-6.24	

Source: Primary Data, 2022
Information: [a] significant at the α 0.01 level. [b] significant at the α 0.05 level. [c] significant at the α 0.1 level.

These findings are consistent with previous studies conducted by (Hardiyanti et al., 2022 ; Lubis et al., 2021; Setiawan & Inayati, 2020; Agatha & Wulandari, 2018; Fianda et al., 2016), all of which assert that seeds have a positive and significant impact on potato production. According to the research conducted in the study location, farmers predominantly used the Granola potato variety, which is recognized as one of the superior potato varieties. On average, respondents used 1,896 kilograms of seed per hectare.

The coefficient of the N fertilizer variable was negative and significant at the level of α = 0.01 during the dry season and

 e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

planting season dummy, with coefficient or elasticity values of -0.1, -0.3, and -0.21. To meet the assumptions of the Cobb Douglas function, the negative sign of the N fertilizer variable should be avoided and should be positive.

The recommended dosage by BPTP Jambi (2015) is Urea 150 kg, SP-36 450 kg, KCl 300 kg, ZA 150 kg, and organic fertilizer 6,000 kg per hectare, which is equivalent to N, P, and K fertilizers of 100.5 kg per hectare, 270 kg per hectare, and 180 kg per hectare, respectively. However, on average, farmers in the research location applied 117.22 kg of N fertilizer per hectare, which exceeded the recommended dosage. Excessive use of N fertilizer can reduce harvest yields, single potato weight, soil quality, and potato plant productivity (Fang et al., 2023) ; Ayyildiz, 2021). The coefficient of variable K fertilizer is negatively signed and not significantly influential towards potato production, which is in line with (Maruapey, 2012). that K fertilizer application does not significantly affect the growth and production of maize. Meanwhile, the research results of (Kusnadi et al., 2011) stated that K fertilizer does not significantly affect rice production.

The coefficient of family labor variable during the rainy and dry seasons does not significantly affect potato production, while the combined dummy season has a significant effect. This is because farmers in the research location cultivate crops other than potatoes, making it difficult for them to focus on managing their farms due to time, labor, and other resource constraints, which affects crop production.

External labor has a significant negative effect on potato production during the rainy season, but a positive effect during the dry season. External labor does not pay enough attention to potato farming because they do not have an emotional attachment to the crops they plant. These results contradict (Sahara et al., 2023) statement that labor is a significant and positive production input for potato production. The result of the Independent Sample T-test shows a P-value of 0.701, which means that there is no statistically significant difference between the potato production achieved during the rainy and dry seasons.

Technical Efficiency of Potato Farming

The variables used include age, education, experience, non-potato farming income, distance, farmer group, access to credit, and participation in agricultural extension. Table 3 indicates that potato farming in Merangin Regency has not achieved maximum technical efficiency (TE=1), but the relative technical efficiency value is high. The average technical efficiency value during the rainy season is 0.73, while during the dry season, it is 0.89. This means that potato farming during the rainy season has been able to produce 73% of its potential production, while during the dry season, it was able to reach 89%. Therefore, there is still room for improvement in the technical efficiency of potato farming during the rainy season by addressing factors that affect its technical efficiency.

Table 3 indicates that potato farming in Merangin Regency has not achieved maximum technical efficiency (TE=1), but the relative technical efficiency value is high. The average technical efficiency value during the rainy season is 0.73, while during the dry season, it is 0.89. This means that potato farming during the rainy season has been able to produce 73% of its potential production, while during the dry season, it was able to reach 89%. Therefore, there is still room for improvement in the technical efficiency of potato farming during the rainy season by addressing factors that affect its technical efficiency.

The technical efficiency value of potato farming during the rainy season is 0.918, which means that they have been able to produce 91.8% of their potential production, while during the dry season, the production can only reach 84.4%. These figures indicate that there is still an opportunity to increase potato production by achieving technical efficiency. According to (Coelli et al., 2005), farming with a technical efficiency value of

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

more than 0.70 is considered efficient. These results show that potato farming in Merangin Regency has been technically successful during both the rainy and dry seasons. The Independent Sample T-test results show a significant statistical difference between the technical efficiency achieved by potato farming during the rainy and dry seasons. The use of different inputs and socio-economic management on each farmer's farm shows differences in technical efficiency values. The use of different inputs affects the technical efficiency value of potato farming produced (Utari et al., 2022).

