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Economic Analysis of Rice Production In North-East (Borno, Yobe and Adamawa States), Nigeria

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ABSTRACT

This study examines the economic analysis among rice farmers in three selected states in North-East Nigeria. The objective is to examine economic analysis of rice farmers in North-East, Nigeria. A multistage sampling technique was uses to collect primary data from 300 rice farmers in three states **(**(Borno, Yobe and Adamawa States). 100 rice farmers were drawn from each state. The study adopted Data Envelopment Analysis (DEA), Stochastic Frontier Analysis (SFA) model and Statistical Test of Gross Margin to test the hypotheses. The result of the hypotheses tested revealed that rice farmers in the study areas were not economically efficient in the production and there is a significant relationship between rice farmers' inputs and rice output in the study area. The result of Gross Margin test further revealed that the production of rice in North-East, Nigeria is profitable. The study recommends that research institutes should undertake a thorough extension exercise to advise the rice farmers in the study area on the recommended input usage and application rates and that rice farmers in the study area should increase the use of inputs such as seed, fertilizer, and mechanization among others since increasing these inputs has the potential to increase rice output in the area.

Keywords: Economic Efficiency, Data Envelopment Analysis, Stochastic Frontier, Gross Margin

INTRODUCTION

Rice is one of the main staple crops in Nigeria and featured among the five food crops (cassava, maize, wheat, rice and sugar) whose production is to be promoted for attainment of food self-sufficiency. Apart from being a food crop, rice equally becomes a commercial crop on which many agro-based industries depends for raw materials (Oluwatayo, Sekumade & Adesoji, 2008). Oil processed from bran is both for food and industrial uses. Hull is used for fuel, packing material, industrial grinding, fertilizer manufacture, and in the manufacture of an industrial chemical called furfural. The straw is used for feed, livestock bedding, roof thatching, mats, garments, packing and broom straws. The bye products of milling including bran and rice polish (finely powered bran and starch resulting from polishing) are used as livestock feed. Thus, rice can be considered very vital to the economic growth of the nation through its contribution to food security and poverty alleviation.

Nigeria is the largest producer of rice in Africa, yet it remains one of the world's highest importers due to high demand and consumption. While local production has increased significantly, challenges like high fertilizer costs, insecurity and limited mechanization continue to create gap between production and consumption. Nigeria rice production rose from 3.7 million metric tons in 2017 to 4.0 million metric tons in 2018 (FAO, 2026). In spite of this, only 57 percent of the 6.7 million metric tons of rice consumed in Nigeria annually is locally produced leading to a deficit of about 3 million metric tons, which is either imported or smuggled into the country illegally. As of 2026, the Nigerian rice market is characterized by

a structural deficit, where consumption consistently outstrips domestic production. The market size for rice in Nigeria continues to expand, driven by a growing population and urbanization (Business Plans Nigeria, 2026). Despite domestic production gains, the country still faces a supply gap that fuels demand for high-quality local brands

A number of broad economic and environmental constraints have been identified that are militating against improving rice production and economic efficiency levels as well as higher output by rice farm households in Nigeria (Rapu, 2016). These are: low utilization of fertilizer and other farm chemicals, use of poor varieties of rice seeds, impact of market failures, failure of extension services, and lack of rural infrastructure. Other factors include: frequent floods, irregular patterns of rainfall, water shortage, and poor credit delivery to farmers. As a consequence, many small-scale rice farmers are trapped in subsistence levels of rice production, discouraging taking actions to promote a higher productive and economic efficiency and the commercialization of rice production

To stimulate rice production base across the states in Nigeria, a number of programme and projects have been put in place by federal and state government and these include: the Federal Rice Research Station (FRRS), established in 1970 and in 1974 the FRRS changed to the National Cereals Research Institute (NCRI); the River Basin Development Authorities (RBDAs), established in 1977; and Abakaliki Rice Project (ARP), established in 1978; the Presidential Initiative on Rice (PIR), established in 1999; the National Program for Food Security (NPFS), the first and second phases were launched in 2001 and 2007 respectively and Agricultural Transformation Agenda (ATA) was launched in 2012 among others.

