



ANALYSIS OF PRODUCTION RISK AND TECHNICAL EFFICIENCY OF RICE FARMING IN TARABA STATE, NIGERIA

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ABSTRACT

The study examined rice production risks and technical efficiency in Taraba State, Nigeria. Multi-stage sampling technique was used in selecting 390 rice farmers in the 2024 farming season. Primary data was collected with the aid of questionnaire. Data was analysed using descriptive and inferential statistics. The results indicated that the average age of the farmers was 45 years old, predominantly male (84.36%), married (76.15%), with an average household size of five persons, cultivating 2.43 hectares, and possessing 11 years of experience. The results also revealed that 61.28% had formal education, majority (69.23%) were not cooperative members and lacked access to extension services (87.69%). The trans-log stochastic frontier production function indicated that seeds, fertilisers, agrochemicals, and labour significantly and positively affected rice output, with inputs showing increasing returns to scale. Technical efficiency ranged from 0.11 to 0.99, with a mean of 0.83, indicating that farmers were technically efficient but still produced 17% below the frontier. Seeds and fertilisers were risk-reducing inputs, whereas agrochemicals and labour increased production risk. Technical efficiency improved with larger household size, higher education, more farming experience, and modern land cultivation techniques. This study concludes that input factors influence both rice output and production risk and also rice production in the study area is technically efficient, though it remains below the frontier level. The study recommends encouraging educated individuals with larger households to engage in rice farming, promoting better use of seeds and fertilisers; and enhancing government support for extension services.

Keywords: Production, Risk, Technical, Efficiency, Rice, Farming.

INTRODUCTION

Rice (*Oryza sativa* L) is a crucial cereal crop, providing about 20% of global dietary energy (FAO, 2024) and supporting the livelihoods of many smallholder farmers, especially in developing countries (Alabi *et al.*, 2024). Its importance is growing, particularly in Africa and Nigeria, where demand often exceeds domestic supply, leading to food shortages and increased imports (Igwegbe *et al.*, 2025). Urbanization, population growth, and rising incomes are key factors driving higher rice consumption in Nigeria (Etim, 2024). According to NAERLS, rice production in Taraba State has generally increased, with yields ranging from 2.11 to 2.20 tonnes per hectare between 2017 and 2024, and total production rising from 366,120 tonnes in 2017 to 449,365 tonnes in 2024. The cultivated area has also grown slightly over this period.

Rice production in Taraba State faces challenges such as high input costs, climate variability, pests, limited access to quality seeds, and inadequate extension services, all of which negatively impact yield and farmer income. Persistent issues like weak institutions, poor infrastructure, suboptimal postharvest management, and ineffective marketing also hinder productivity improvements. While previous studies have focused on production, value addition, and marketing (Rukwe *et al.*, 2023; Aboki *et al.*, 2020), there is limited research on risk management. This study addresses this gap by examining both production risk and technical efficiency among rice farmers in Taraba State to better understand their impact on productivity and risk management. The broad objective of the study was to analyse production risk and technical efficiency of rice farmers in Taraba State, Nigeria, while the specific objectives of the study were to:



- i. describe the socio-economic characteristics of the respondents in the study area,
- ii. analyse the production risks associated with each input used in rice production,
- iii. analyse the factors influencing the technical efficiency level of rice farmers in the study area, and
- iv. estimate the technical efficiency level of rice farmers in the study area.