Table 3. Distribution and Average Values of Technical Efficiency in Potato Farming in Merangin Regency, 2022.

Technical Efficiency	Rainy Season		Dry Season		Combined	
	Total	%	Total	%	Total	%
0.31-0.40	3	0.06	0	0	1	0.01
0.41-0.50	3	0.06	1	0.02	5	0.05
0.51-0.60	6	0.12	1	0.02	14	0.14
0.61-0.70	6	0.12	2	0.04	27	0.26
0.71-0.80	8	0.16	3	0.06	18	0.18
0.81-0.90	17	0.32	10	0.2	33	0.32
0.91-1.00	8	0.16	34	0.66	4	0.04
Total	51		51		102	
Average	0.73		0.89		0.72	
Lowest	0.36		0.48		0.38	
Highest	0.93		0.97		0.94	

Source: Primary Data, 2022

Factors Influencing the Technical Efficiency of Potato Farming.

Frontier 4.1 software is used to simultaneously estimate technical inefficiency effects and production functions. The analysis of factors determining the technical inefficiency in potato farming is presented in **Table 4**. The value of sigma-squared (σ^2) represents the total variance of two error components, inefficiency effects (ui) and noise effects (vi). The σ2 values in the three production functions are 0.129, 0.126, and 0.09, with the rainy season and dry season being significant at 5% each, and the combined function significant at 1%. This indicates that the error components ui and vi are normally distributed. The likelihood ratio-test (LR) in the three production functions yields values of 12.87, 11.52, and 13.25. There is no technical inefficiency effect in the potato production model in all three production functions because these values are lower than the critical value from the Kodde and Palm table, which is 14.853 at 5%.

The values of gamma (γ) in the three production function models are 0.83, 0.73, and 0.71, meaning that 83%, 73%, and 71% of the error term within the production functions, respectively, are caused by inefficiency effects, while the remaining 17%, 27%, and 29% are attributed to noise effects such as climate, pests, diseases, and others. The age variable has a significant impact on potato production during the dry season but not during the rainy season or the combined season. The coefficient aligns with expectations, with a positive sign indicating that older farmers have lower technical efficiency in potato cultivation due to a reduction in their physical strength.

The average age of potato farmers is 39 years, placing them in the productive age range, which makes them reasonably efficient in farming. Older age has a positive influence on the inefficiency of potato farming. The research shows that older farmers exhibit lower technical efficiency in potato cultivation due to a decline in their physical strength (Sultana et al., 2023 ; Lun et al., 2023; Atamja & Yoo, 2022).

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

Membership in farmer groups has a significant and negative impact on the technical inefficiency of potato farming, consistent with the findings of (Rizkiyah et al., 2014). Farmer groups provide access to information, training, and resources that can enhance technical efficiency.

Tabel 4. Factors Influencing Inefficiency in Potato Farming in Merangin Regency in 2022

Variables		Rainy Season		Dry Season		Combined	
		Coeff	t-ratio	Coeff	t-ratio	Coeff	t-ratio
Constant		1.2	0.38	0.57	0.43	0.83	0.49
Z_1	Age	0.08	0.15	1.63 [c]	2.41	0.16	0.45
Z_2	Education	-0.04	-0.16	-0.55	-2.53	-0.16	-1.04
Z_3	Experience	0.33	0.95	0.07	0.36	0.13	0.82
Z_4	Income	0.02	0.05	-0.89	-2.75	-0.19	-1.12
Z_5	Distance	-0.05	-0.25	-0.25 [c]	-1.37	-0.01	-0.12
Z_6	Gapoktan	-0.21 [c]	-1.43	-0.34 [b]	-2.01	-0.15 [b]	-1.78
Z_7	Access to credit	-0.07	-0.38	1.03 [b]	2.09	0.18	0.91
Z_8	Participation in Agricultural Extension	-0.46 [c]	-1.66	-0.15	-0.77	-0.05	-0.46
	Sigma square (σ^2	0.129 [b]	1.92	0.126 [b]	2.19	0.09 [a]	2.83
	Gamma	0.82 [a]	4.27	0.73 [a]	4.46	0.71 [a]	2.69
	LR-test	12.87		11.52		13.25	

Source: Primary Data, 2022
Information: [a] significant at the α 0.01 level. [b] significant at the α 0.05 level. [c] significant at the α 0.1 level.