Despite these numerous efforts and policies to increase rice farming, there has not been any significant improvement in North-East Nigeria. The difficulties in improving the yield could be attributed to the inefficient farm management despite the intensive use of inputs.

Statement of problem

Nigeria is currently experiencing food crisis, which has been attributed to low productivity in the agricultural sector necessitating huge food imports. In Nigeria, demand for rice had been increasing at a much faster rate than in any other African countries since mid-1970 (FAO, 2021). Rice being a major staple crop in Nigeria is of vital concern to agricultural policy decisions. Current production is about 4.0 million tonnes and average yield is less than 3.5 tonnes per hectare. This is far below the potentials of the Nigerian rice sector. A recent empirical research shows that local rice farmers in Nigeria can raise yield to about 7.5 tonnes/ha and national production could hit 7.5 million (IITA, 2022).

The average yield of rice production in the North East like other zones in Nigeria is low when compared to other West African states. The federal government under the ANCHOR borrower scheme distributes farm inputs to 13, 992 rice farmers in North East to boost rice production in the states in 2018. Input distribution was aimed to boosting rice production in the study area so as to bridge the gap created by the banned of rice importation by the federal government.

Despite numerous efforts and policies to increase rice production, in North East is still agriculturally backward in Nigeria and there has not been any significant improvement in North east rice-subsector. Thus, there has been a growing gap between the demand for rice and its supply arising from low productivity. According to International Development Research Centre, (2015), the poor output realized by farmers may be an indication that resources needed in the production of the crop are not being used at their optimal levels. The relatively little emphasis laid by farmers on the crop raises the question as to whether it is profitable to grow the crop or not. This situation calls for an assessment of the resources needed for its production and how these resources are managed by its cultivators. This vital information which is lacking at the moment has created a vacuum which this researchers has the main objective of filling. The major objective of this study is to estimate the Economic Efficiency of rice production in North East, Nigeria.

Objectives of the study

i. Investigate the economic efficiency level of rice farmers in North East, Nigeria.
ii. Examine if there is any significant relationship between farm inputs and rice output in the selected states in North East, Nigeria.
iii. Determine the profitability of rice production in North East, Nigeria

Research Questions

i. What is the economic efficiency level of rice farmers in in North-East Nigeria?
ii. What is the technical relationship between farm inputs and rice output in North-East Nigeria?
iii. How profitable is rice production in North-East, Nigeria?

Research Hypotheses

Ho_1: Rice farmers in the study area are not economically efficient in the production of rice in North-East, Nigeria.
H_{O2}: There is no significant relationship between farm inputs and rice output in North-East, Nigeria.
H_{O3}: Rice production in the study area is not profitable in North-East, Nigeria.

LITERATURE REVIEW

Conceptual Review

Economic efficiency refers to the complete minimization of economic waste either, for any observed level of output, inputs are minimized, or for any observed level of inputs, outputs are maximized, or some combination of the two (Coelli, 1995). Economic efficiency (EE) consists Technical and allocative efficiencies. Technical efficiency (TE) measures the ability of a farmer to produce the maximum feasible output from a given bundle of inputs or produce a given level of output using the minimum feasible amounts of inputs. According to Koopmans (1951) a producer is technically efficient if, and only if, it is impossible to produce more of any output without producing less of some other output or using more of some input. As indicated by Fraser and Cordina, TE can also be defined in terms of the production function that relates the level of various inputs. It is a measure of a farm's success in producing maximum output from a given set of input.

According to Rahman (2003), there are three aspects of the relationship that influence efficiency of farm production are: farm – farmer relationship, farm – institution relationship and farm – production relationship.

Farm-farmer relationship: This describes the influence of farmer's socio-economic characteristics on farm production. Age, farming experience, farm size, education, household size, income, cooperative participation and land ownership status of farmers has been identified as factors that influence farm production

Farm-institution relationship: Efficiency can be driven by some institutions such as rendering essential services in the areas of Agricultural extension, credit, research, infrastructure etc.