METHODOLOGY

The Study Area

The study was conducted in Taraba State, Nigeria, located in the northeast between longitudes 9°30'E–11°45'E and latitudes 6°25'N–9°30'N. The state shares borders with Bauchi, Gombe, Adamawa, Cameroon, Nasarawa, Plateau, and Benue. With a population of 4,262,566 (NPC, 2024) and a 3.5% annual growth rate, Taraba covers 54,473 km² and consists of 16 local government areas and two special development areas. Temperatures range from 18°C to 42°C, with low humidity in January and February. About 80% of residents depend on subsistence agriculture, supported by favourable climate, soil, and hydrology for growing crops like maize, rice, millet, and groundnut, as well as livestock, fishing, and forestry. (Oruonye *et al.*, 2024)

Sampling Technique

A multi-stage sampling technique was used to select respondents. Three key agricultural zones were purposively chosen for their significant rice production. Within each zone, blocks were randomly selected proportionally to their total number, followed by the random selection of three cells per block. From a list of 15,807 rice farmers provided by TADP, 390 farmers were randomly chosen from 27 farming cells, with the sample size proportionate to each cell’s population, using the Yamane (1967) formula.

Sample Size

This study determined its sample size for rice-based farmers in Taraba State using the formula for estimating sample size established by Yamane (1967) as used by Reuben *et al.* (2024) is defined as follows:

$$n = \frac{N}{1+N(e)^2} \dots\dots\dots 1$$

Where n = sample size, N= total population, and e= level of precision.

The total sample size of rice farmers in the selected LGAs was calculated to be N=15807, with a margin of error (e) of 0.05, corresponding to a 95% confidence interval.

$$\text{Thus } n = \frac{15807}{1+15807(0.05)^2} = 390.$$

The sample size for each of the three selected Agricultural Zones in the State was established according to the relative concentration of rice-based farmers in those zones. In Zone I, the calculation yields $n = \frac{6474}{15807} \times 390 = 160$. In Zone II, n is calculated as $n = \frac{4550}{15807} \times 390 = 112$. In Zone III, $n = \frac{4783}{15807} \times 390 = 112$.

The total sample size was 390.

Methods of Data Collection

Data for the study were collected through the administration of questionnaires to the respondents randomly drawn from the study area.

Methods of Data Analysis

Both descriptive and inferential statistics were used to achieve the study's objectives. Descriptive statistics were used to analysed socio-economic characteristics, while the stochastic production frontier model addressed production risk, factors influencing technical efficiency, and the technical efficiency levels of rice farmers.



Model Specification

Test of hypotheses

The hypotheses were examined by using the generalized likelihood-ratio statistic (LR), which was described follows:

$$LR = -2[\ln \{L(H_0)\} - \ln \{L(H_1)\}] \dots (2)$$

Log [L(H₀)] and [L(H₁)] represent the likelihood values under the null and alternative hypotheses, respectively, as provided by the stochastic frontier analysis. The calculated λ is compared to the critical value χ² 0.95 based on the number of restrictions. If λ exceeds χ² 0.95, the null hypothesis is rejected at the 5% significance level.

Stochastic frontier model with flexible risk properties

A generalized Kumbhakar (2002) SFA model featuring a flexible risk properties is specified as follows:

$$Y_i = f(X_i; \beta_i) + g(X_i; \varphi_i) V_i - q(Z_i; \delta) U_i \dots (3)$$

Y_i represents the output from the ith farm, while f(X_i; β_i) is the deterministic output function with X_i as input variables and β_i as estimated coefficients. The function g(X_i; φ_i) describes output risk, where φ_i are the risk function coefficients. The technical inefficiency model is shown as g(Z_i; δ), with δ representing the effects of explanatory variables. V_i captures random noise (production risk), and U_i indicates farm-specific technical inefficiency. Considering inputs and inefficiency effects, the mean output for the ith farmer is expressed as:

$$E(Y_i/x_t; u_i) = f(x_t, \beta) - g(x_i; \varphi) U_i \dots (4)$$

$$TE_i = \frac{E(Y_i/x_i; u_i)}{E(Y_i/x_i; u_i) - 0} = \frac{f(x_i; \beta) - g(x_i; \varphi_i) U_i}{f(x_i; \beta)} = 1 - \frac{g(x_i; \varphi_i) u_i}{f(x_i; \beta)} \dots (5)$$

