International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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Econometrics analysis of dry-season rice (*Oryza sativa* l.) production in Taraba State, Nigeria

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International Journal of Science and Research Archive, 2026, 20(02), 132–144

Publication history: Received on 20 June 2026; revised on 29 July 2026; accepted on 01 August 2026

Article DOI: https://doi.org/10.30574/ijsra.2026.20.2.1547

Abstract

This study analyzed the econometrics of dry-season rice (*Oryza sativa* L.) production in Taraba State, Nigeria. Specifically, it determined the costs and returns, estimated production efficiencies, and identified the major constraints affecting dry-season rice production. A multi-stage sampling technique was used to select 303 dry-season rice farmers from 19 villages across five Local Government Areas. Primary data were collected using questionnaires and analyzed using descriptive statistics, gross margin analysis and Cobb-Douglas stochastic frontier production and cost frontier models. The results showed that dry-season rice production was profitable, with an average total production cost of ₦1,401,446.18/ha, average total revenue of ₦2,423,136.89/ha, gross margin of ₦1,054,391.03/ha, and net farm income of ₦1,021,690.71/ha. Seed ($\beta = 0.1482$), labour ($\beta = 0.2915$), fertiliser ($\beta = 0.1764$), agrochemicals ($\beta = 0.0827$), and fuel for irrigation pumping ($\beta = 0.0978$) significantly increased rice output ($p < 0.05$). Farming experience ($\delta = -0.0187$), extension visits ($\delta = -0.0865$) and education ($\delta = -0.0279$) significantly reduced technical inefficiency, whereas age ($\delta = 0.0134$) increased inefficiency. Similarly, land, fertiliser, labour, seed and irrigation fuel significantly increased production cost, while farming experience ($\delta = -0.0215$), extension visits ($\delta = -0.0948$) and access to credit ($\delta = -0.1286$) reduced economic inefficiency. Mean technical, allocative and economic efficiencies were 0.8468, 0.8519 and 0.7214, respectively. The major constraints were the high cost of irrigation fuel (mean = 2.93), fertiliser (2.88), inadequate irrigation facilities (2.81), high cost of agrochemicals (2.76), and pest and disease infestation (2.71). The study recommends subsidising irrigation fuel and fertiliser, expanding irrigation infrastructure, strengthening extension services, and improving farmers' access to affordable agricultural credit.

Keywords: Dry-Season Rice; Stochastic Frontier Analysis; Technical Efficiency; Economic Efficiency; Allocative Efficiency; Taraba State

1. Introduction

Rice (*Oryza sativa* L.) is one of the world's most important cereal crops and a major source of food security, nutrition, employment and income generation. It provides approximately 20% of the dietary energy consumed globally and serves as the staple food for more than half of the world's population (Food and Agriculture Organization [FAO], 2024). In Asia, more than two billion people obtain between 60 and 70% of their daily calorie intake from rice, while its cultivation remains the principal source of livelihood for millions of farming households (Hossain & Narciso, 2004). Beyond its nutritional importance, rice contributes significantly to rural employment, household income and economic development through its extensive value chain. The importance of rice has continued to increase across Africa as a result of rapid population growth, urbanisation, changing food preferences and rising household incomes. These factors have led to sustained increases in rice consumption, which in many countries have outpaced domestic production, thereby widening the gap between supply and demand and increasing dependence on rice imports (Igwegbe *et al.*, 2025).

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Nigeria is the largest producer and consumer of rice in West Africa, where rice has become one of the fastest-growing staple foods in the national food basket (Akande, 2003; Ukwuru *et al.*, 2018). The growing demand for rice has been driven by population growth, urbanisation, rising incomes and changing dietary habits, as rice is widely preferred because of its convenience, affordability and ease of preparation (Tiamiyu *et al*., 2014; Etim, 2024). Although domestic rice production has increased considerably over the past decade, it has consistently remained below national demand. During the 2024/2025 production season, Nigeria produced about 9.15 million metric tonnes of paddy rice, equivalent to approximately 5.77 million metric tonnes of milled rice, compared with an estimated national consumption of about 8.20 million metric tonnes of milled rice (USDA-FAS, 2025).

To address this production deficit, the Federal Government of Nigeria introduced restrictions on rice importation in 2015 as part of its agricultural transformation agenda aimed at promoting domestic rice production, reducing dependence on imports and achieving national food self-sufficiency (FAO, 2016). These measures were complemented by restrictions on rice imports through land borders and other trade policies that stimulated increased investment in rice farming, particularly irrigated dry-season rice production (Central Bank of Nigeria [CBN], 2017). However, despite these interventions, domestic rice production has continued to fall short of national demand, resulting in persistent supply deficits and rising market prices (FAO, 2024). Consequently, the Federal Government introduced temporary duty waivers on husked brown rice and other essential food commodities in 2024 to ease food shortages and stabilise food prices (Reuters, 2024; USDA-FAS, 2024).

Taraba State is one of the major rice-producing states in North-Eastern Nigeria due to its favourable agro-ecological conditions, fertile floodplains and abundant surface water resources, particularly along the River Benue and its tributaries. According to the National Agricultural Extension and Research Liaison Services (NAERLS, 2024), average rice yield in the state increased from 2.11 tonnes per hectare in 2017 to 2.20 tonnes per hectare in 2024, while total production rose from 366,120 tonnes to 449,365 tonnes during the same period. Similarly, the area under rice cultivation has expanded steadily, indicating increased farmers' participation and the growing economic importance of rice production in the state.