Farm-production relationship: Production of farm produce involves different relationships between inputs and outputs. Production relationship provides tools for analysing problems of production and resource-use efficiency. According to Rahman, (2003), farm production efficiency may be analysed under three micro-economic relationships.

Factor-Product relationship in which the economists tries to determine the most profitable amount of resource to use to produce a given level of output or to determine the most profitable amount of output to produce at a given level of input.

Factor-Factor relationship for determining the most profitable combination of inputs in producing a given level of output (cost minimization) or to determine the most profitable level of output to produce at a given combination of resources (output maximization).

Product-Product relationship: This determines the most profitable level of input to use to produce a given combination of products or to determine profitable combination of products at a given level of input.

Theoretical Framework

Practical applications of efficiency measurements have relied upon the parsimonious specifications of the type of production technology associated with the producers.in other words, production technologies are used to represent relationships between inputs and output(s). Following Coelli, O'Donnell associated, it is assumed that producers are using nonnegative vector of inputs denoted by $x = (x_1, x_2.....,x_N)$ ϵR^{+N} to

produce nonnegative vector of outputs denoted by $y = (y_1, y_2.....,y_M) \in R+^M$. . The technology set (T) for a producer therefore, can be defined as:

$T \equiv \{(x, y)$: x can produce y$\}$

The above framework was based on the production theory, by applying the stochastic frontier function. The framework was organized in stipulations of feedback and influence mechanisms of farm efficiency levels. It focuses on input-output transformation efficiency, policy recommendations, and effects.

Empirical Review

Osemwengie & omotioma (2024) investigated the impact of rice production on Nigeria economy using time series data between 1987 and 2022. Secondary data was sourced from United States Department of Agriculture (USDA) and World Development Indicator (WDI) 2023. The estimation of the model was carried out using the Fully Modified Ordinary Least Squares (FMOLS) technique. The findings from the study among others showed that a unit increase in local rice production (LRP) will lead to 1.3 billion increases in real gross domestic product (RGDP), and this suggests a significant positive relationship between LRP and RGDP. Similarly, a positive relationship between rice importation (IMR) and RGDP was observed. This of course negates the a priori expectation, and the result indicates relatively higher price of locally produced rice due to its high demands and the ban on imported rice. The study however suggests the need for the government to provide necessary machinery and modern equipment for rice farmers coupled with social amenities like fertilizers, good roads to access rice Nigerians youth into commercial rice farming and hence boost massive rice production so as to lower the price of locally produced rice.

Vihi, Makwin, Jesse, Owa, Selzing, Ochelle & Mwolgwan (2023) investigated how profitable and technically effective rice farming was in Quan' Pan Local Government Area of Plateau State, Nigeria. Using a multistage sample method, 120 respondents were drawn. Findings from the study showed that the entire cost (total cost) of farming operation/ha incurred by the farmers was 139,733 while the average output obtained per hectare was 699kg at a prevailing market/selling price of 285/kg. The total revenue (TR) measured in naira value of 199, 215 was realized. Gross margin (GM) and net farm income (NFI) stood at 70,932 and 59.482 respectively. The return on investment (ROI) was 0.42 meaning that for every naira spent on rice production, a profit of 0.42 is made. Age, educational level, farm size, farming experience and extension contact all had positive direct relationship with net income from rice production at 1%. The rice growers' mean technical efficiency score was 0.659. Major constraints to rice production were high fertilizer prices (72%), inadequate capital (53%), and lack of improved seeds (47%). The research suggests that government should subsidize farming inputs like recommended fertilizer and herbicides so as to reduce the over bearing cost burden of these inputs on farmers. Financial institutions should make credit facilities available and affordable to the farmers.

