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RESEARCH ARTICLE

Determinants of Technical Efficiency among Rice Farmers in Kebbi State, Nigeria

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ABSTRACT

This study examines the determinants of technical efficiency among rice farmers in Kebbi State, Nigeria, using data from 120 respondents. A Cobb–Douglas Stochastic Frontier Model was applied to estimate farm-level technical efficiency, followed by a Tobit regression to identify socioeconomic and institutional factors influencing efficiency. Results show a relatively high mean yield supported by substantial use of seed, fertilizer, labor, and organic inputs. Training participation, access to credit and adoption of environmentally sustainable practices significantly enhance technical efficiency, while cluster membership negatively affects it, suggesting coordination challenges within farmer groups. Distance to market exhibits a weak positive influence, whereas age shows no significant effect. The study concludes that improving technical efficiency requires strengthening training and extension services, expanding access to credit, and addressing structural inefficiencies within farmer clusters. These findings provide evidence-based insights for policymakers and stakeholders aiming to boost rice productivity and promote sustainable agricultural development in Kebbi State.

Key words: Technical efficiency, rice farmers, Kebbi State

INTRODUCTION

Rice has become one of the most important staple crops in Nigeria, with rising demand driven by population growth, urbanization, and changing dietary preferences. Kebbi State stands out as one of the leading rice-producing regions in the country due to its favorable floodplains, irrigation potentials, and the influence of programs such as the Anchor Borrowers Programme (ABP).[1] Despite these advantages, productivity among rice farmers across Kebbi State remains below expected levels, suggesting the presence of technical inefficiency. Technical efficiency reflects a farmer's ability to maximize output from a given bundle of inputs, and understanding the factors that shape this efficiency is essential for enhancing productivity without necessarily expanding cultivated land. According to Muhammad *et al.*,[2] Dandago and Abdullahi,[3] and Abubakar and Suleiman[1] show that rice farmers in northern Nigeria exhibit wide variations in efficiency levels due to differences in managerial skills, access to credit, technology adoption, production risks, and institutional support systems.

Previous research indicates that socio-economic characteristics such as education, age, household size, labor, farming experience, and extension contact play critical roles in shaping productivity levels among smallholder rice farmers.[4,5] Similarly, access to improved inputs, mechanization, irrigation, and farm size have been identified as key determinants of the ability of farmers to reach the

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production frontier. Given Kebbi State's strategic importance in the national rice development agenda, a deeper understanding of the determinants of technical efficiency can support policymakers, extension agencies, and other stakeholders in designing interventions that enhance yield, reduce wastage of resources, and improve the livelihoods of rural farming households.

Statement of the Research Problem

Although Kebbi State is nationally recognized as a rice-production hub, productivity among rice farmers remains significantly below potential. Evidence from recent studies shows that many farmers operate below the frontier production level due to inefficiencies associated with suboptimal use of inputs, limited knowledge of modern agronomic practices, inadequate access to credit, and weak extension delivery systems.[3,6] This low level of technical efficiency contributes to persistent yield gaps and undermines efforts to achieve national rice self-sufficiency.

Despite the challenges, limited empirical research work has rigorously examined the specific determinants of technical efficiency among rice farmers in Kebbi State using robust frontier modeling approaches. The absence of detailed empirical evidence on what drives or limits farmers' technical efficiency has resulted in interventions that are often generic and insufficiently targeted. This creates a critical knowledge gap that this study seeks to address. This research, therefore, seeks to estimate the current technical efficiency levels among rice farmers in Kebbi State using an appropriate frontier model.

By identifying the determinants of technical efficiency, this study provides an evidence-based foundation for enhancing rice-sector planning in Kebbi State. It is justified not only academically by filling a documented research gap but also practically, by supporting more effective allocation of public resources, guiding donor-supported programs, and improving the overall productivity and sustainability of rice production in the state. The study will therefore serve as a crucial input for ongoing national food security strategies. This study focuses on rice farmers across selected local government areas within the major rice-producing zones of Kebbi State, including areas where both irrigated and rainfed rice systems are practiced. The study uses primary data gathered through structured questionnaires and applies a Stochastic Frontier Model to estimate technical efficiency.

METHODOLOGY

This study investigates the technical efficiency of rice-cultivating farms and then identifies determinants of technical efficiency. The study employs a two-stage empirical approach to identify these relationships. First, the Cobb–Douglas stochastic frontier function is used to identify the current state of farmers' technical efficiency. Then Tobit regression was employed to investigate what factors influence farmers' technical efficiency. The stochastic frontier analysis model was used to solve this problem, as in this model, the error term is separated into technical inefficiency and statistical noise.[7,8] The inputs used in the model include: seed quantity (kg), chemical fertilizer (kg), organic fertilizer (kg), capital (N) land (ha), and labor (man-days). The dependent variable is Rice yield in kilograms. The production function is specified as:

$$In\,(Y_i) = \beta 0 + \sum_{k=1}^{4} (\beta_0 * In(Xk1) + V_i - U_i$$

Where:

- Y_i = Output (total wheat production in kg) of the ith farm
- X_{ki} = Quantity of the kth input used by the ith farm
- β_k = Parameters to be estimated
- v_i = Two-sided random error term, $v_i \sim N\,(0, \sigma_v^2)$
- u_i = Non-negative inefficiency term, $u_i \sim N^{+}\,(0, \sigma_u^2)$

The inefficiency component u_i captures the shortfall of actual output from the potential frontier output, given the input levels. Technical efficiency (TE) for each farm is calculated as:

$$\text{TE} = \frac{Y_i}{Y_I *} = EXP(-U_i)$$

Where:

Y_i = Observed output

Y_{i*} = Frontier (maximum possible) output given inputs

$\text{TE}_i \in [0,1,]$ with values closer to 1 indicating higher efficiency

After identifying technical efficiency scores of farms, we employ a Tobit regression model to examine factors of farm-level technical efficiency. The latent Tobit model is specified as:

$$TE_i^* = Y_0 + Y_1 ESI + Y_2X_1 + Y_3X_2 + Y_4X_3 + Y_5X_4 + Y_6X_5 + \varepsilon_i$$

Where:

TE_i^* = Latent (unobserved) technical efficiency score for the ith farm

$TE_i = TE_i^*$ IF $0 < TE_i^* < 1$; otherwise, it is censored at the bounds

ESI = Environmental sustainability index for the ith farm

X_1 =Age

X_2 =Access to credit

X_3 =Cluster membership

X_4 = Participation in trainings

X_5 = Distance to market

RESULTS AND DISCUSSION

Table 1 presents the descriptive statistics of the major production and socioeconomic variables used in the study. The results show that the average rice yield per hectare is 28,544.31 kg, indicating a relatively high level of productivity among the sampled farmers. This performance suggests that rice production in the study area benefits from favorable agro-ecological conditions and improved farm management practices. Similar yield levels have been reported in Kebbi State by Ibrahim *et al.*,[9] who attributed increased productivity to the adoption of improved rice varieties, fertilizer use, and participation in organized production systems.

Table 1: Descriptive statistics

Variable	Mean	Standard deviation
Rice yield per ha (kg)	28544.31	8107.6
Rice land (ha)	3.55	3.27
Seed used (kg)	4015.5	715.9
Organic fertilizer (kg)	23256.2	8893.4
Chemical fertilizer (kg)	1071.9	470.7
Labor (man-days)	143.4	31.8
Farmers' Age (years)	44.7	10.25
Access to credit	0.496	0.5
Cluster Membership (binary)	0.504	0.502
Training participation	0.529	0.501
Distance to market	0.88	0.8
Number of observations	120	

Source: Field survey 2025

The average farm size of the respondents is 3.55 ha, suggesting that farmers operate at a semi-commercial scale rather than purely subsistence farming. This finding supports the observation of Ndaghu and Maurice[10] that rice farming in northern Nigeria is gradually shifting from smallholder production to medium-scale operations, which can improve resource allocation and farm efficiency. The mean seed input is 4,015.5 kg, indicating substantial use of planting materials. Appropriate seed rates are important for improving technical efficiency and crop productivity by reducing seed wastage and ensuring optimal plant population.[11]

Regarding soil fertility management, the average quantity of organic fertilizer applied is 23,256.2 kg, highlighting the importance of organic manure in maintaining soil fertility. The relatively large quantity used may reflect its availability locally or support from organized farming initiatives such as cluster systems. According to Oluwatayo and Adetoro[12] noted that organic manure enhances soil structure and nutrient availability, thereby improving farm performance. In addition, farmers apply an average of 1,071.9 kg of chemical fertilizer, indicating relatively intensive input use. Balanced fertilizer application is widely recognized as a key determinant of agricultural productivity and efficiency.[13] The average labour use is 143.4 man-days, confirming the labor-intensive nature of rice production in Kebbi State, where adequate labor is required for timely farm operations.[14]

In terms of socioeconomic characteristics, the mean age of farmers is 44.7 years, placing most respondents within the economically active age group. Farmers in this category often combine experience with openness to new technologies, which can enhance efficiency.[15] About 49.6% of farmers have access to credit, enabling them to finance essential inputs and adopt improved technologies.[16] Approximately 50.4% belong to production clusters, which can facilitate access to inputs, extension services, and markets.[17] In addition, 52.9% have participated in agricultural training programs, reflecting moderate exposure to capacity-building initiatives that improve

managerial ability and efficiency.[18] Finally, the average distance to market is 0.88 km, indicating that most farmers are located close to market outlets, which reduces transportation costs and encourages the adoption of improved technologies.[19]

Tobit Model of Determinants of Technical Efficiency

Table 2 presents the Tobit regression results showing the influence of selected socioeconomic variables on the technical efficiency of rice farmers. The Environmental Sustainability Index (Coef. = 0.086) is positive and statistically significant, indicating that farmers who adopt environmentally sustainable production practices tend to achieve higher technical efficiency. This suggests that practices such as improved soil management, conservation methods, and environmentally friendly farming techniques enhance productivity by maintaining soil fertility and reducing environmental degradation. This result supports the findings of Dauda and Mohammed[20] who reported that sustainable farming practices improve farm efficiency through better soil health and long-term productivity.

