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Determinants of technical efficiency of small-scale rice farmers in Edo North Ecological Zone, Edo State, Nigeria

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ABSTRACT

The study estimated technical efficiency of farmers with a view to isolate significant factors that affect farmer's efficiency in the study area. A two-stage sampling procedure involving purposive and simple random sampling was used to select 250 rice farmers for the study. Data were obtained using a structured questionnaire which was administered to the farmers. The data obtained were analyzed with the use of descriptive statistics and stochastic production function through Maximum Likelihood Estimation (MLE) method using the computer program for frontier version 4.1. Results show that most (68.4%) of the small-scale rice farmers were male and 78.4% were married with mean age of 43 years, as well household size of 7 persons respectively in the study area. About 86% of the farmers had formal education, with about 13 years-experience in rice farming and an average farm size of 2.9 hectares. Most (51.6%) of the farmers had contact with Extension Agent and use hired labour (54.8%). Average farm net income for the rice farmers was ₦599,681.28 per hectare. The MLE for technical efficiency shows that farm size, seeds herbicides and pesticides use influenced output of rice production in the study area while farming experience (-2.4260), literacy level (-02.6402, age of farmers (-2.6402) and source of capital (-1.3329) respectively jointly contributed to increase farmers efficiency in the study area. The study concluded that rice farming is profitable in the study area and recommends implementation of an integrated rice farming development program combining education, mentorship, financial support, and enhanced extension services. Focus on optimizing farm management, increasing technical efficiency, and boosting profitability across diverse farmer demographics.

Keywords: Maximum likelihood; RIFAN; stochastic frontier model

INTRODUCTION

Nigeria is an agrarian country, and agriculture remains a major source of livelihood for majority of the country's population. Rice production is paramount for the attainment of sustainable food security and agricultural development, and its consumption has continued to increase without a commensurate increased output in recent times. Rice has become a crucial staple in Nigeria, with consumption steadily outpacing domestic production. Recent data indicate an annual production of around 5.0-5.4 million metric tons (MMT), while

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consumption has reached 6.8-7.2 MMT, resulting in a deficit of approximately 1.8 MMT per year (USDA, 2021). This growing gap underscores the urgent need for Nigeria to boost its rice production to meet increasing demand and achieve food security goals

Rice is a monocot that is typically cultivated as an annual plant. According to Smith (2018), rice can be produced almost everywhere in the world which come in various form, colour and dimension. There are about 100,000 species of rice today, *Oryza sativa* (Asian rice) and *Oryza glaberrima* are regarded as staple food across Asian-pacific and it has become very important food in several continents including Africa, Latin America (United Nation Food and Agriculture Organization (FAO) 2019). Rice can grow on Mangrove Swamp, rainfed upland, irrigated lowland, rain fed lowlands ecosystems. In Nigeria we have Fadama rice, Ofada rice, Foro rice, upland rice, Low land rice, Ekpoma rice, Abakaliki rice, Benue rice, Kano rice, Nasarawa rice, Sokoto rice and other varieties grown in different parts of the country (Yurkushi, 2018).

Small scale Rice production (SSRP) is basically an enterprise with limited manpower and financial turnover. Small scale enterprise is the enterprise whose personel fall below 51 and 100 persons (Usman, 2014). Every country has different definition of small-scale enterprise, some define it in terms of employees, while others define it in terms of investment in plants and equipment (Akinwumi and Dato, 2016).

In Nigeria, we have three major categories of business: large/giant, medium and small enterprise. Small scale farmers play a significant role in Nigeria's social and economic growth. The ban by the Nigerian Federal Government on importation of rice in 2018 boasted the quantity and quality on rice output in Nigeria with domestic production estimated at (₦685 billion) ($1.9 billion) making the country now second largest producer of rice in Africa (Oladiebo & Fajuyigbe, 2019) this has also offered Nigeria the opportunity to export rice to earn sufficient revenue. Nigeria possesses diverse ecological zones with significant potential for paddy rice cultivation. According to (Familusi & Oranu, 2020). The country has between 4.6 million and 4.9 million hectares of land suitable for rice production, theoretically capable of meeting the domestic demand. This vast agricultural resource underscores Nigeria's capacity to achieve self-sufficiency in rice production, given appropriate cultivation practices and supportive policies. Federal Ministry of Agriculture and Rural Development (FMARD), 2012). Small-scale rice farmers in the region struggle to achieve optimal production despite favorable ecological conditions. This underperformance can be attributed to a combination of factors including limited access to modern inputs, inadequate infrastructure, and knowledge gaps.

The primary objective of this study was to estimate the technical efficiency of small-scale rice farmers in Edo North Ecological Zone of Nigeria. It specifically determines the costs and returns of small-scale rice enterprises and evaluate the farmer's technical efficiency in the study area.