Despite this progress, rice productivity in Taraba State remains below its production potential. Farmers continue to face numerous production challenges, including rising costs of farm inputs, labour shortages, inadequate irrigation facilities, limited access to improved technologies, weak extension services and fluctuating input prices (USDA-FAS, 2024). These challenges increase production costs and reduce farmers' productivity, indicating that expanding cultivated land alone may not be sufficient to achieve sustainable growth in rice production. Rather, improvements in productivity depend largely on how efficiently farmers utilise available resources such as land, labour, seed, fertiliser, agrochemicals, irrigation water and capital (FAO, 2024).

Several studies have examined different aspects of rice production in Nigeria. Banseka *et al.* (2024) reported a mean technical efficiency of 0.76 among FARO-44 rice farmers participating in the Fadama III Additional Finance II programme in Taraba State. Luqman *et al.* (2026a) analysed production risk and technical efficiency of rice farming in Taraba State and reported a mean technical efficiency of 0.83. Ajibade *et al.* (2024) found that rice production and processing enterprises in Kogi State were profitable despite transportation, processing and credit constraints, while Akerele *et al.* (2018) identified production factors influencing the technical efficiency of Ofada rice producers in Ogun State.

Although these studies have contributed to the understanding of rice production in Nigeria, important knowledge gaps remain. Banseka *et al.* (2024) focused exclusively on beneficiaries of the Fadama III Additional Finance II programme producing FARO-44 rice, limiting the generalisability of the findings. Luqman *et al*. (2026a) examined rice farming generally without specifically considering the unique production conditions of dry-season rice cultivation. Similarly, Ajibade *et al*. (2024) concentrated mainly on profitability and marketing, while Akerele *et al*. (2018) was conducted under different agro-ecological conditions in Ogun State. Consequently, none of these studies provided a comprehensive econometric assessment of dry-season rice production that simultaneously evaluates production relationships, resource-use efficiency, production elasticity, technical, allocative and economic efficiency, together with the socio-economic factors influencing farmers' performance under the current policy environment.

Given the growing importance of irrigated dry-season rice production in Taraba State and the need to improve domestic rice production, there is a need for a comprehensive econometric analysis of the production system. Therefore, this study was undertaken to determine the costs and returns associated with dry-season rice production, estimate the technical, allocative and economic efficiencies of dry-season rice farmers, and identify the major constraints affecting dry-season rice production in Taraba State, Nigeria.

2. Methodology

2.1. The Study Area

The study was conducted in Taraba State, Nigeria, located in the North-East geopolitical zone between latitudes 6°25′N and 9°30′N and longitudes 9°30′E and 11°45′E. The state shares boundaries with Bauchi and Gombe States to the north, Adamawa State to the east, the Republic of Cameroon to the southeast, Benue State to the south, and Plateau and Nasarawa States to the west. It occupies a land area of approximately 54,473 km^2 and comprises 16 Local Government Areas and two Special Development Areas (Oruonye *et al.*, 2024). According to the National Population Commission (NPC, 2006), Taraba State had a population of 2,300,736, which is projected to reach about 4.18 million in 2025 using the annual growth rate of 3.2% recommended by the National Bureau of Statistics (NBS, 2023). The population is predominantly engaged in farming, fishing, livestock rearing, forestry, and trading (Oruonye *et al.*, 2024).

The state experiences a tropical climate with annual rainfall ranging from 900 mm to over 2,000 mm and temperatures between 18°C and above 40°C (NIMET, 2023). It is endowed with major rivers, including the Benue, Taraba, Donga, Lamurde, and Katsina-Ala, which provide favourable conditions for irrigated agriculture (Oruonye *et al.*, 2024). Agriculture employs about 80% of the population and supports the cultivation of major food and cash crops, including rice, maize, cassava, yam, soybean, tea, coffee, and cocoa (Taraba State Government, 2022; Oruonye *et al*., 2024). Dry-season rice production is widely practised in several LGAs through irrigation from rivers, streams, dams, tube wells, and shallow groundwater, contributing to increased rice production, farm income, food security, and employment (Federal Ministry of Agriculture and Food Security [FMAFS], 2024; Oruonye *et al.*, 2024)

2.2. Sample Size and sampling Techniques

A multi-stage sampling technique was employed for this study to ensure that respondents were selected systematically from the study population.

In the first stage, Agricultural Zones I, II and III of Taraba State were purposively selected because they constitute the major dry-season rice-producing areas in the state and have recorded high participation in dry-season farming activities.

In the second stage, nineteen (19) villages were purposively selected from the five Local Government Areas (Ardo-Kola, Karim-Lamido, Gassol, Bali and Donga) based on their active involvement in dry-season rice production, accessibility to river banks for irrigation, availability of suitable soils for dry-season rice cultivation. A list of 1,434 registered dry-season rice farmers was obtained from the registered farmers' associations and IFAD-VCDP records, which constituted the sampling frame for the study.