Cluster Membership (Coef. = –0.08) has a negative and highly significant coefficient, implying that farmers who belong to production clusters tend to have lower technical efficiency. Although clusters are designed to promote coordination and access to resources, the result suggests that institutional or management challenges may reduce their effectiveness. Bureaucratic delays, weak coordination among members, or rigid production arrangements may limit farmers' flexibility in managing their farms.[21] also noted that political interference in some farmer clusters can lead to inefficient input allocation and poor farm performance.

Table 2: Tobit model estimating technical efficiency determinants

Variable	Coefficient	Std. Error
Environmental sustainability index	0.086**	0.047
Age	0.0017	0.0012
Cluster membership	−0.08***	0.027
Training participation	0.077***	0.028
Access to credit	0.071**	0.027
Distance to market	0.03*	0.017
Constant	0.58***	0.065

Source: Field survey 2025. Note: *** $P<0.01$, **$P<0.05$, * $P<0.1$. Model statistics: LR Chi-square (6)=47.47, Pseudo R^2 = 0.0561, Observations=120

Training Participation (Coef. = 0.077) positively and significantly influences technical efficiency. This indicates that farmers who attend agricultural training programs are more efficient in using production inputs. Training enhances farmers' knowledge of improved agronomic practices, input management, and modern production technologies, which contribute to higher productivity. This finding is consistent with Jamilu *et al.*,[22] who reported that farmer education and training significantly improve technical efficiency in rice production across northern Nigeria.

Access to Credit (Coef. = 0.071) also shows a positive and significant effect on technical efficiency. Availability of credit enables farmers to purchase improved seeds, fertilizers, and agrochemicals, and to hire labor when needed. This helps farmers implement recommended production practices and improve farm performance. The result agrees with Awotide *et al.*[23]), who found that credit access significantly enhances efficiency among rice farmers participating in the ABP.

Distance to Market (Coef. = 0.03) has a positive but weakly significant effect, suggesting that farmers located slightly farther from markets may utilize inputs more carefully to offset transportation costs. While Tijjani *et al.*[14] reported that longer market distances reduce efficiency,[24] argued that farmers in moderately distant locations may achieve higher efficiency due to reduced land pressure near market centers.

The constant term (Coef. = 0.58) is positive and highly significant, indicating a relatively strong baseline level of technical efficiency among the farmers. The likelihood ratio statistic (LR Chi-square = 47.47) confirms the overall significance of the model, while the R^2 value of 0.0561 is typical for cross-sectional agricultural efficiency studies where farm-level variations are difficult to fully explain.

CONCLUSION

The study examined the production characteristics and socioeconomic factors affecting the technical efficiency of rice farmers in the study area. Descriptive statistics revealed that rice farmers

achieve relatively high productivity, with an average yield of about 28,544 kg/ha. This level of productivity may be attributed to favorable agro-ecological conditions, the use of improved seeds, and the application of both organic and inorganic fertilizers. The average farm size of 3.55 ha indicates that rice production in the area is gradually shifting from subsistence to semi-commercial farming. Farmers also make considerable use of labor and soil fertility inputs, reflecting the labor-intensive nature of rice production in Kebbi State. In addition, most farmers are within the economically active age group, while a moderate proportion have access to credit, belong to production clusters, and participate in agricultural training programs, all of which influence farm productivity and management decisions.

The Tobit regression results further show that several socioeconomic variables significantly influence technical efficiency. Environmental sustainability practices, participation in training programs, and access to credit were found to positively and significantly improve farmers' efficiency. This implies that farmers who adopt sustainable soil management practices, receive training, and have financial support are better able to utilize production inputs effectively. However, cluster membership was found to negatively affect technical efficiency, possibly due to coordination challenges, bureaucratic delays, or inefficiencies in input distribution among members. Distance to market showed a weak positive effect, suggesting that farmers may manage inputs more carefully when faced with transportation costs. Overall, the findings indicate that improving farmers' access to training, financial resources, and sustainable production practices can significantly enhance technical efficiency and productivity in rice farming.

RECOMMENDATIONS

1. Strengthening farmer training and extension services: Agricultural development programs should intensify farmer training and extension services to promote improved agronomic practices, sustainable soil management, and efficient input utilization. Regular capacity-building programs will enhance farmers' managerial skills and technical knowledge, thereby improving farm productivity and efficiency.
2. Improving access to agricultural credit and reforming cluster systems: Financial institutions and government programs should expand farmers' access to affordable credit to enable the timely purchase of quality inputs such as improved seeds and fertilizers. At the same time, existing cluster farming arrangements should be restructured to improve transparency, coordination, and equitable distribution of inputs to ensure that cluster participation contributes positively to farmers' technical efficiency.

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