METHODOLOGY

The Study Area

Edo state has three ecological zones Edo South comprising of rainforest and some mangrove swamp, Edo central comprising of little rain forest and savanna, Edo North which is made up of more savanna and a little rainforest. The state is situated in the south-south geopolitical region of Nigeria. It covers an estimated land area of 19,714 km^2 with HDI of

0.530 and a population of 44,461137 people (NPC,2024); located between latitudes $06^{0}30^{l}$ and $07^{0}0^{l}$ North and between longitudes $05^{0}45^{l}$ and $06^{0}0^{l}$ East at an average elevation of about 88 m (Ogbeitun, 2018).

The state produces crude oil; also note for the following agricultural produces: rubber, cocoa, cashew nuts, yam, rice, amongst others, and blessed with precious stones like Quartz, Amethyst, Mica, Dolomite, Granite stone, limestone (EDSMA, 2018).

The study was conducted in Edo North Ecological Zone which consist of six (06) LGAs (Akoko Edo, Estako East, Estako West, Estako Central, Owan West and Owan East) of the state. Edo North Ecological Zone has an estimated population of 1,973,000people with an estimated area of 4,711km^2 with a growth rate of 35.7% (National Population Commission (NPC, 2024 with climatic condition suitable for growing crops like cocoa, palm produce, rice, cassava, plantain, guinea corn, fruits and vegetables. Farmers here practice rainfed and irrigated farming. It is bounded in the North by Kogi State, in the East by River Niger Beach, in the west by Ondo State and in the south by Esan North East and Ovia North East Local Government areas (EDSMA, 2013).

Sample Size and Sampling Procedure

The study sample frame was made up of 7,066 registered rice farmers under Rice farmers Association of Nigeria (RIFAN) which comprise four (4) Local Government Areas, having the highest number of registered farmers in the study area. Yamane's formula was used to determine the sample size, as presented below:

$$n = \frac{N}{1+N(P^2)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where n= required sample size
N= number of registered rice farmers and
E= level of precision or margin of error 0.06

A two-stage sampling procedure involving purposive sampling of four (4) LGAs out of the six LGAs where the highest number of active registered farmers are located (Estako West, Estako Central, Owan West and Owan East) and the second stage involves proportionate sampling of 267 farmers. However, only two hundred and fifty (250) questionnaires were found and used for data analysis.

Data Collection

The study employed both primary and secondary data. The primary data was obtained through a cross-sectional survey conducted in four (4) LGAs out of the six LGAs where the highest number of active registered farmers are located (Estako West, Estako Central, Owan West and Owan East. The instrument used for the survey was a semi-structured questionnaire which was made up of both close ended and open – ended questions. Secondary data were obtained from the internet source, libraries, and offices of EDADP and RIFAN in Edo North.

Data Analysis

The socioeconomic characteristics of the farmers were analysed with the use of descriptive statistics such as mean ($\bar{x}$), percentage (%) and frequency count while costs and returns on the investments of rice production was determined by Gross margin (GR) analysis

and also the stochastic frontier model (SFM) was used to estimate farmers efficiencies as adopted from Egboidion and Ada-Okungbowa (2012; Ahmed & Melesse (2018); Abate (2019). The empirical model of the function is specified explicitly as follows:

$InY = bo + b11nX1i + b21nX2i + b31nX3i + b41nX4i + b51nX5i + b61nX6i + (Vi – Ui)..$ (2)

Where ij are the j^{th} observation of the i^{th} farmers

í Stands for the ith farmerY= out of rice produced in kg per ha

X_1 = farm size (hectares)

X_2 = quantity of seeds planted (Kg/ha)

X_3 = Labour used in (man/day)/ha

X_4 = Quantities of herbicides used in (litres)/ha

X_5 = Quantity of pesticides used in (litre/ha)

X_6 = Quantity of fertilizers used in (kg/ha)

$B_0 – B_6$ = were parameters estimated

The individual farmer's TE was defined in terms of observed output (Y) to the corresponding frontier output (Y^{th}) giving the technology available expressed as follows:

$TE = \frac{Y_i}{Y_i} = \frac{E(Y_i/U_iX_i}{E(Y_i/U_i=0,X_i} = E\ (\exp\ (-U_i / \Sigma)$ ……. (3)

Therefore, $TE = \exp\ (-U_c)$

TE has values between zero (0) and one (1) were 1 denote complete efficient farmer, 0 denote inefficient farmer.