Technical efficiency becomes:

$$TE_i = 1 - TI_i \dots (6)$$

The representation of technical inefficiency, TI, is as follows:

$$TI_i = \frac{g(x_i; \varphi) u_i}{f(x_i; \beta)} \dots (7)$$

The variability of output or production risk is expressed as follows:

$$Var(Y_i/x_i, u_i) = g^2(x_i; \varphi) \dots (8)$$

$$\frac{\partial V(Y)}{\partial x_j} = \frac{\partial g^2(x, \varphi)}{\partial x_j} = 2g(x; \varphi) g_j(x, \varphi) \dots (9)$$

Thus, $\frac{\partial g^2(x, \varphi)}{\partial x_j} < 0 \leftrightarrow$ Risk decreasing of the jth input

$\frac{\partial g^2(x, \varphi)}{\partial x_j} = 0 \leftrightarrow$ Risk neutral of the jth input and

$\frac{\partial g^2(x, \varphi)}{\partial x_j} > 0 \leftrightarrow$ Risk increasing of the jth input.

The log likelihood function for the observed farm output is parameterized according to the distributional assumptions of the random errors.

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \text{ and } \gamma = \sigma_u^2 / \sigma_v^2 \geq 0 \text{ (Aigner et al., (1977)).}$$

Empirical Model Specification

This study's empirical application aligns with the models developed by Kumbhakar, S. C. (2002). The Trans log model is assumed for the deterministic component of the production frontier and is expressed as follows:

$$\ln y_i = \beta_0 + \sum_{j=1}^4 \beta_j \ln x_{ji} + 0.5 \sum_{j=0}^4 \beta_j \ln x_{ji}^2 + \sum_{j=1}^4 \sum_{k=1}^4 \beta_{ij} \ln x_{ij} \ln x_{ji} + \varepsilon_1 \dots (10)$$

β_j denotes the unknown true values of the technology parameters. If, β_{ij} = 0 then the translog stochastic frontier model reduces to the Cobb-Douglas model given as: +ε_i = g(x_i; φ)v_i - q(z_i; δ)u_i According to the decision rule, if the estimated risk parameter for an input is negative, it reduces risk; if positive, it increases risk; and if zero, the input is risk-neutral. Risk-increasing inputs raise variation in rice output, while risk-reducing inputs lower it.



Mean Production Function Specifications

This study employed trans-log stochastic production function model with flexible risk specification as follows:

$$\ln y_i = \beta_0 + \sum_{j=1}^4 \beta_j \ln x_{ji} + 0.5 \sum_{j=0}^4 \beta_j \ln x_{ji}^2 + \sum_{j=1}^4 \sum_{k=1}^4 \beta_{jk} \ln x_{ji} \ln x_{kj} + \varepsilon_1 \dots (11)$$

Where the stochastic disturbance term, ε_j is presented as:

$$\varepsilon_j = g(x_i; \varphi)v_i - q(z_i; \delta)u_i$$

Production risk

The linear production risk function is specified as:

$$g(x_i; \varphi)v_i = \varphi_0 + \sum_{m=1}^4 \varphi_m x_{mi} \dots (12)$$

Where x_m^s denotes the input variables, as outlined in Table 1. φ_m^s represents the unknown true coefficients of the risk model parameters and v_i^s represents the pure noise effects. When φ_m^s is negative, the corresponding input decreases output variance and vice versa, Just and Pope (1979). X_{0i} represents land to be measured in hectares, X_{1i} represents seed to be measured in kgs, X_{2i} represents fertilizer to be measured in kgs, X_{3i} represents Agrochemicals to be measured in litres per hectare, X_{4i} represents labour to be quantified as the number of people per day on the rice farm.

Linear Technical Inefficiency Model

The linear technical inefficiency model is given as:

$$q(z_j, \delta) = \delta_0 + \sum_{j=1}^9 \delta_j z_{ij} \dots (13)$$

Where δ_i^s denote the unknown true values of the parameters of the technical inefficiency model and z_j^s are the exogenous explanatory variables.

