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COMPARATIVE PROFITABILITY AND TECHNICAL EFFICIENCY OF SMALL-SCALE RICE FARMERS WITH AND WITHOUT ACCESS TO IMPROVED PRODUCTION TECHNOLOGY IN NORTH CENTRAL NIGERIA

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Abstract

This study evaluated comparative profitability and technical efficiency of small-scale rice farmers with and without access to improved production technology in North Central Nigeria. A multistage sampling technique was adopted for this study. The data were collected through a well-structured questionnaire of 1500 small-scale rice farmers with access to technology and 1500 small-scale rice farmers without access to technology making a total of 3000 rice farmers in the study area. The results showed that the average age of the sampled rice farmers with access to technology was 36 years, while those without - 46 years. The results showed that the rice production was profitable for both farmers with and without access to technology. The statistically significant factors influencing the rice production for small-scale farmers with access to technology were the land size ($p<0.01$), labour ($p<0.01$), fertilizer ($p<0.01$) and agrochemical ($p<0.01$), while the statistically significant factors influencing the rice production for small-scale farmers without access to technology were land size ($p<0.01$), labour ($p<0.01$) and agrochemical ($p<0.10$). The major challenges faced by the small-scale rice farmers with access to technology were the poor credit facilities, shortage of farm input, inadequate rainfall season, high cost of labour and instability in the planting calendar. The F-Chow test showed that there was significant impact on the technical efficiency, productivity and profitability of rice farmers with access to improved technology. Therefore, the study recommends that inputs such as improved seed varieties, fertilizers and chemical inputs should be provided to farmers.

Keywords: profitability, technical efficiency, rice farmers, small-scale, with and without access to technology

INTRODUCTION

Rice (*Oryza sativa)* is an important food crop in Nigeria; it is one of the major staples and a strategic commodity to Nigeria's economy. Nigeria's demand for rice is about 7.9 million metric tonnes per year of which about 2 million, an average, metric tonnes are imported. The country spends between $500 million and $1 billion on rice importation per annum since 2002 (RMM, 2017). Furthermore, the yield per hectare of locally produced rice stands at about 2 metric tonnes compared to the global average of 6.0 metric tonnes due to poor seed quality, low soil fertility, low use of fertilizer, iron toxicity, poor adoption of improved technology, in addition to problems of pests and diseases (Adesina, 2012). The rice consumers in Nigeria generally perceive the local rice as poor in quality. Therefore, achieving the rice self-sufficiency goal of the government requires changes in the level of production, processing and marketing of rice that meets the quality demand of local consumers. The rice production is a vital component of Nigeria's agricultural sector, particularly in the North Central region, where the small-scale farmers constitute a significant portion of the farming population (FAO, 2020). However, the small-scale rice farming in the region faces challenges, including low productivity, resource constraints, and limited access to modern agricultural technologies (Adeyemo & Arokoyo, 2018). To address these challenges, the adoption of technology has been identified as a potential solution to improve the profitability and efficiency of small-scale rice farming. This study aims to investigate the comparative profitability and technical efficiency of small-scale rice farmers in North Central Nigeria, focusing specifically on the utilization of technology. By comparing farmers who have adopted improved production technology with those who have not, this research seeks to provide insights into the potential benefits and challenges associated with technological interventions in the rice farming sector. The use of technology in agriculture has the potential to enhance productivity by improving resource allocation, reducing production costs, and increasing yield levels. Agricultural development is undermined by poor access to modern technologies and low investment or finance. In other words, the agricultural growth and development is not possible without yield-enhancing technological options because merely expanding the area under cultivation to meet the increasing food demand of the growing populations is no longer sufficient (Obisesan et al., 2016). To increase agricultural productivity using improved agricultural technologies that enhance sustainable food and fibre production is critical for sustainable food security and economic development (Obayelu & Ajayi, 2018). The introduction, access and use of improved agricultural technologies and management practices are tools needed to improve agricultural productivity, which serves as the key to global food security and fight against poverty. It is a challenge for agricultural researchers to understand how these technologies are used and with what impact (Obisesan et al., 2016). Technological interventions, such as improved seed varieties, use of agrochemicals mechanization, and precision farming techniques, can contribute to the higher yields and improved farm profitability. Additionally, a technology adoption may lead to increased technical efficiency by enabling farmers to optimize the use of inputs and to achieve higher output levels per unit of resources employed. However, the adoption of technology by the small-scale rice farmers may face several barriers, including limited access to capital, lack of awareness and knowledge about available technologies, and inadequate infrastructure. These challenges can hinder the adoption process and limit the potential benefits that technology can offer to the small-scale rice farmers.

Efficiency can be defined as the possibility of firms producing a certain optimal level of product from a given bundle of inputs or a certain level of output at minimum cost (Adeyemi et al., 2017). The efficiency forms an important factor in productivity growth especially in an economy in which resources are scarce and opportunity for new technologies are deficient. A technically efficient firm is one that produces the maximum output for a given amount of inputs, conditional on the production technology available to it. The profitability and technical efficiency of small-scale rice farmers in North Central Nigeria can vary significantly depending on their adoption or non-adoption of technology. However, there is a gap in empirical research examining the comparative performance of these two groups. This study seeks to address this gap by exploring the following research questions:

(i) What are the socio-economic characteristics of the small-scale farmers with and without access to improved production technology?