Ezekiel, Felix, Ameh & Gold (2021) examined Gender Analysis in Economic Efficiency of Rice Farmers in Kogi State, Nigeria. The study analyzed differences in economic efficiency of male and female headed rice farming households in Ibaji Local Government Area, Kogi State. A three (3) stage sampling technique was used to select 120 rice farmers comprising 60 Males and 60 females for the study with the aid of a structured questionnaire. Descriptive Statistics, Data Envelopment Analysis (DEA), Ordinary least squares regression and a 4 point Likert-type rating scale were used to analyze the data. The result of DEA analysis revealed a mean technical efficiency under the constant returns to scale (TECRS) of 0.90 and 0.92 for households headed by male and female respectively. The mean technical efficiency under the variable returns to scale (TEVRS) was 0.95 and 0.93 for male and female headed households respectively. The allocative efficiency (AE) of male headed households was 0.72 while that of female was 0.61. Male headed households achieved a mean economic efficiency (EE) of 0.66 as against 0.56 achieved by their female counterparts. The mean scale efficiency (SE) of male headed households was 0.95 as against 0.99 achieved by female counterparts. The T- test results revealed significant differences in the mean output, AE, SE and EE scores of the rice farmers. The ordinary least square regression analysis showed that gender ($P < 0.05$) is a significant factor affecting economic efficiency of the rice farmers.

Emma-Ajah, Ume, Ucha & Chukwu (2021) investigated economic efficiency of small holder swamp rice farmers across gender in Anambra State, Nigeria was studied. The objectives of the study were to determine the level of economics efficiency and its determinants across gender and identify and analyze the constraints to swamp rice production in the study area. Multi-stage random sampling technique was used to select 120 swamp rice farmers (60 males and 60 females). Mean, maximum likelihood method and factor analysis was employed to address the objectives of the study. The result of mean economic efficiency of the male group (0.65) was higher than that of the female group (0.61). The cost of production of swamp rice to both male and female was affected by prfert (price of fertilizer), cptal (capital) and larent (Land rent). The determinant factors to economic efficiency that cut across both gender were educa (educational level), farmexp. (Farming experience) and memorg (membership of organization), while only Accredit (credit) was to male farmer group.

Chiekezie, Obiekwe, Ugwumba, & Ozor (2020) examined the determinants and level of economic efficiency of rice production in Anambra State, Nigeria. The specific objectives were to: estimate the level of economic efficiency attained by rice farmers in the area; ascertain the determinants of level of economic efficiency attained by the farmers and assess the nature of returns to scale of rice production in the study area. Two hypotheses tested were: there is no significant difference between the levels of economic efficiency attained by farmers in the selected agricultural zones and socio-economic characteristics of the rice farmers do not significantly influence their economic efficiency level. Primary data were used for the study and Multistage, purposive and random sampling methods were used select 378 respondents. The collated data were analyzed by means of descriptive and inferential statistical tools such as Ordinary Least Squares (OLS) regression, Cobb Douglas Stochastic Frontier Production function and Scheffe's Multiple Comparison test. Findings indicated a minimum economic efficiency score of 0.86, maximum of 0.99 and mean of 0.95 for rice farmers in the study area. Scheffe's Multiple Comparison test indicated significant difference between means of economic efficiency scores and per hectare profits of farmers from paired agricultural zones. Maximun Likelihood Estimation of the Cobb Douglas stochastic frontier production regression showed that the production factors of land, labour and other inputs significantly and positively influenced economic efficiency level of the farmers.

Yusuf, Kang & Rabiul (2020) Studies on the efficiency of rice production focused on the technical and allocative efficiency. The objective of this study is to identify the economic efficiency of fertilizer, hybrids, and farmland on rice farming. Using the multistage and purposive sampling, questionnaires distributed to a random sample of 768 rice farmers. The stochastic frontier result shows that an average rice farmer could economically save inputs worth of 29.54% to meet the most efficient counterpart in the study area. The worst rice farmer could economically save the cost of inputs by 86.18% to meet the best counterpart.

Hussaini, Oladimeji, and Sanni (2019) presented the determinants and profitability of rice farmers investment in value addition activities in Kebbi State and found that the net return of farmers in stage one value addition (parboiling, winnowing and drying) indicate the average rate of return on investment was #1 invested in value addition in the study, a profit of #1 and 25 kobo was made and more so it could be decided that value added to rice in the study area was though on a small scale, and economically viable. -stoning) of value addition reveals that the average rate of return on investment (return per naira invested) was #1.33 indicating that for every #1 invested in the study area; and for the category three of value addition (parboiling, winnowing, drying, de-stoning and bagging) activities a profit of #1 and 35 kobo was made. Thus, it could be concluded that the value addition in the study area is profitable.