Equation 11, 12 and 13 were simultaneously estimated using STATA software.

The study included various exogenous variables such as age, household size, education level, farming experience, extension visits, access to credit, land cultivation methods, planting techniques, and harvesting practices (see Table 2).

The model to identify factors of inefficiency, U_i , is expressed as:

$$U_i = b_0 + b_1 Z_1 + b_2 Z_2 + b_3 Z_3 + b_4 Z_4 + b_5 Z_5 + b_6 Z_6 + b_7 Z_7 + b_8 Z_8 + b_9 Z_9 \dots (14)$$

Where:

- Z_1 = Age (years)
- Z_2 = Household size (number)
- Z_3 = Educational level (No formal 0, otherwise 1)
- Z_4 = Farming experience (years)
- Z_5 = Extension contacts (Had contact 1, otherwise 0)
- Z_6 = Access to credit (Yes 1, otherwise 0)
- Z_7 = cultivation technique (machine method 1, manual 0)
- Z_8 = Planting technique (1 if broadcasting is used for, transplanting 0).
- Z_9 = Harvesting practices, use machine 1, manual 0.
- b_0 = Constant
- $b_1 - b_9$ = regression coefficient

Table 1: Description of Input Variables in Rice Production

Variable	Variable description	Measurement	A priori Expectation
x_{1i}	Seed	Kilograms/hectare	Positive/Negative
x_{2i}	Fertilizer	Kilograms/hectare	Positive/Negative
x_{3i}	Agrochemicals	Litres/hectare	Positive/Negative
x_{4i}	Labour	Man-days/hectare	Positive/Negative

Note: Land is not included in the variable analysis because all the variables will be measured in their respective units per hectare.

Source: Field Survey, 2025

Table 2: Description of Exogenous Variables

Variable	Variable description	Measurement	A priori Expectation
z_{1i}	Age	Years	Positive/Negative
z_{2i}	Household size	Number	Positive/Negative
z_{3i}	Education level	No formal 0, otherwise 1	Positive/Negative
z_{4i}	Farming experience	Years	Positive/Negative
z_{5i}	Extension contacts	Had contact 1, otherwise 0	Positive/Negative
z_{6i}	Access to credit	Yes = 1, otherwise = 0	Positive/Negative
z_{7i}	Cultivation technique	Use tractor 1, otherwise 0	Positive/Negative
z_{8i}	Planting technique	Use broadcasting 0, transplanting 1	Positive/Negative
z_{9i}	Harvesting technique	Use tractor 1, otherwise 0	Positive/Negative

Source: Field Survey, 2025.

RESULTS AND DISCUSSION

Socio-economics Characteristics of the Respondents in the Study Area

The average age of farmers was 45 years, ranging from 22 to 76, with a 12-year variation. The distribution indicates that rice farming in the study area was primarily conducted by middle-aged farmers, who are in their economically active and physically productive years. This corroborates with the work of David *et al.* (2025) on their study of determinants of risk management strategies and household income sources among rice farmers in Kebbi and Ebonyi States, Nigeria. Household size averaged 5, with a range of 1 to 16 and a variability of 4. A moderate household size guarantees adequate family labour to support production activities. This aligns with the findings of Kolawole *et al.* (2025) in their study that an average household size of 5 individuals reflects the common extended family model in rural Nigeria. Farmers had an average of 11 years of experience, from 1 to 40 years, with a variability of 7. This result supports the findings of Egbodion *et al.* (2024) regarding the factors influencing technical efficiency among small-scale rice farmers in the Edo North Ecological Zone, Nigeria, who reported an average farming experience of 12 years. Only 38.72% had no formal education, 61.28% had formal education. This agrees with the findings of Obianefo *et al.* (2024) that most rice farmers in Nigeria had completed primary (30.7%) and secondary (49.49%) school education while 13.4% had completed tertiary education. Most (87.69%) had no contact with extension agents. The lack of advisory support likely impedes the adoption of modern rice production techniques. This finding contradicts the study conducted in southwestern Nigeria, where Ojo *et al.* (2020) indicated that around 53% of farmers had access to extension services. Regarding field management, 78.97% used tractors, 21.03% used crude tools, 98.46% used broadcasting for planting, and 96.67% harvested manually. Research conducted in Ogun State indicates that small-scale rice farmers utilising mechanisation realised markedly greater productivity than their counterparts who used manual methods (Adetarami *et al.*, 2025).