(ii) What are the comparative costs, returns and profitability of small-scale rice farmers with and without access to improved production technology?

(iii) What is the comparative technical efficiency of small-scale rice farmers who have adopted technology versus those who have not?

(iv) What are the factors influencing technical efficiency of small-scale farmers with and without access to improved production technology?

(v) What are the challenges faced by small-scale rice farmers with and without utilizing technology effectively in the study area?

MATERIALS AND METHODS

Area of Study

The study was conducted in North Central Nigeria which is comprised of six states namely Kwara, Kogi, Niger, Nasarawa, Plateau and Benue states. Niger State, and Nasarawa State were selected for the study. Niger State lies between Latitudes 3^0 20’ and $7^0$40' North of the equator and Longitudes 8^0 11′ and $11^0$2′ East of the Greenwich Meridian (Niger State Ministry of Information and communication, 2008). The State shares boundaries in the North with Zamfara, Kebbi States and Federal Capital Territory, Abuja. It also shares common boundary with Republic of Benin at Babana in Borgu Local Government Area in Niger state. It is located in the Guinea Savannah agro-ecological zone in Nigeria, with annual rainfall of 1100 mm in the north and 1600 mm in the south (Niger State Ministry of information and communication, 2008). Nasarawa State is bounded in the North by Kaduna State, in the West by the Abuja Federal Capital Territory, in the South by Kogi and Benue States and in the East by Taraba and Plateau States. The State lies between Latitudes7° 45’ and 9° 25’ North of the equator and between Longitudes7° and 9° 37° East of the Greenwich meridian. The average annual temperature is 28.4°C and about 839 mm of precipitation falls annually. Most of the crops produced by farmers in these states are rice, cowpea cassava, groundnut sesame seed, sorghum etc. Livestock like goats, pigs, cows and sheep are also reared.

Method of data collection

Data used for this study were obtained from primary sources. The relevant primary data was obtained from rice farmers in two selected states in the study area. The main instrument for data collection was a pre-tested structured interview which was scheduled and administered on the respondents by trained enumerators under the supervision of the researchers.

Sampling technique and sample size

The target populations for this study were rice farmers in North Central Nigeria. A multistage random simple sampling technique was used for the study. The two States randomly selected were Niger and Nasarawa State. A cross sectional data was used for the study comprising of 1500 rice farmers that were exposed to improved rice production. Furthermore, another set of 1500 that were not exposed to the technologies were selected as well. Therefore, a total of 3000 rice farmer were used for the study. The following formula was used to calculate the sample size (Yamane, 1967):

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

Where,

n = Desired sample size

N = Finite size of the population

e =Maximum acceptable margin of error as determined by the researcher

Method for data analysis

Descriptive statistics

Descriptive statistics such as frequency distribution, mean, and standard variation were used to capture the socio-economics characteristics of the respondents.

Budgetary technique

Farm Budgetary Analysis were used to capture costs, returns and profitability ratios of rice farmers. The Budgetary Analysis involved the estimation of net farm income and return on Naira invested (ROI) which was used to determine the profitability of rice production of respondents with and without access to improved production. Following Olukosi & Erhabor (1988), the net farm income was estimated on per hectare basis as follows:

$$GM = TR - TVC \quad (2)$$

$$GM = \sum_{i=1}^{n} P_i Q_i - \sum_{i=1}^{n} P_j X_j \quad (3)$$

$$NFI = GM - TFC \quad (4)$$

Where,

NFI= Net Farm Income; GM = Gross Margin (₦/ha); TR= Total Revenue (₦); P_i = Price Rice in (₦), Q_i = Total quantity of rice (Kg/ha); P_j= Price of Input (₦/Kg); X_j = Quantity of Input Used (Kg/ha)

TFC = Total Fixed cost per hectare (₦) (Average annual depreciation cost for all input was used)

Financial analysis

According to Alabi et al. (2020), the gross margin ratio is defined as follows:

$$\text{Gross Margin Ratio} = \frac{\text{Gross Margin}}{\text{Total Revenue}} \quad (5)$$

According to Olukosi & Erhabor (1989), the operating ratio (OR) is defined as follows:

$$\text{Operating Ratio} = \frac{\text{TVC}}{\text{GI}} \quad (6)$$

Following Lawal (2008) return on Naira invested (ROI) was obtained as follows:

$$RORI = \frac{NI}{TC} \quad (7)$$

Where,

RORI = Rate of Return per Naira Invested (Units);

NI = Net income (Naira);

TC = Total Cost (Naira).

Decision rule: ROI value should be greater than one for an enterprise to be profitable.