Akerele, Onasanya, Dada, and Odio (2018) analysis the technical tfficiency of Ofada Rice Producers in Ogun State, Nigeria using stochastic frontier approach. The result of technical efficiency revealed that rice producing farms are not fully efficient in the study area. The mean efficiency of farms in the study area is 75.6%. The implication of this is that there is still a need to increase the scope of rice production in the area by 24.4%. This study however failed to look at institutional or socio-economic factors that could be influencing the profit efficiency levels of the farmers.

Mundia (2018) examines technical efficiency of smallholder rice farming in Lukulu district of Zambia. The result of A Cobb-Douglas functional form of the stochastic frontier model was used and the results

indicated that, estimates for rice farm size, fertilizer and Agrochemical have significant positive effect on rice production, meanwhile, seed quantity and, labor have positive sign but insignificant. The average technical efficiency of rice in smallholder farming is at 76.9% implying that, there is scope to further increase the output by 23.1% without increasing the levels of input usage. The inefficiency effect model revealed that planting method, extension services, access to credit, and number of cattle owned by the farmer have positive effects on technical efficiency. While age, education, gender, household size, marital status and seed type, are insignificant. However, varieties, marketing information access, and group membership were not included in the study as part of factors contributing to inefficiency.

Linh, Lee, Peng and Chung (2017) analysed the technical efficiency of rice farmers in Dong Thap province using two-stage DEA approach. Estimated results in the first stage of DEA showed that the farmers achieved relatively high overall technical efficiency and scale efficiency score 0.801 and 0.966, respectively and most of the rice producers operated their farms at decreasing returns to scale. The study also indicated positive impacts of education on technical efficiency while other factors including credit access, training and rice cultivated area showed negative influences on the rice farm efficiency. The approach does not take into account measurement errors and other noise in the data.

Sania, Hina, Muhammad and Khan (2017) estimated technical efficiency analysis of rice production in Pakistan and puddle conditions: a case study of selected Districts of Punjab Province, Pakistan using SFA. The result of the Stochastic frontier analysis On average technical efficiency of sample rice farmers is 86 percent, which indicates that rice farmers in selected areas can increase the production of rice 14 percent only by managing efficiency level, without increasing input quantities. This study however failed to look at institutional aspects such as access to credit, varieties, membership of corporative society etc as factors affecting the technical efficiency of rice farmers in the study area.

Ajoma, Ezihe and Odoemenem (2016) undertake a research on allocative efficiency of rice production in Cross River state, Nigeria using SFA. The result revealed that farm size, labour, quantity of seed and quantity of fertilizer had positive and significant influence on rice production in a production pattern that exhibit decreasing return to scale (0.70). Also the results indicated that there was gross inefficiency in the allocation of productive resources among rice farmers in the study area. Apart from fertilizer which had allocative efficiency index of 0.50, inputs such as farm size, labour, seed, pesticide and herbicide were under- utilized implying sub-optimal resource allocation in rice farming in Cross River state, Nigeria. This study however failed to look at institutional or socio-economic factors that could be influencing the efficiency levels of the farmers.

Abiola, Mad, Nasir, Alias and Ismail (2016) investigated factors that influence technical and allocative of paddy rice production in Mada, Malaysia. A Cobb-Douglas stochastic frontier production function, which incorporates technical inefficiency model, was estimated using the SF technique. The result revealed that farmers were under-utilized in the use of pesticide and herbicide and were over- utilized in the use of seed, fertilizer and labour respectively.