Output and Input Variables

Table 3 shows that the average rice yield in the study area was 2,080 kg (2.08 metric tonnes) per hectare, slightly below the national average for Taraba State of 2.09 metric tonnes per hectare (NAERLS, 2024). This lower yield reflects the production challenges and resource constraints faced by local farmers.

Table 3: Output and Input Variables

Variable	Variable Definition	Mean	Minimum	Maximum	Standard Deviation
Output	Kg per Ha	2080	1245	2902	73.22
Seed	Kg per Ha	83.73	51	125	6.84
Fertilizer	Kg per Ha	147.16	86	197	10.28
Agrochemicals	Litre per Ha	3.51	2.3	6	0.87
Labour	Man-days per Ha	77	39	99	7.99

Source: Field Survey, 2025.



The study's findings indicate that, on average, farmers utilized 83.73 kg/ha of seed, 147.16 kg/ha of fertilizer, 3.51 L/ha of agrochemicals, and 77 man-days/ha of labor to yield an average of 2080 kg/ha of rice. Production varied, with minimum and maximum outputs of 1245 kg/ha and 2902 kg/ha, respectively, resulting in a coefficient of variation of 73.22. The average yield suggests most farmers are below the maximum potential yield, prompting the need to investigate the factors influencing technical efficiency in rice production. This agrees with the work of Islam *et al.* (2025).

Hypotheses test

Table 4 shows that the null hypothesis supporting the Cobb-Douglas model was rejected at the 0.05 significance level, indicating that the trans-log model is more suitable for the data.

Table 4: Hypothesis Test for Model Specification and Statistical Assumptions of Stochastic Frontier model with flexible risk properties

Null Hypotheses	Loglikelihood of H_0	Loglikelihood of H_a	Test Stat. (Δ)	Degree of Freedom	Critical Value (Δ) ²	Decision Rule	Conclusion
$H_{01}: \beta_{jk} = 0$	824.776	890.096	130.640	1	2.71	Reject H_0	Trans-log is appropriate
$H_{02}: \varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = 0$	984.205	1066.434	164.458	4	8.8	Reject H_0	Production risk explains output variability
$H_{03}: \delta_1 = \delta_2 = \delta_3 = \delta_9 = 0$	984.205	1066.434	164.458	9	16.3	Reject H_0	Exogenous variables affect variation
$H_{04}: \lambda=0$	984.205	1066.434	164.458	1	2.7	Reject H_0	Presence of Inefficiencies

Source: Field Survey, 2025. **Note:** Taken from Kodde and Palm (1986) using 5% level of significance.

Diagnostic Statistics

The diagnostic statistics in Table 5 showed that the stochastic trans-log model fits the data well. The estimated sigma square (0.0011766) and lambda (1.6581) were both significantly different from zero, confirming the suitability of the model and the reliability of its assumptions. The positive lambda value indicated that variations in output were mainly due to technical inefficiency, production risk, and stochastic noise, meaning ordinary least squares is not appropriate. This supports findings by Kara *et al.* (2019) and Ali *et al.* (2024). The gamma value (0.733), significant at the 1% level, suggests that about 73% of rice output variation is due to technical inefficiencies, consistent with Agnaza *et al.* (2022), who found a similar pattern in Togo. Table 5 presents the maximum likelihood estimates of the trans-log stochastic frontier production function.