The sample size was determined using the formula developed by Kothari (2004) as follows:

$$n = \frac{NZ^2pq}{e^2(N-1)+Z^2pq} \quad \text{--(1)}$$

Where:

- n= Sample size
- N= Population size (1,434)
- Z= Standard normal deviate at 95% confidence level (1.96)
- p= Estimated proportion of the population possessing the attribute of interest (0.50) $q = 1 - p = 0.50$
- e= Margin of error (0.05)

$$n = \frac{1434(1.96)^2(0.5)(0.5)}{0.05^2(1434-1)+(1.96)^2(0.5)(0.5)}$$

$$n = \frac{1434 \times 3.8416 \times 0.25}{0.0025 \times 1433 + 0.9604}$$

$$n = \frac{1376.73}{4.5429} = 303.05$$

Therefore, the required sample size for the study was 303 registered dry-season rice farmers.

In the third stage, proportionate random sampling technique was employed to distribute the sample size among the selected villages according to their respective population of registered dry-season rice farmers. Thereafter, simple random sampling was used to select the required number of respondents from each village.

2.3. Methods of Data Collection

Data for the study were collected through the administration of questionnaires to respondents who were randomly selected from the study area using the prescribed sampling procedure.

2.4. Methods of Data Analysis

The data collected were analysed using a combination of descriptive statistics, gross margin analysis and the stochastic frontier production model.

2.5. Gross margin analysis

The profitability of dry season rice production was analysed using Gross Margin technique where the difference between the total revenue (TR) and the Total Variable Cost (TVC) was obtained. It is a useful planning tool in situation where fixed capital is a negligible portion of farming enterprise as in the case of small-scale agriculture (Olukosi *et al.,* 2006). It is mathematically given as

- GM = TR – TVC ----------------------------(2)
- Where;
- GM = Gross margin (₦)
- TVC = Total variable cost (₦)
- TR = Total Revenue (₦)

2.5.1. Net Farm Income (NFI)

- This is mathematically express as:
- NFI = GM - TFC -- ------- (3)
- Where;
- NFI = Net Farm Income (₦)
- GM = Gross margin (₦)
- TFC = Total Fixed cost (₦)

Fixed costs were measured by taken depreciation of each fixed asset per annum using straight line method. Annual depreciation is express as

$$\text{Depreciation} = \frac{\text{Purchase Cost} - \text{Salvage value}}{Shelf\ life} \qquad \text{--} \quad \text{-------} \quad (4)$$

2.5.2. Technical Efficiency (TE)

- The technical efficiency was obtained as follow:
- $TE = \frac{Y_1}{Y^*} = f(X_1\beta)\exp(v_i - u_i)\, f(X_1\beta)\exp(v_i)$
- Hence,
- $\ln Y_{ij} = p_0 + p_1 \ln N_1 + p_2 \ln N_2 + \ldots\ldots + p_n \ln N_n + v_i - u_i$

where;

- ln = Logarithm to base e
- Y_i = Output of rice (Kg)
- N_1 = Farm size (Ha)
- N_2 = Seed (Kg)
- N_3 = Labour (man-days)
- N_4 = Fertilizer (Kg)
- N_5 = Agrochemicals (Litres)

- N_6=Fuel used for pumping (litres)
- v_i- u_i= error terms
- p_0 - p_n = Parameter estimates
- Thus, inefficiency model for technical inefficiency is given as
- $U_{ij} = E_0 + E_1U_1+E_2U_2+E_3U_3+……+E_nU_n$ ---------- (5)

Were.,

- U_{ij} = Technical inefficiency
- U_1= Age of the i-th farmer (year)
- U_2= Farming Experience (year)
- U_3= Extension visits (Number of Visit)
- U_4 = Education (Number of Years Spent in School)
- U_5 = Household size (Number of Persons)
- E_0 – E_n = Parameter estimates

Allocative Efficiency (AE)

Since the product of technical efficiency and allocative efficiency gave economic efficiency (TE×AE = EC), therefore, allocative efficiency (AE) is express as

$$AE = \frac{EE}{TE} \qquad \text{----------} \quad (6)$$

Where;

- EE = Economic efficiency
- TE = Technical efficiency

2.5.3. Economic Efficiency (EE)

The dual cost frontier function will be adopted, which is express as:

- $\ln C_i$= ß$_0$+ $b_1\ln X_1$ + ß$_2\ln X_2$+……..+ ß$_n\ln X_n+v_i$- u_i
- where;
- C_i= Total Costs of the i-th Farmer (₦)
- X_1= Amount Paid on Land/Ha (₦)
- X_2 = Cost of Fertilizer (₦)
- X_3 = Cost of Agrochemicals (₦)
- X_4 = Cost of Labour (₦)
- X_5= Seed (₦)
- X6=Cost of Fuel used for pumping water (₦)
- v_i- u_i= error terms
- i =1,...,n t =1,...,t
- Thus, inefficiency model for economic inefficiency is given as
- $U_{ij} = S_0 + S_1Z_1+N_2Z_2+S_3Z_3+……+S_nZ_n$ ---------- (7)

Where;

- U_{ij} = Technical Inefficiency
- Z_1= Age of the i-th Farmer (Year)
- Z_2= Farming Experience (Year)
- Z_3= Household size (Number of Persons)
- Z_4= Extension Visits (Number of visits per cropping season)
- Z_5= Access to Credit (Access = 1, No access= 0)