3. METHODOLOGY

The study will be conducted in three selected States (Borno, Yobe and Adamawa state) in the North East region of Nigeria. Geographically, the North East is the largest geopolitical zone in the nation, covering nearly one-third of Nigeria's total area. In terms of the environment, the zone is primarily divided between the semi-desert Sahelian savannah and tropical west Sudanian savannah ecoregions. The region has a population of about 26 million people, around 12% of the total population of the country. It is known for liverstock and growth of crops which contribute greatly to the economy of the country. The Map of North-East Nigeria showing the study areas is shown in fig. 1. The population for the study will be made up of the entire rice farmer in the selected states. One hundred (100) Rice farmers will be purposively sampled from each of the three selected states. The study adopts a cross sectional sample survey. Primary data was used for data collection in this study. These data was obtained through the use of structured questionnaire and oral interview. Inputs and output prices were taken based on the prevailing market prices in the study area during the 2025 production period. This was drawn from the market record (secondary data). The DEA efficiency Analysis under constant return to scale, variable return to scale,

cost efficiency analysis and allocative efficiency scores were used to test hypothesis (H_{O1}) in the study area, the stochastic production function was used to test hypotheses (H_{O2})) to achieved objective ii and statistical gross margin to test (H_{O3}) achieve objective iii.

Fig. 1: Map of North East showing the study areas.

Empirical Model Specification

The model specifications were organized in blocks representing each of the selected approaches of estimation.

Data Envelopment Analysis (DEA) Models

Following Taraka, Latif and Shamsudin (2010) and Ceyhan and Hazneci (2010), the input-orientation for the Data Evolvement Analysis (DEA)-Charnes, Cooper & Rhodes (CCR); and Data Envelopment Analysis –Banker Charnes & Cooper (BCC) models were employed to estimate the technical efficiency (TE_n) of the rice farmers in the samples. The DEA-BCC models associated with Banker, Charnes, & Cooper (1984) allowed for Variable-Return-to-Scale assumption for the producers references technology

The DEA_CCR models introduced by Charnes, Cooper & Rhodes (1978) assumed constant return-to-scale for the reference technology. In this study, the DEA models employed were: DEA-CCR and DEA-BCC.

Therefore, linear programming was formulated by assuming that farmers' produces single rice output as Y_i and using input vectors denoted as X_i to X_n to measure the technical, allocative and economic efficiency of the rice farming in the three selected local government areas.

The input-oriented constant returns to scale DEA frontier is defined by the solution to N linear programs of the form:

Min θ,

θλ

subject to $-y_i + Y\lambda_i \geq 0$,

$\Theta x_i - \lambda X \geq 0$, ----------(1)

$\lambda \geq 0$

Where;

Y represents output, X_i represent inputs vector, Θ a scalar and λ̂ is an n X_i vector of constant. That is, each farmer produces a quantity of rice output represented by Y with multiple inputs given by X_i for (X_1…, X_9). The Θ value varies from 0 to 1. A farm is full efficient when reaching technical efficiency score one while inefficient farm has efficiency score lower than one while inefficient farm has efficiency score lower than one where θ is a scalar and λ is an Nx_i vector of constants. The value of θ is an index of technical efficiency for the ith firm and will satisfy $0 \leq \theta \leq 1$ with value of 1- θ indicating a point on the frontier and hence a technically efficient firm, according to Farrell (1957) definition. Thus, 1 -θ measures how much a firm's inputs can be proportionally reduced without any loss in output.

Economic Efficiency

Economic efficiency was used to achieve objective i. The product of technical and allocative efficiency provides an overall economic efficiency measures and was used to test hypothesis H_{O1}. The combination of technical and allocative provides the index of economic efficiency as given by EE = TE X AE.----------(2)

It is assumed that $0 \leq (TE \text{ X } AE) \leq 1$. Therefore (TE X AE) =1 implies that farmers are both technically and allocative efficient and the first hypothesis (H_{O1}) that farmers in the study area are not economically efficient will be rejected. Alternatively, [1-(TE X AE)] indicates that farmers are not economically efficient, [1-(TE X AE)] measures the proportional reduction that farmers can achieve by becoming technically and allocatively efficient.