Technical inefficiency is assumed to come from farmer's personal characteristics and model is defined as follows:

$U_{ij} = b_o + \delta_1 Z_{1ij} + \delta_2 Z_{2ij} + - - - - \delta_7 Z_7ij$ ……. (4)

Where:

U_{ij} = inefficiency of the i^{th} farmer

Z_1 = farming experience in (years)

Z_2 = sex of respondents (1male 0 female)

Z_3 = household size of respondents (no of persons in a household)

Z_4 = extension contact (no of meetings with farmers)

Z_5 = Year of formal schooling (years)

Z_6 = age of farmers in (years)

Z_7 = source of capital (1= personal savings, 0= otherwise)

$B_1 - \delta_7$ = parameters estimated.

Equation 2 and 3 were estimated using maximum likelihood estimation at same time using the computer program frontier 4.1, Coelli, 2005).

RESULTS AND DISCUSSION

Socioeconomic characteristics of Rice farmers in the Study Area

The socioeconomic characteristics of farmers result presented were for sex, marital status, age, household size, educational level, farming experience, contact with extension agent and labour.

Result shows that majority (68.4%) of the farmers were male which implies that rice production was dominated by male rice farmers in the study are. The result is in line with the findings of Egbodion and Ahmadu (2015) who reported in the study of Abakalaki rice that male dominated the enterprise.

Table 1: Socio-economic characteristic of small-scale rice farmers in the study area (n =250)

Variables	Frequency (f)	Percentage	Mean (x)
Sex			
Female	79	31.6	
Male	171	68.4	
Age of farmers (years)			
< 30	46	18.4	
31-40	74	29.6	
41-50	69	27.6	42.7
51-60	41	16.4	
61-70	19	7.6	
71 and above	1	0.4	
Marital status			
Married	196	78.4	
Single	21	8.4	
Widow	13	5.2	
Widower	20	8	
Household size (Individuals)			
1-5	86	34.4	
6-10	121	48.4	
11-15	34	13.6	7
16-20	8	3.2	
>20	1	0.4	
Educational Level			
No formal Educational	36	14.4	
Primary Education	59	23.6	
Junior Secondary Education	10	4	
Senior Secondary Education	98	39.2	
Adult Education	13	5.2	
Tertiary Education	34	13.6	
Farming experience			
1-10	152	60.8	
11-20	60	24	
21-30	25	10	12.5
31-40	9	3.6	
41-51	4	1.6	
Primary Occupation			
Civil	2	0.8	
General Trading	2	0.8	
Rice farming	137	54.8	
Artisans	2	0.8	
Agro-processing	1	0.4	
General Crop Farming	106	42.4	
Source of capital			
Bank loan	2	0.8	
Loan from Family members	40	15.1	
Loan from Cooperative	17	6.4	

Government Loan	11	4.2	
Personal savings	167	63	
Loan from Friends	13	4.9	
Esusu (Thrift)	15	5.6	
Farm size (hectares, ha)			
<1.00	45	18	
1.01-2.00	64	25.6	
2.01-2.00	51	20.4	2.9
3.01-4.00	31	12.4	
4.01-4.00	59	23.6	
Model of land Acquisition			
Family Land	38	15.2	
Rented/ Hired	141	56.4	
Inherited	26	10.4	
Village lot	43	17.2	
Cooperative	2	0.8	
Contact with Extension Workers			
Yes	129	51.6	
No	121	48.4	
Type of Labour			
Family labour	5	2	
Hired labour	137	54.8	

Source: Field Survey, 2023.

The result also shows that most (78.4%) of the rice farmers were married with mean age of 43 years. A probable reason for this could be that most of the youth in the study area in the study area could have migrated to urban centers in search for white collar jobs or other business, thereby neglecting rice farming. Result further revealed that the average household size of the farmers was 7 persons, education level was 85.6% and that had formal education from the totality of primary (23.6%), junior secondary (4.0%), senior secondary (39.2%), tertiary (13.6%) and adult education (5.2%). This finding support Ada-Okungbowa and Egbodion (2017) who had posited that literacy level of farmers had a positive and significance influence on farmer's efficiency in production decision and adoption of innovation. Result also shown that the rice farmers had an average farming experience of 13 years in the study area which indicates the period an individual farmer was involved in rice production, knowledge and skill gain in the process overtime. This experience has a lot of positive effects on farmer's farm outputs. Most (51.6%) of the farmers had contact with extension agents with farm size of 3.0 hectares and got their labour from hire labour (54.8%) for their farming activities, this finding collaborates Oladiebo and Fajuyigbe (2017). who asserted that there is a positive correlation between household size and labour availability for agricultural production, the absence of this will mean that the farmer will go for hire labour.