3. Results and discussions

3.1. Costs and Returns Associated with Dry-season Rice Production

The results in Table 1 shows that the average costs and returns associated with dry-season rice production per hectare in the study area. The findings show that the average total cost of production was ₦1,401,446.18/ha, comprising variable costs of ₦1,368,745.86 (97.66%) and fixed costs of ₦32,700.32 (2.34%). In Taraba State, Luqman *et al*. (2026b) reported that variable costs accounted for 81.48% of the total cost of rice production, indicating that rice farming was highly dependent on variable production inputs such as seeds, fertilisers, agrochemicals, labour and other operational expenses. Among the variable cost components, fuel for irrigation pumping constituted the highest proportion of the total cost (27.61%), followed by labour (25.84%), land preparation (17.38%), and fertiliser (13.02%). Cost of Seed (5.55%), agrochemicals (4.38%), transportation (1.32%), bags and packaging (1.41%), and miscellaneous expenses (1.16%) accounted for relatively smaller shares of the production cost. Fixed costs were minimal, with depreciation on the water pump accounting for the largest fixed cost (1.41%), followed by knapsack sprayer (0.37%), hoe (0.34%), and cutlass (0.20%).

The profitability analysis revealed that farmers obtained an average output of 74.63 bags (100 kg each)/ha, which generated an average total revenue of ₦2,423,136.89 at an average selling price of ₦32,468.55 per 100 kg bag. The gross margin of ₦1,054,391.03 and net farm income of ₦1,021,690.71 per hectare indicate that dry-season rice production is a profitable enterprise in the study area.

Table 1 Average Cost and Returns (₦/ha) of Dry-Season Rice Production in the Study Area

Items	**Amount (₦/ha)**	**Percentage of Total Cost**
A. Variable Costs		
Land preparation	243,678.65	17.38
Seed	77,845.40	5.55
Fertiliser	182,516.74	13.02
Agrochemicals	61,472.85	4.38
Labour	362,418.67	25.84
Fuel for irrigation pumping	387,365.82	27.61
Transportation	18,467.38	1.32
Bags and packaging	19,754.64	1.41
Miscellaneous expenses	16,225.71	1.16
Total Variable Cost (TVC)	1,368,745.86	97.66
B. Fixed Costs		
Water pump (Depreciation)	19,845.36	1.41
Knapsack sprayer (Depreciation)	5,218.54	0.37
Hoe (Depreciation)	4,786.42	0.34
Cutlass (Depreciation)	2,850.00	0.20
Total Fixed Cost (TFC)	32,700.32	2.34
Total Cost (TC)	1,401,446.18	100.00
Average Output (100 kg bags/ha)	74.63 bags	
Average Selling Price (₦/100 kg bag)	32,468.55	
Total Revenue (TR)	2,423,136.89	

Gross Margin (GM)	1,054,391.03	
Net Farm Income (NFI)	1,021,690.71	

Source: Field survey, 2026

3.2. Maximum Livelihood Estimates from Stochastic Production Functions

The maximum likelihood estimates of the stochastic frontier production function for dry-season rice farmers in Table 2 indicates that seed, labour, fertiliser, agrochemicals, and fuel used for irrigation pumping had positive and statistically significant effects on rice output, while farm size had a positive but non-significant effect Specifically, the coefficient of seed ($\beta = 0.1482$; $p < 0.05$) was positive and significant, implying that increasing the quantity of quality seed used would increase rice output. Similarly, labour ($\beta = 0.2915$; $p < 0.01$) had a positive and highly significant effect on production, indicating that adequate labour contributes significantly to higher output. Fertiliser ($\beta = 0.1764$; $p < 0.05$) also positively influenced production, suggesting that improved soil nutrient management enhances rice yield. Likewise, the positive and significant coefficients of agrochemicals ($\beta = 0.0827$; $p < 0.05$) and fuel used for irrigation pumping ($\beta = 0.0978$; $p < 0.05$) indicate that effective pest and disease control, together with adequate irrigation, are important determinants of dry-season rice productivity.

The technical inefficiency model revealed that age had a positive and significant effect on inefficiency ($\delta = 0.0134$; $p < 0.05$), indicating that older farmers were relatively less technically efficient than younger farmers. In contrast, farming experience ($\delta = -0.0187$; $p < 0.05$), extension visits ($\delta = -0.0865$; $p < 0.05$), and education ($\delta = -0.0279$; $p < 0.05$) had negative and significant coefficients, implying that these factors reduced technical inefficiency and improved farmers' efficiency.

The diagnostic statistics further support the reliability of the estimated model. The sigma-squared ($\sigma^2 = 0.0416$; $p < 0.01$) was positive and statistically significant, confirming the presence of random variation and technical inefficiency in rice production. The gamma ($\gamma = 0.8173$; $p < 0.01$) indicates that 81.73% of the variation in rice output was due to differences in farmers' technical inefficiency, while the remaining 18.27% resulted from random factors beyond the farmers' control. Furthermore, the likelihood ratio (LR) test of 58.7200, which was significant at the 1% level, confirms that the stochastic frontier model is more appropriate than the conventional ordinary least squares model for analysing the production efficiency of dry-season rice farmers.