Table 5: Maximum Likelihood Estimates of the Trans-log Mean Output Function

Variable	Parameters	Estimates	Standard Error	P>[z]
Constant	α_0	.8378305	.2943944	0.004
Ln Seed	α_1	.8075795	.5061501	0.111
Ln fertilizer	α_2	.3107228	.5642939	0.582
Ln Agrochemical	α_3	.6273632	.1848286	0.001
Ln Labour	α_4	1.612176	.201896	0.000
$\frac{1}{2}$ Ln (Seed) ²	α_{11}	1.3324	.4055486	0.001
$\frac{1}{2}$ Ln (fertilizer) ²	α_{22}	.1287709	.3052332	0.673
$\frac{1}{2}$ Ln (Chemical) ²	α_{33}	.2295852	.1009122	0.023
$\frac{1}{2}$ Ln (Labour) ²	α_{44}	.007873	.032769	0.810
Ln Seed× Ln fertilizer	α_{12}	1.993768	.5948848	0.001
Ln Seed × Ln AgroChem	α_{13}	1.390934	.3385583	0.000
Ln Seed× Ln Labour	α_{14}	.2168314	.1908908	0.256
Ln fertilizer× Ln Chemical	α_{23}	2.19898	.3786297	0.000
Ln fertilizer× Ln Labour	α_{24}	1.041979	.1662432	0.000
Ln Chemical× Ln Labour	α_{34}	.5389748	.1395259	0.000
Variance Parameters				
Sigma-squared (u)		0.0177146		
Sigma-squared (v)		0.0293734		
Lambda ($\lambda = \sigma_u/\sigma_v$)		1.658142		
sigma2		0.0011766		
Gamma ($\gamma = \lambda^2 / (1 + \lambda^2)$)	0.733			

Source: Field Survey, 2025. *, **, *** corresponds to 10%, 5% and 1% significance level respectively.

Estimates of Production Risk

Production risk in inputs was significant in the production process. The result (Table 6) of the study showed that fertilizer and seed were significantly risk-decreasing inputs in the study area, while labour and agrochemicals were risk-increasing inputs. The result implies that effective and proper management of fertilizer and seed will reduce output variability and stabilize rice yield with the present technology. The estimate of fertilizer and seed as risk-decreasing input agrees with findings of Kara *et al.* (2024) regarding production risk and technical efficiency in ADP Zone 1 of Taraba State. Similarly, the finding that labour increases risk aligns with the study conducted by Akolgo *et al.* (2025) regarding production risk and technical efficiency in Ghana. In their study, labour was categorised as a risk-reducing input. Depending on the empirical data under analysis, production inputs can either increase or decrease risk, Akolgo *et al.* (2025).

Table 6: Maximum Likelihood Estimates of the Linear Production Risk Function

Variable	Parameter	Estimate	Standard Error	P>[z]
Constant	Ψ_0	-8.087781*	1.754777	0.000
Seed	Ψ_1	-12.01183*	1.446318	0.000
fertilizer	Ψ_2	-7.849919*	1.446565	0.000
Agrochemical	Ψ_3	21.83467*	1.699962	0.000
Labour	Ψ_4	9.23285*	.9824342	0.000

Source: Field Survey, 2025 * corresponds to 1% significance level.

Technical Inefficiency Model Estimates

The technical inefficiency model provided valuable insights into efficiency differences among rice farmers. Table 7 shows that, of the nine variables analysed, seven had the expected negative coefficients, with four being statistically significant. Negative coefficients indicate factors that improve



technical efficiency. Specifically, household size, education level, farming experience, and cultivation technique were found to significantly reduce technical inefficiency.