Elasticity of Production and Returns to Scale

Technical efficiency estimates result (Table 2) shows that the level of the TE of farmers in the study area ranged between 0.358 and 0.981 with an average value of 0.888, indicating that an average rice farmer was operating about 11.2% below the frontier which is

an efficiency gap. However, these farmers with a return to scale of 0.873 were operating on the economic region of production. Hence, the efficiency associated with rice production in the study area can be traced to farmer's personal characteristics.

Table 2: Elasticity of production and returns to scale

Inputs	Elasticity of Production
Farm size (X_1)	0.113
Seed (X_2)	0.687
Labour (X_3)	0.135
Herbicide (X_4)	-0.126
Pesticide (X_5)	0.054
Fertilizers (X_6)	0.010
Returns to scale (RTS)	0.873

Source: Computation from field survey, 2023

Determinant of Technical Efficiency among Small Scale Rice Farmers in the Study Area

The determinants of technical inefficiency among the small-scale rice farmers are presented in Table 3 the variables described the factors that affect the famer's production efficiency in the study area. The sign presented and magnitude of the independence variables coefficients in the inefficiency model is crucial for obtaining the observed level of farmers' efficiency. While a positive coefficient has the effect of increasing efficiency of farmers, a negative sign indicated that the coefficient has the effect of decreasing technical inefficiency and increasing efficiency of farmers.

It is observed from the results presented in table III that farming experience (-0.0274), Extension contact with farmers (-0.0299) and source of capital (-0.0031) respectively jointly contributed to increase the TE of rice farmers in the study area. However, only farming experience, contact with extension agent, literacy level and age of farmers were significant at 1%. This finding is in consonance with apriori expectation that education, farming experience and contact with extension agent can improve farmers ability to adopt innovation and practice new ways of farming. Education: The positive impact of education on technical efficiency supports the findings of Ada-Okungbowa and Egbodion (2017), who posited that literacy level of farmers had a positive and significant influence on farmer's efficiency in production decision and adoption of innovation. These findings partially contrast with some previous research:

It was further observed that the coefficients of sex (0.0078) and household size (0.0013) were positive implying that these variables reduced farmers efficiency in rice production in the study area. However, the effects of these variables were not significant

While our study found a non-significant positive effect (reducing efficiency), studies like (Alabi *et al.,* 2024) in Nigeria found that female farmers were more efficient in rice production, highlighting the need for further investigation into gender dynamics in rice farming efficiency. While Household size Our finding of a non-significant positive effect (reducing efficiency) contrasts with Kazeem (2020), who asserted a positive correlation between household size and labour availability for agricultural production. This discrepancy might be due to differences in regional contexts or the specific nature of rice farming in our study area. The values of coefficient obtained for variance ($\boldsymbol{\sigma 2}$) (0.165) , gamma (γ) (0.960) were significant at 1 % level of significance respectively and positive indicating a goodness

of fit of the model and that about 96.0% of the total variation in rice output of farmers is due to technical inefficiency .The result also indicated a likelihood value of 146.82 which implied that the data provided a more accurate representation of the relationship between the input and output . The coefficients of the input were positive except Herbcides (-0.126) and significant at 1 %.

Table 3: Determinant of technical efficiency among small-scale rice farmers in the study area

Variables	Coefficients	Standard error	t-ratio
Constant	5.362	0.124	43.208***
Farming experience	-0.0274	0.0113	-2.4260***
Sex	0.0078	0.0729	0.1072
Household size	0.0013	0.0106	0.1236
Extension service contact	0.6645	0.2794	-2.4171***
Literacy level	0.1291	0.0489	-2.6402***
Age	-0.0299	0.0123	-2.4279***
Source of capital	-0.0031	0.0236	-1.3329
Farm size	0.113	0.039	2.888***
Seeds	0.687	0.085	8.098***
Labour	0.135	0.085	1.642
Herbicides	-0.126	0.083	-3.815***
Pesticides	0.054	0.033	1.938*
Fertilizer	0.010	0.028	1.353
Sigma squared ($\sigma 2$)	0.165	0.007	3.199***
Gamma (γ)	0.960	0.052	70.855***
Log Likelihood	146.818		
R^2	0.25		
F-statistic	13.71		
N= sample Size	250		

*** Significance at 1%Source: Field survey, 2023

CONCLUSION

The study indicates that rice farming in the study area is profitable, but output remains low due to several factors affecting farmers' efficiency. The average technical efficiency of rice farmers was 0.888, suggesting an efficiency gap of 11.2%. While most farmers operate in the economic region of production, there is still room for improvement. Factors such as farming experience, extension contact, and source of capital positively influenced technical efficiency, while variables like sex and household size appeared to reduce efficiency, though not significant. To boost rice sector productivity and sustainability, there is a need to implement a comprehensive program integrating farmer education, technological innovation, financial support, gender-inclusive policies, targeted research, and rural infrastructure development.

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