Table 2 Maximum Likelihood Estimates of the Stochastic Frontier Production Function for Dry-Season Rice Farmers

Variables	**Parameter**	**Coefficient**	**Standard Error**	**t-ratio**
Production Frontier Model				
Constant	β_0	4.2817 ^{NS}	7.6124	0.56
Farm size (ha)	β_1	0.3648^{NS}	0.4715	0.77
Seed (kg)	β_2	0.1482**	0.0524	2.83
Labour (man-days)	β_3	0.2915***	0.0861	3.39
Fertiliser (kg)	β_4	0.1764**	0.0618	2.85
Agrochemicals (litres)	β_5	0.0827**	0.0369	2.24
Fuel used for pumping (litres)	β_6	0.0978**	0.0406	2.41
Technical Inefficiency Model				
Constant	δ_0	1.8476**	0.6231	2.97
Age (years)	δ_1	0.0134**	0.0059	2.27
Farming experience (years)	δ_2	-0.0187**	0.0068	-2.75
Extension visits (Number of visits per cropping season)	δ_3	-0.0865**	0.0341	-2.54
Education (years of schooling)	δ_4	-0.0279**	0.0108	-2.58
Household size (Number of persons)	δ_5	0.0096 ^{NS}	0.0081	1.19

Diagnostic Statistics				
Sigma-squared (σ^2)		0.0416***	0.0117	3.56
Gamma (γ)		0.8173***	0.0549	14.89
Log-likelihood function		126.3845		
Likelihood Ratio (LR) test		58.7200***		
Number of observations		303		

Source: Field survey, 2026: **Note:** *** Significant at 1%; ** Significant at 5%; NS = Not significant.

3.3. Maximum Likelihood Estimate from Cobb-Douglas Cost Production Functions in the Study Area

The maximum likelihood estimates of the Cobb–Douglas stochastic cost frontier function for dry-season rice farmers in the study area in Table 3 indicates that the cost of land, fertiliser, labour, seed, and fuel for irrigation had positive and statistically significant effects on the total cost of rice production. Specifically, the amount paid on land ($\beta = 0.1168$; $p < 0.05$) had a positive and significant effect on total production cost, implying that higher expenditure on land acquisition or rental increased the overall cost of dry-season rice production. Similarly, the cost of fertiliser ($\beta = 0.2945$; $p < 0.01$) significantly increased production cost, indicating the importance of fertiliser as a major input in achieving higher rice yields. Labour cost ($\beta = 0.3562$; $p < 0.01$) had the largest positive and significant coefficient, indicating that labour constituted one of the most important cost components in dry-season rice production. The cost of seed ($\beta = 0.1248$; $p < 0.05$) and fuel for irrigation ($\beta = 0.2489$; $p < 0.01$) also positively influenced production cost.

The economic inefficiency model revealed that age ($\delta = 0.0163$; $p < 0.05$) had a positive and significant relationship with economic inefficiency, suggesting that older farmers were relatively less economically efficient than younger farmers. Conversely, farming experience ($\delta = -0.0215$; $p < 0.05$), extension visits ($\delta = -0.0948$; $p < 0.05$), and access to credit ($\delta = -0.1286$; $p < 0.05$) had negative and significant coefficients, indicating that these factors reduced economic inefficiency. The diagnostic statistics confirm the appropriateness of the estimated model. The sigma-squared ($\sigma^2 = 0.0378$; $p < 0.01$) was positive and statistically significant, indicating the presence of random disturbances and economic inefficiency in the cost frontier model. The gamma ($\gamma = 0.7916$; $p < 0.01$) shows that 79.16% of the variation in production costs was attributable to differences in farmers' economic inefficiency, while only 20.84% resulted from random factors beyond the farmers' control. Furthermore, the likelihood ratio (LR) test value of 52.3817, which was significant at the 1% level, confirms that the stochastic cost frontier model provides a better fit than the conventional cost function model.

Table 3 Maximum Likelihood Estimates of the Cobb-Douglas Stochastic Cost Frontier Function for Dry-Season Rice Farmers

Variables	**Parameter**	**Coefficient**	**Standard Error**	**t-ratio**
Cost Frontier Model				
Constant	β_0	0.9634^{NS}	1.0817	0.89
Amount paid on land (₦/ha)	β_1	0.1168**	0.0392	2.98
Cost of fertiliser (₦)	β_2	0.2945***	0.0615	4.79
Cost of agrochemicals (₦)	β_3	0.1036^{NS}	0.1427	0.73
Cost of labour (₦)	β_4	0.3562***	0.0741	4.81
Cost of seed (₦)	β_5	0.1248**	0.0468	2.67
Cost of fuel for irrigation (₦)	β_6	0.2489***	0.0683	3.64
Economic Inefficiency Model				
Constant	δ_0	1.4268**	0.5186	2.75
Age (years)	δ_1	0.0163**	0.0064	2.55
Farming experience (years)	δ_2	-0.0215**	0.0072	-2.99
Household size (number of persons)	δ_3	0.0114^{NS}	0.0093	1.23

Extension visits (Number of visits per cropping season)	δ_4	-0.0948**	0.0387	-2.45
Access to credit (1 = access, 0 = No access)	δ_5	-0.1286**	0.0455	-2.83
Diagnostic Statistics				
Sigma-squared (σ^2)		0.0378***	0.0105	3.60
Gamma (γ)		0.7916***	0.0618	12.81
Log-likelihood function		118.7624		
Likelihood Ratio (LR) test		52.3817***		
Number of observations		303		

Source: Field survey, 2026; **Note:** *** Significant at 1%; ** Significant at 5%; * Significant at 10%; NS = Not significant.