CONCLUSION

Production factors such as land area and seeds have a significant influence on potato production in Merangin Regency during the rainy season, while during the dry season, the influencing factors are land area, seeds, and P fertilizer. There are no statistically significant differences. in potato production achieved between the rainy season and the dry season. In terms of technical efficiency, potato farming in Merangin is classified as efficient, with an average level of technical efficiency in the dry season of 0.89, which is higher than the rainy season of 0.73. Statistically, there is a difference in the level of technical efficiency between the rainy season and the dry season. From socio-economic factors, we found that there are some factors determining the potato farmer efficiency, namely Gapoktan and Participation in Agricultural Extension, Access to Credit, and Distance from three regression models. Therefore, it is advisable for farmers to pay careful attention to the use of all production factors during the rainy season and avoid excessive use. Technical efficiency can be further improved by optimizing the use of production factors needed to achieve maximum results. Membership in farmer groups also has a positive impact in reducing technical inefficiencies.

REFERENCES

Adawiyah, R., Edison, & Rahman, A. (2022). Analisis keuntungan usahatani kentang dan faktor- faktor yang mempengaruhinya di Kabupaten Kerinci. *Sibatik Journal : Jurnal Ilmiah Bidang Sosial, Ekonomi, Budaya, Teknologi Dan Pendidikan*, *2*(1), 305–328. https://doi.org/10.54443/sibatik.v2i1.549

Agatha, M. K., & Wulandari, E. (2018). Analisis faktor-faktor yang mempengaruhi produksi kentang di Kelompok Tani Mitra Sawargi Desa Barusari Kecamatan Pasirwangi Kabupaten Garut. *Jurnal Ilmiah Mahasiswa Agroinfo Galuh*, *4*(3), 772–778. https://doi.org/10.25157/jimag.v4i3.1643

Arora, N. K. (2019). Impact of climate

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

change on agriculture production and its sustainable solutions. *Environmental sustainability*, *2*(2), 95-96.

Atamja, L., & Yoo, S. (2022). *Analysis of the technical efficiency of potato farmers in Mezam Division of the Northwest Region of Cameroon*. *34*(2), 118–133. https://doi.org/10.22698/jales.20220013

Ayyildiz, E. (2021). Nitrogen uptake effects on potato yield and quality [North Dakota State University]. In *North Dakota State University of Agriculture and Applied Science* (Issue April). https://doi.org/10.4324/9781315721606-101

[BPTP] Balai Pengkajian Teknologi Pertanian, 2015. Petunjuk Teknis Budidaya Kentang. Badan Penelitian Dan Pengembangan Pertanian Kementerian Pertanian.

BPS. Statistics Merangin (2024). Kabupaten Merangin Dalam Angka 2023. Merangin: BS-Statistics Indonesia

BPS. Statistics Indonesia. 2023. Statistics of Horticulture 2022. Jakarta: BPS-Statistics Indonesia

Coelli, Rao D S P, O'Donnell C J, & Battese G E. (2005). *An Introduction to Efficiency and Productivity Analysis.* (Second Edition). Springer.

Damayanti, Y., Saputra, A. (2019). Analisis penggunaan input yang mempengaruhi produksi usaha tani kentang di Kabupaten Merangin. In Seminar Nasional Pembangunan Pertanian Berkelanjutan Berbasis Sumber Daya Lokal (pp. 829-836).

Debertin, D. L. (2012). *Agricultural Production Economics* (second edition). Macmillan Publishing Company.