Stochastic Frontier (SF) Model Estimations

The stochastic production function was used to achieve objective ii. In this study, the production and cost functions of the rice producers were specified as Cobb-Douglas production. The Cobb-Douglas Stochastic Frontier production function is express as follow in this study as:

$\mathbf{Y_i}= Y(x_{ki},\beta)e^{Ei}$ i=1 …n, k=1…k----------(3)

Where;

Y_i= is the output of the ith farm, x_{ki}, is the vector of k inputs of the ith farm, β is the vector parameter, E_i is a farm specific composed error term. The stochastic frontier is called a "composed" model because the error term consists of two independent element namely $E_i = V_i - U_i$

where is the error term, where V_i and U_i are independent of each other, V_i is an identically and independently normally distributed random error that captures the stochastic effects outside the farmers control, and U_i is a one-sided efficiency component that captures the technical inefficiency of the farmer.

The stochastic production functions for the estimation of technical efficiency of rice farmers were expressed in a log-linear form as:

$\ln Y = \beta o + \sum_{i=1}^{9} \beta j \ln X_i + \sum_{i=j}^{9} \sum_{k=1}^{9} \beta jk \ln x_{kj} + \varepsilon_I$ ----------(4)

$\varepsilon_i = g(x_i; \psi) - q(x_i; Z_i)$ ----------(5)

$\ln Y_i = \beta o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + + V_i - U_i$----(6)

Where;

ln = Natural Logarithm

Y_i = Quantity of rice output (kg)

X_1 = Farm size (ha)

X_2 = Quantity of seed used (kg)

X_3 = Quantity of fertilizer (kg)

X_4 = Labor input used (both family and hired labor) (man days)

X_5 = cost of hiring machine (#)

X_6= quantity of insecticide (liters)

X_7=quantity of herbicides (Liters)

X_8= green manure (kg)

X_9=Irrigation service (#)

β_o = Intercept

β_1-β_9 = Regression coefficient

The *a-prior* expectation for each of the production inputs were positive on output, meaning that output elasticity for each parameter was expected to be positive in is the logarithm to base.

The hypothesis (H_{O2}) that there is no significant relationship between farm inputs and rice output in North-East, Nigeria was tested for statistical significance for each of the β_i coefficients. The hypothesis (H_{02}) is tested at 5% levels of significance with (n- k) degrees of freedom, using a two tailed test. The hypothesis tested took the following form:

H_{O2}: $\beta_i=0$

H_A: $\beta_i \neq 0$

Where n = number of observations

K = number of parameters estimated

The null hypothesis was tested comparing the estimated t*statistic with the tabulated value at five percent level of significance. The null hypothesis was accepted if t* statistic is less than the tabulated value with (n-k) degree of freedom for the relevant estimates β_1 to β_9.

-t (0.025) <t*<t (0.0.025)

Where t*= estimated statistic.

On the other hand, the null hypothesis of the of the relevant estimates β_1 to β_9 is rejected if the estimated t* statistic is greater than the tabulated value at (n-k) degree of freedom and five percent level of significance.

If H_{O2} is accepted, it means that there is no significant relationship between farm inputs and rice output in selected states. Conversely, its rejection indicated that the variable influenced rice output.

Statistical Test of Gross Margin

The Statistical Test of Gross Margin was used to achieve objective (iii). The test of significance will be computed with the paired T-test to shows if there is a significant difference between cost and return. If the calculated T*value is exceeds the critical value (Tt-critical two tails), then the null hypothesis (Ho_3) will be rejected at 5% probability level.

DATA PRESENTATION AND ANALYSIs

The DEA efficiency Analysis under constant return to scale, variable return to scale, cost efficiency analysis and allocative efficiency scores were used to test hypothesis 1 (H_{O1}), which state that Rice farmers in the study area are not economically efficient in the production of rice.

The process of decomposing technical efficiency scores of rice farmers under constant returns to scale ($TE_{CRS)}$ into scale efficiency (SE) and pure technical efficiency under variable returns to scale (TE_{VRS}) provides useful information on the direction of what to be done at farms' level and policy environment in order for the rice production to operate at the efficient frontier level in the short and long term.