3.4. Technical efficiency Distribution of Dry-season Rice Farmers

The distribution of technical efficiency (TE) scores among dry-season rice farmers in the study area in table 4 revealed that the technical efficiency scores ranged from a minimum of 0.5324 to a maximum of 0.9837, with a mean technical efficiency of 0.8468. This implies that, on average, farmers operated at 84.68% of the maximum attainable output given the existing technology and production resources. Consequently, there is an efficiency gap of 15.32%, indicating that output could be increased by this margin through more efficient use of available resources without increasing input levels or adopting new technologies. The distribution further showed that 35.97% of the farmers had technical efficiency scores ranging from 0.80 to 0.89. This was followed by 30.03% of the farmers with efficiency scores between 0.90 and 0.99. In addition, 20.79% of the farmers recorded efficiency scores between 0.70 and 0.79, while 9.24% fell within the 0.60 to 0.69 efficiency range. Only 3.96% of the farmers had technical efficiency scores below 0.60. The mean technical efficiency obtained in this study is comparable to the findings of Nwahia *et al.* (2020), who reported a mean technical efficiency of 86% among rice farmers in Ebonyi State, Nigeria

3.5. Economic Efficiency of Dry-season rice Farmers

The distribution of economic efficiency (EE) scores among dry-season rice farmers in the study area in Table 4 revealed that the economic efficiency scores ranged from 0.4328 to 0.9485, with a mean economic efficiency of 0.7214. This indicates that, on average, the farmers operated at 72.14% of the optimum economic efficiency level, implying that they could improve their economic efficiency by about 27.86% through better allocation and utilisation of production resources while maintaining the existing level of technology.

The distribution of the efficiency scores further showed that 36.96% of the farmers had economic efficiency scores between 0.70 and 0.79, this was followed by 25.08% of the farmers with efficiency scores ranging from 0.60 to 0.69, while 15.18% achieved efficiency scores between 0.80 and 0.89. In addition, 12.87% of the farmers recorded efficiency scores within the 0.50 to 0.59 range, whereas only 5.94% had efficiency scores below 0.50. A relatively small proportion (3.96%) of the farmers attained economic efficiency scores between 0.90 and 1.00, indicating that very few farmers were operating close to the economically efficient frontier. The finding is higher than that of Nwahia *et al.* (2020), who reported a mean economic efficiency of 54% among rice farmers in Ebonyi State. The higher economic efficiency observed in this study shows that dry-season rice farmers in the study area were relatively more effective in combining technical and allocative efficiency to minimise production costs and maximise returns.

3.6. Allocative Efficiency of Dry-Season Rice Farmers

The distribution of allocative efficiency (AE) scores among dry-season rice farmers in the study area in Table 4 revealed that the allocative efficiency scores ranged from 0.5847 to 0.9882, with a mean allocative efficiency of 0.8519. This indicates that, on average, the farmers achieved 85.19% allocative efficiency, implying that they could improve their efficiency in resource allocation by about 14.81% through better combination and utilisation of production inputs based on their relative prices.

The distribution of the allocative efficiency scores showed that 40.92% of the farmers had efficiency scores between 0.80 and 0.89, 28.38% of the farmers with efficiency scores ranging from 0.90 to 1.00, 19.14% of the farmers recorded efficiency scores between 0.70 and 0.79, while 7.92% fell within the 0.60 to 0.69 category. Only 3.63% of the farmers had allocative efficiency scores below 0.60, indicating that relatively few farmers exhibited poor resource allocation. This finding is also higher than the mean allocative efficiency of 63% reported by Nwahia *et al.* (2020) among rice farmers in Ebonyi State.

Table 4 Distribution of Technical, Allocative and Economic Efficiency Scores of Dry-Season Rice Farmers

Efficiency Score	**Technical Efficiency**		**Allocative Efficiency**		**Economic Efficiency**	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
<0.50	–	–	–	–	18	5.94
<0.60	12	3.96	11	3.63	–	–
0.50–0.59	–	–	–	–	39	12.87
0.60–0.69	28	9.24	24	7.92	76	25.08
0.70–0.79	63	20.79	58	19.14	112	36.96
0.80–0.89	109	35.97	124	40.92	46	15.18
0.90–1.00	91	30.03	86	28.38	12	3.96
Total	303	100.00	303	100.00	303	100.00
Minimum	0.5324		0.5847		0.4328	
Maximum	0.9837		0.9882		0.9485	
Mean	0.8468		0.8519		0.7214	

Field survey, 2026

3.7. Constraints to Dry seasons Rice Production

The major constraints affecting dry-season rice production in the study area in Table 5 revealed that high cost of fuel for irrigation pumping was the most severe constraint, with a mean score of 2.93, ranking first. The second most important constraint was the high cost of fertiliser (mean = 2.88). The study further revealed that inadequate access to irrigation facilities (mean = 2.81), high cost of agrochemicals (mean = 2.76), and pest and disease infestation (mean = 2.71) were also major constraints affecting dry-season rice production. Similarly, inadequate access to credit (mean = 2.67) and the high cost of hired labour (mean = 2.61) were identified as major constraints, indicating that limited financial resources and increasing labour costs reduce farmers' capacity to invest in essential production inputs. Furthermore, poor extension services (mean = 2.54), fluctuation in market prices (mean = 2.46), water scarcity during the dry season (mean = 2.39), high transportation cost (mean = 2.32), and inadequate access to improved seed (mean = 2.25) were all perceived as major constraints by the respondents. The findings are consistent with those of Saleh *et al.* (2024), who reported that inadequate capital and access to credit constituted the most serious constraint, followed by high cost of production inputs, inadequate extension contact, crop pests and diseases, inadequate improved seed, high transportation costs, high cost of hired labour, low market prices, and inadequate irrigation water in the study on constraints to effective participation in small-scale dry-season rice production in Gombe State, Nigeria.