Fang, X., Xiang, Z., Ma, H., Wang, F., Wang, Q., & Li, P. (2023). Effect of N fertilizer dosage and base/topdressing ratio on potato growth characteristics and yield. *Agronomy*, *13*(3). https://doi.org/10.3390/agronomy13030909

Fatchullah, D. (2016). Pengaruh jarak tanam dan kedalaman tanam terhadap pertumbuhan dan hasil tanaman kentang (Solanum tuberosum L.) Generasi Dua (G2) Varietas Granola. *Prosiding Seminar Nasional Pengembangan Teknologi Pertanian*, *September*, 95–105.

Fianda, A., Fadli, F., & Zuriani, Z. (2016). Analisis faktor-faktor yang mempengaruhi produksi kentang di Kecamatan Timang Gajah Kabupaten Bener Meriah. *Agrifo : Jurnal Agribisnis Universitas Malikussaleh*, *1*(1), 42. https://doi.org/10.29103/ag.v1i1.1080

Hardiyanti, S. P., Ekowati, T., & Roessali, W. (2022). Technical efficiency and economic analysis of usage production factors of potato farming in Ngablak Sub-District, Magelang Regency. *Agrisocionomics: Jurnal Sosial Ekonomi Dan Kebijakan Pertanian*, *6*(2), 269–278. https://doi.org/http://ejournal2.undip.ac.id/index.php/agrisocionomics

Kabeakan, N., Habib, A., & Manik, J. (2021). Efisiensi teknis penggunaan faktor-faktor produksi pada usahatani jagung di Desa Pintu Angin, Laubaleng, Kabupaten Karo, Sumatera Utara, Indonesia. *Agro Bali : Agricultural Journal*, *5*(1), 42–49. https://doi.org/10.37637/ab.v5i1.841

Kementerian Pertanian. (2022). Angka Tetap Hortikultura Tahun 2021. *Direktorat Jenderal Hortikultura Kementerian Pertanian*, 197.

Kusnadi, N., Tinaprilla, N., Susilowati, S. H., & Purwoto, A. (2011). Analisis efisiensi usahatani padi di beberapa sentra produksi padi di Indonesia. *Jurnal Agro Ekonomi*, *29*(1), 25–48. https://doi.org/10.21082/jae.v29n1.2011.25-48

Lubis, F., Syaifudidin, & Yusniar Lubis. (2021). The analysis of production factors and income of potato farming.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

Agrica, *14*(1), 195–208. https://doi.org/10.15294/jejak.v13i1.21965

Lun, R., Luo, Q., Gao, M., Li, G., & Wei, T. (2023). How to break the bottleneck of potato production sustainable growth—a survey from potato main producing areas in China. *Sustainability (Switzerland)*, *15*(16). https://doi.org/10.3390/su151612416

Maruapey, A. (2012). Pengaruh pupuk kalium terhadap pertumbuhan dan produksi produksi berbagai jagung pulut (Zea mays ceatina.L). *Jurnal Ilmiah Agribisnis Dan Perikanan*, *5*(2), 33–45.

Mulyono, D., Syah, M. J. A., Sayekti, A. L., & Hilman, Y. (2017). Kelas benih kentang (Solanum tuberosum L .) berdasarkan pertumbuhan , produksi , dan mutu produk. *Jurnal Hort*, *27*(2), 209–216. https://doi.org/10.21082/jhort.v27n2.2017.p209-216

Nainggolan, S., Yanita, M., & Yumanita, S. (2022). Analisis Daya Saing Usahatani Kentang Dan Dampak Kebijakan Pemerintah Di Provinsi Jambi-Indonesia. *Journal Of Agribusiness and Local Wisdom (JALOW)*, *5*(1), 104–115. eissn:2621-1300 (e) ; 2621-1297 (p)

Nugraheni, S. S., Tinaprilla, N., & Rachmina, D. (2022). Pengaruh penggunaan benih bersertifikat terhadap produksi dan efisiensi teknis usahatani kentang di Kecamatan Pangalengan. *Jurnal Agribisnis Indonesia*, *10*(2), 389–401. https://doi.org/10.29244/jai.2022.10.2.389-401

Purwanti, T. S., Syafrial, S., Huang, W. C., & Saeri, M. (2022). What drives climate change adaptation practices in smallholder farmers? evidence from potato farmers in Indonesia. *Atmosphere*, *13*(1), 1–15. https://doi.org/10.3390/atmos13010113

[PUSDATIN]. Pusat Data dan Informasi Pertanian (2022). Statistik Konsumsi Pangan Tahun 2022. Sekretariat Jendral Kementrian Pertanian.