Table 1: ***Average Economic Efficiency Scores***

Frontier	TE	AE	EE(TE X AE)
DEA-TE_{CRS}	0.592	0.295	0.175
DEA-TE_{VRS}	0.721	0.295	0.213

Source: Calculated From DEA-TE_{CRS}, DEA-TE_{VRS} and AE

The result of hypothesis that rice farmers in the study area are not economically efficient in the production of rice is presented in Table 1. The mean economic efficiency among the rice farmers under DEA-TE_{CRS} and DEA-TE_{VRS} are 0.175 and 0.213 respectively. They are all below unity indicating that the rice farmers are economically inefficient. Thus, the null hypothesis ($H_{O1)}$ which stated that rice farmers are not economically efficient in the production of rice is accepted while the null hypothesis is rejected.

Table 2: ***Maximum likelihood Estimate of the Translog Stochastic Production Frontiers***

Variable	**coefficient**	**standard error**	**t-ratio**
Constant	5.906	0.222	26.667*****
Ln farm size	0.274	0.052	5.325*****
Ln seed	0.326	0.051	6.352*****
Ln fertilizer	0.014	0.008	1.773*****
Ln labour	-0.02	0.013	-0.161*****
Ln machine	-1.216	0.296	-1.786*****
Ln insecticides	0.384	0.294	1.304*****
Ln herbicides	0.530	0.383	1.345
Ln green manure	0.002	0.010	1.211
Ln irrigation	0.210	0.310	1.341*****
Sigma square $\sigma 2$	1.324	0.332	4.597
Gamma	0.57	0.129	4.171*****
Likelihood function	-463.4		
Chi square	103		

Prob.> Chi-square	0.0
Min-efficiency	5
Max efficiency	88
Mean efficiency	63
F-statistics	(F=15.534; P= 2.35*)

*** Estimate is significant at 5% level**

Source: STATA Version 14.1 Computer software

The F- value in Table 2 is 15.534 and is statistically significant at 5 percent which implied that there is a significant relationship between farm inputs and rice output in the study area. Therefore, the null hypothesis (H_{O2}), which states that there is no significant relationship between farm inputs and rice output, is rejected while the alternative hypothesis that there is a significant relationship between farm inputs and rice output is accepted.

The results in Table 2 also revealed that there is a positive and significant relationship between rice output and farm size, quantity of seed planted, fertilizer applied, irrigation service and insecticides applied at 5% level of probability. This indicated that efficient use of these variables will increase significantly the rice output in the study area.

Table 3: ***Statistical Test of Gross Margin***

Items	**Value**	**T-value**	**level of significance**
Mean of returns (#)	512,000	T*=17.05	0.05
Mean of cost (#)	419,788	Tt= 2.326	
Variance of return (#)	388,608,000		
Variance of cost (#)	318,619,092		
R_1 sample of return	300		
R_1 sample of cost	300		

Source: Author's Survey, 2026

The test of significance is computed and it shows a significant difference between cost and return. The null hypothesis (H_{O3}) which states that rice production is not profitable in the three states was tested using the result of the paired T-test presented in Table 3. It reveals that calculated T*value is 17.05 and exceeds the critical value (Tt-critical two tails) of 2.33. Therefore the null hypothesis (Ho_3) is rejected at 5% probability level. The result of the analysis indicates that rice production is profitable in the study area.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Based on the findings of this study, the mean economic efficiency among the rice farmers under DEA-TE_{CRS} and DEA-TE_{VRS} are 0.175 and 0.213 respectively which were all below unity indicating that the rice farmers are economically inefficient in North East Nigeria. The results of S.F revealed that there is a positive and significant relationship farm inputs and rice output in the study area. This indicated that efficient use of the farm inputs will increase significantly the rice output in the study areas. Finally, the production of rice in the study area was found to be profitable and this has the potential of contributing to improved livelihoods of the rice farmers in North-East Nigeria

Recommendations

1. The study recommends that research institutes should undertake a thorough extension exercise to advise the rice farmers in the study area on the recommended input usage and application rates.
2. The study recommends that rice farmers in the study area should increase the use of inputs such as seed, fertilizer, other cost and mechanization cost since increasing these inputs has the potential to increase rice output

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