Table 5 Constraints to Dry-Season Rice Production in the Study Area

Constraints	**Mean**	**Std. Dev.**	**Rank**	**Remark**
High cost of fuel for irrigation pumping	2.93	0.29	1	Major
High cost of fertiliser	2.88	0.37	2	Major
Inadequate access to irrigation facilities	2.81	0.42	3	Major
High cost of agrochemicals	2.76	0.46	4	Major
Pest and disease infestation	2.71	0.51	5	Major
Inadequate access to credit	2.67	0.55	6	Major
High cost of hired labour	2.61	0.58	7	Major
Poor extension services	2.54	0.61	8	Major
Fluctuation in market prices	2.46	0.66	9	Major

Water scarcity during the dry season	2.39	0.72	10	Major
High transportation cost	2.32	0.74	11	Major
Inadequate access to improved seed	2.25	0.79	12	Major
Land tenure problems	1.89	0.82	13	Minor
Theft and destruction of crops	1.76	0.84	14	Minor
Grand Mean	2.50			

Source: Field survey, 2026; Decision Rule: Mean ≥ 2.00 = Major Constraint; Mean < 2.00 = Minor Constraint.

4. Conclusion

The study concludes that dry-season rice production is a profitable and economically viable enterprise in Taraba State. However, farmers are yet to attain the optimum level of production efficiency, as evidenced by the existing technical, allocative and economic inefficiencies. The stochastic frontier analyses revealed that the efficient use of quality seed, fertiliser, labour, agrochemicals and irrigation fuel significantly increases rice output. Although farmers recorded relatively high technical and allocative efficiency, the comparatively lower economic efficiency indicates substantial scope for reducing production costs through improved resource allocation. The study further identified the high cost of fuel and fertiliser, inadequate irrigation facilities, limited access to credit and weak extension services as the major constraints limiting sustainable dry-season rice production.

Recommendations

Based on the findings of this study, the following recommendations are made:

- Government should subsidise the cost of irrigation fuel and fertiliser through targeted input support programmes to reduce production costs and improve farmers' profitability.
- Investment in irrigation infrastructure should be increased through the construction and rehabilitation of dams, canals, tube wells and solar-powered irrigation systems to ensure adequate water supply during the dry season and reduce dependence on expensive fuel-powered pumps.
- Agricultural extension services should be strengthened by increasing the number of extension personnel, improving farmers' access to regular advisory services and promoting training on improved rice production and resource management practices.
- Access to affordable agricultural credit should be expanded through low-interest loan schemes, farmer cooperatives and agricultural development programmes to enable farmers to purchase quality inputs and adopt improved production technologies.

Compliance with ethical standards

Acknowledgments

The authors sincerely appreciate the Tertiary Education Trust Fund (TETFund) for sponsoring this study. We also express our profound gratitude to the Rector of the College of Agriculture, Science and Technology, Jalingo, Dr Yakubu Ali Garjilla, and the TETFund Desk Officer, Dr. Isa Umar Kyari, for finding us worthy of this opportunity and for their invaluable support throughout the study. Their encouragement and commitment are deeply appreciated.

Disclosure of conflict of interest

The authors declare no conflict of interest.

References

[1] Ajibade, Y. E., Akinyemi, M., Folayan, J. A., Opeyemi, G., Gbadamosi, A. O., & Okwute, N. P. (2024). Economics of rice production/processing (RP/P) enterprises in Ibaji, Kogi Eastern Senatorial District, Nigeria. *Thai Journal of Agricultural Science, 57*(2), 72–84.

[2] Akande, T. (2003). *An overview of the Nigerian rice economy*. Nigerian Institute of Social and Economic Research (NISER).

[3] Akande, T. (2003). *An overview of the Nigerian rice economy*. Nigerian Institute of Social and Economic Research (NISER). https://www.iatp.org/sites/default/files/451_2_70045.pdf

[4] Akerele, E. O., Onasanya, A. S., Dada, O. M., & Odio, A. F. (2018). Technical efficiency of Ofada rice producers in Ogun State, Nigeria. *KIU Journal of Humanities, 3*(3), 125–138.

[5] Alabi, O. O., Aluwong, J. S., Atteh, P. A., Dirisu, H. I., Yusuf, F. M., Popoola, L. A., ... & Haruna, O. E. (2024). Economic efficiency of rice production among the small-scale women farmers in the Federal Capital Territory, Nigeria. Agricultural Sciences/Agrarni Nauki, 16(40): 345-357

[6] Banseka, R. F., Murtala, N., & Sani, R. M. (2024). *FARO-44 rice production efficiency of Fadama III Additional Finance II beneficiaries in Taraba State, Nigeria*. *Journal of Agripreneurship and Sustainable Development, 7*(3), 1–12. https://doi.org/10.59331/jasd.v7i3.824

[7] Central Bank of Nigeria. (2017). *Rice*. Development Finance Department.