Rizkiyah, N., Syafrial, & Hanani, N. (2014). Faktor-faktor yang mempengaruhi efisiensi teknis usahatani kentang (Solanum Tuberosum L) dengan pendekatan Stochastic Production Frontier (kasus Desa Sumber Brantas Kecamatan BumiajiKota Batu). *Habitat*, *25*(1), 25–31.

Rosdiana, E., Rahayu, S., Ferdiansyah, M., & Sari, V. K. (2023). Aplikasi berbagai penambahan pupuk organik dan penggunaan mulsa terhadap produksi benih kentang varietas granola kembang. *AGROTEKNIKA*, *6*(1), 23–34. https://doi.org/10.55043/agroteknika.v6i1.154

Sahara, D., Wulanjari, M. E., & Triastono, J. (2023). *Optimasi penggunaan input produksi pada usahatani kentang di Dataran Tinggi Dieng , Jawa Tengah*. *28*(4), 612–619. https://doi.org/10.18343/jipi.28.4.612

Salan, M. S. A., Hossain, M. M., Sumon, I. H., Rahman, M. M., Kabir, M. A., & Majumder, A. K. (2022). Measuring the impact of climate change on potato production in Bangladesh using Bayesian Hierarchical Spatial-temporal modeling. *PLoS ONE*, *17*(11 November), 1–13. https://doi.org/10.1371/journal.pone.0277933

Saptana. (2012). Konsep efisiensi usahatani pangan dan implikasinya bagi peningkatan produktivitas. *Forum Penelitian Agro Ekonomi*, *30*(2), 109. https://doi.org/10.21082/fae.v30n2.2012.109-128

Sarvina, Y. (2019). Dampak perubahan iklim dan strategi adaptasi tanaman buah dan sayuran di daerah tropis. *Jurnal Penelitian Dan Pengembangan Pertanian*, *38*(2), 65–76. https://doi.org/10.21082/jp3.v38n2.2019.p65-76

Setiawan, A. B., & Inayati, C. (2020). *The*

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1627

analysis of production factors and income of potato farming. *13*(1), 17–29. https://doi.org/10.15294/jejak.v13i1.21965

Sultana, S., Hossain, M. M., & Haque, M. N. (2023). Estimating the potato farming efficiency: A comparative study between stochastic frontier analysis and data envelopment analysis. *PLoS ONE*, *18*(4 APRIL), 1–15. https://doi.org/10.1371/journal.pone.0284391

Syawaluddin, Imelda Sari Harahap, & Hery Solat. (2023). Analysis of rainfall as an agroclimatological element on production and determination of potato (Solanum Tuberosum L.) Planting Season in South Tapanuli Regency. *Formosa Journal of Sustainable Research*, *2*(1), 155–172. https://doi.org/10.55927/fjsr.v2i1.2689

Ulum, S., Rondhi, M., & K, E. B. (2018). Efesiensi teknis usaha tani kentang di Kabupaten Lumajang. *Pembangunan Pertanian Dan Peran Pendidikan Tinggi Agribisnis: Peluang & Tantangan Di Era Industri 4.0*, 1–18.

Utari, S. S., Rachmina, D., & Tinaprilla, N. (2022). Efisiensi Teknis Usaha Tani Bawang Merah di Provinsi Aceh. *Jurnal Ilmu Pertanian Indonesia*, *28*(1), 114–122. https://doi.org/10.18343/jipi.28.1.114

Wassihun, A. N., Koye, T. D., & Koye, A. D. (2019). Analysis of technical efficiency of potato (Solanum tuberosum L.) production in Chilga District, Amhara National Regional State, Ethiopia. *Journal of Economic Structures*, *8*, NA. https://link.gale.com/apps/doc/A604936951/AONE?u=anon~7c8f324f&sid=googleScholar&xid=d991981a