Table 7: Stochastic Frontier Estimation of Farm Level Technical Inefficiency Factors

Variable	Parameter	Estimate	Standard Error	P>[z]
Constant	(Z ₀)	-6.9692*	1.498052	0.000
Age	(Z _{1i})	-0.3559561	0.3368948	0.291
Household Size	(Z _{2i})	-3.356**	1.578	0.020
Education Level	(Z _{3i})	-.3986409*	.155204	0.010
Farming Experience	(Z _{4i})	-.6517398*	.189861	0.001
Extension Contact	(Z _{5i})	-0.0002	0.008	0.976
Access to Credit	(Z _{6i})	-.6544419	.5281848	0.215
Cultivation Tech	(Z _{7i})	-0.266*	0.154	0.000
Planting Tech	(Z _{8i})	1.107	1.193	0.354
Harvesting Tech	(Z _{9i})	0.038	0.048	0.429

Source: Field Survey, 2025 *,** corresponds to 1% and 5% significance level respectively.

As expected, the coefficients for planting and harvesting techniques were positive but not statistically significant, indicating that broadcasting and manual harvesting methods are less technically efficient than transplanting and mechanized harvesting. Older, more experienced farmers showed slightly higher efficiency, but the correlation was weak, suggesting reliance on traditional methods may limit efficiency. This is consistent with Agnaza *et al.* (2022).

Access to credit was negatively correlated with inefficiency but not significant, implying that while credit can reduce inefficiency, few farmers in the area actually utilize it. This aligns with Akolgo *et al.* (2025). Education level had a significant negative effect on inefficiency at the 1% level, meaning more educated farmers were more efficient, supporting findings by Chen *et al.* (2025) that education improves technology adoption and efficiency.

Extension contact was not significant and showed a positive effect on inefficiency, suggesting that extension visits in the study area do not improve technical efficiency, possibly due to inadequate training or insufficient interaction. This is similar to findings by Alam *et al.* (2024). Household size was negative and significant at the 5% level, indicating larger households utilize labour more effectively, thus reducing technical inefficiency, which is in line with Olohunbebe *et al.* (2025). On planting technique, transplanting, though not statistically significant, was associated with greater technical efficiency compared to broadcasting, which is in agreement with Chikezie *et al.* (2024). The use of tractors for land cultivation was significantly linked to lower technical inefficiency, supporting Manir *et al.* (2025), who found mechanization boosts productivity and profitability. Finally, mechanized harvesting showed a positive but non-significant effect on technical efficiency, contrary to Amponsah *et al.* (2025).

Technical Efficiency Estimates

The estimates of technical efficiency vary between 11% and 99%. Approximately 31% of farmers were operating within the technical efficiency range of 0.89 to 0.99 (see Table 8). The average technical efficiency was 83%. This data indicates that, on average, farmers operate at 17% below the frontier output given the current technology. The potential exists to enhance rice farm output in the study area by an average of 17% in the short term through the adoption of best farming practices.



Table 8: Technical Efficiency Scores Across the Study Area

Technical efficiency	Frequency	Percentage (%)	Cumulative
≤ 0.48	12	3.08	3.08
0.49 - 0.58	2	0.51	3.59
0.59 - 0.68	17	4.36	7.95
0.69 - 0.78	38	9.74	17.69
0.79 - 0.88	202	51.79	69.49
0.89 - 1.00	119	30.51	100
Total	390	100	100
Mean	0.83		
Minimum	0.11		
Maximum	0.99		
Standard Deviation	0.12		

Source: Field Survey, 2025.

This result aligns with Bulus *et al.* (2023), who found an average technical efficiency of 81% among rice farmers in Wukari LGA, Taraba State, ranging from 29.5% to 89.5%. Similarly, Obianefo *et al.* (2021) reported that lowland rice producers in Anambra State had a higher average technical efficiency (84.2%) compared to upland producers.

CONCLUSION AND RECOMMENDATIONS

This study concludes that input factors influence both rice output and production risk. Also rice production in the study area is technically efficient, it remains below the frontier level. Technical efficiency estimates may be inaccurate if risk factors are not considered. The study recommends that policymakers should promote the use of best farming practices and account for production risk in efficiency analyses when inputs are not risk-neutral. Since only cross-sectional data were used, future research should include time series data and additional factors such as soil fertility, temperature, humidity, and drought.

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