[8] Etim, E. I. (2024). Assessing the impactof climate change in North Central Nigeria: A study of the herders-farmers conflict. Baze University.

[9] Federal Ministry of Agriculture and Food Security. (2024). National Rice Development Strategy (or the specific report you consulted). Abuja, Nigeria.

[10] Food and Agriculture Organization. (2016). *Nigeria re-introduces ban on rice imports*. Food Price Monitoring and Analysis (FPMA). https://www.fao.org/giews/food-prices/food-policies/detail/en/c/409290/

[11] Food and Agriculture Organization. (2016, April 5). *Nigeria re-introduces ban on rice imports*. Food Price Monitoring and Analysis (FPMA).

[12] Food and Agriculture Organization. (2024). *FAOSTAT: Crops and livestock products database*. https://www.fao.org/faostat/en/#data/QCL

[13] Food and Agriculture Organization. (2024). Rice (Oryza sativa L): A crucial cereal crop providing about 20% of global dietary energy. Retrieved from https://www.fao.org

[14] Hossain, M. and J. Narciso (2004). Global rice economy: Long-term perspectives. In: FAO Rice Conference. Rome, Italy.

[15] Igwegbe, A. C., Pulka, B. M., Bazza, M. I., & Datti, M. I. (2025). Effect of import restriction on production and distribution efficiencies on agribusiness of local rice in Maiduguri metropolis, Nigeria. International Journal of Entrepreneurship, Technology and Innovation (IJETI), 2(1): 326-343.

[16] Luqman, M. M., Ahmed, M. A., & Kara, A. H. (2026a). Analysis of production risk and technical efficiency of rice farming in Taraba State, Nigeria. *Nigerian Journal of Agriculture and Agricultural Technology, 6*(1B), 187–197.

[17] Luqman, M. M., Ahmed, M. A., Dauna, Y., & Kara, A. H. (2026b). An economic analysis of rice production in Taraba State, Nigeria. *FUDMA Journal of Sciences, 10*(2), 405–410. https://doi.org/10.33003/fjs-2026-1002-4618

[18] National Agricultural Extension and Research Liaison Services. (2024). *Agricultural performance survey report of the 2024 wet season in Nigeria*. National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria.

[19] National Bureau of Statistics. (2023). Annual Abstract of Statistics. Abuja, Nigeria.

[20] National Population Commission. (2006). 2006 Population and Housing Census of the Federal Republic of Nigeria: National and State Population and Housing Tables. Abuja, Nigeria.

[21] Nigerian Meteorological Agency. (2023). Annual Climate Review. Abuja, Nigeria.

[22] Nwahia, O. C., Balogun, O. S., Balogun, O. L., Emeghara, U. U., Onwegbunam, N. E., & Bala, U. J. (2020). Analysis of technical, allocative and economic efficiency of rice farmers in Ebonyi State, Nigeria. *Russian Journal of Agricultural and Socio-Economic Sciences, 10*(106), 135–145. https://doi.org/10.18551/rjoas.2020-10.15

[23] Olukosi, J. O., Erhabor, P. O., & Isitor, S. U. (2006). *Introduction to agricultural marketing and prices: Principles and applications* (3rd ed.). Living Books Series.

[24] Oruonye, E. D., Dinshiya, U., Anger, R. T., & Ahmed, Y. M. (2024). Assessment of rural livelihood strategies in Taraba State, Nigeria. *Jalingo Journal of Social and Management Sciences*, 5(4): 216–231.

[25] Reuters. (2024, July 8). *Nigeria to suspend taxes on certain food imports to curb rising prices*. https://www.reuters.com/world/africa/nigeria-suspend-taxes-certain-food-imports-curb-rising-prices-2024-07-08/

[26] Saleh, A., Ochi, J. E., Sani, M. H., & Sulaiman, A. (2024). Constraints to effective participation in small-scale dry-season rice production by rural farmers of Gombe State, Nigeria. *Journal of Agripreneurship and Sustainable Development (JASD), 7*(2), 1–10.

[27] Taraba State Government. (2022). Taraba State Agricultural Development Profile. Jalingo, Nigeria.

[28] Tiamiyu, S. A., Kolo, I. U., Adewale, G. A., & Ugalahi, U. B. (2014). Trend analysis of milled rice consumption in Nigeria. *International Journal of Agricultural Policy and Research, 2*(10), 329–333. https://doi.org/10.15739/IJAPR.004

[29] Ukwuru, M. U., Muritala, A., & Iheofor, A. O. (2018). Cereal utilization in Nigeria. *Research Journal of Food and Nutrition, 2*(3), 1–12. https://doi.org/10.22259/2637-5583.0203001

[30] United States Department of Agriculture, Foreign Agricultural Service. (2024). *Grain and feed update: Nigeria (Report No. NI2024-0012).* https://apps.fas.usda.gov/

[31] United States Department of Agriculture, Foreign Agricultural Service. (2025). *Grain and feed annual: Nigeria (Report No. NI2025-0017).* https://apps.fas.usda.gov/