Stochastic production frontier model

Stochastic frontier model following Alabi et al. (2022) and Obianefo et al. (2021) was used to estimate technical efficiency values and identify factors determining inefficiency. Productivity of resource use estimate would be calculated from the coefficients of the stochastic frontier model. The explicit model form is presented as:

$$Y_i = f(X_i, \beta)\epsilon, i = 1, \dots, N \quad (8)$$

$$LnY_i = \beta_0 + \sum_{i=1}^{6} \beta_i \, LnX_i + \cdots \beta_n LnX_n + V - U_i \quad (9)$$

$$LnY_i = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + V_i - U_i. \quad (10)$$

Where,

LnY_i = Rice Output (Bags)

X_1 = Land size (ha)

X_2 = Labour (Man days)

X_3 = Rice Seed (Kg)

X_4 = Quantity of Fertilizer (Kg)

X_5 = Agro Chemical Input (Litres)

β_0 = Constant Term

$\beta_1 - \beta_6$ = Parameters to be Estimated

The Technical Inefficiency Component of the Stochastic Frontier Model is stated thus:

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + \alpha_7 Z_7 \quad (11)$$

Where,

U_i = Technical Inefficiency Component

Z_1 = Education (Years Schooling)

Z_2 = Age of Farmers (Years)

Z_3 = Farm size (Hectares)

Z_4 = Farming Experience (Years)

Z_5 = Household Size (Number)

Z_6 = Extension contact (Number)

Z_7 = Sex (1, Male; 0, Otherwise)

α_0 = Constant Term

$\alpha_1 \dots \alpha_7$ = Regression Coefficients.

Table 1. Units of measurements and apriori expectations of variables included in the stochastic frontier efficiency model

Variables	Variable Code	Parameters	Units of Measurements	Apriori Expectations
Technical Efficiency Component				
Land Size	X_1	β_1	Continuous (Hectares)	$+ve$
Labour Input	X_2	β_2	Continuous (Mandays)	$+ve$
Rice Seed	X_3	β_3	Continuous (Kg)	$+ve$
Quantity of Fertilizer	X_4	β_4	Continuous (Kg)	$+ve$
Agrochemical Input	X_5	β_5	Continuous (Litres)	$+ve$
Technical Inefficiency Component				
Educational Level	Z_1	α_1	Continuous (Years)	$-ve$
Age	Z_2	α_2	Continuous (Years)	$\pm ve$
Farm Size	Z_3	α_3	Continuous (Hectares)	$-ve$
Farming Experience	Z_4	α_4	Continuous (Years)	$-ve$
Household Size	Z_5	α_5	Discrete (Number)	$-ve$
Extension Contact	Z_6	α_6	Discrete (Number)	$-ve$
Sex	Z_7	α_7	Dummy (1, Male;0,Otherwise)	$-ve$

F-Chow Test Statistics

According to Dougherty (2007) and Chow (1960) F-Chow test statistics is often used in determining the equality of error variances in two linear regression equations this is the main restriction assumed in Chow test.

The pooled Regression model is specified as;

$$Y_{ij} = \alpha + \beta X_{1ij} + \varphi X_{2ij} + \epsilon_{ij} \qquad (12)$$

If we split the data into two groups, then we have,

$$Y_{ij} = \alpha_{1ij} + \beta_1 X_{1ij} + \varphi_{1ij} X_{2ij} + \epsilon_{ij} \qquad (13)$$

$$Y_{ij} = \alpha_{2ij} + \beta_2 X_{2ij} + \varphi_{2ij} X_{2ij} + \epsilon_{ij} \qquad (14)$$

Where,

Y_{ij} = Output of Rice from farmers with and without access to technology.

Chow test is an application of the F-distribution test, if F-Chow is greater than the F-table, then there is a significant difference between the output of rice farmers with and without technology or otherwise. The model is specified as follows:

$$\text{F} * -\text{Chow Test} = \frac{RSS - (RSS_1 + RSS_2)/K}{RSS_1 + RSS_2/[\text{N}_1 + \text{N}_2 - 2K]} \qquad (15)$$

RSS = Sum of Square Residual from Pooled Data,

RSS_1 = Sum of Squares from the rice producers with access to technology,

RSS_2 = Sum of Squares from rice producers without access to technology

K = Total Number of Parameter,

N_1, N_2 = Number of Observation in Each Group,

Study Hypothesis

H_0: $\beta_1 ij = \beta_{2ij}$: There is no significant differences of productivity between rice farmers with and without access to improved technology. The main hypothesis in the Chow test is that the coefficient (Rice output) is equal for both sub-samples.

RESULTS AND DISCUSSION

Socio-economic characteristics of the small-scale rice farmers with and without access to improved production technology

The results of the socio-economic characteristics of the sampled scale rice farmers with and without technology are presented in Table 2. The average age of the sample rice farmers with technology was 36 years while those without technology was 46 years. This implies that the rice farmers from both categories were still energetic and in their active age of productivity. The rice farmers that adopt technology were much younger than those without technology - there was a difference of 9 years between farmers with technology and those without technology, the younger the rice farmers the higher the chances for them using technology and innovation in rice production that would lead to increase in efficiency and profit maximization (Figure 1). This is in consonance with Okello et al. (2019) who reported an average age of 38 years for rice farmers and in the contrary to the findings of Aboaba (2020) who reported the mean age of rice farmers to be 54 years.

The study also shows that majority (84.2%) of the sampled rice farmers with access to technology were male while majority (83.3%) of the sampled rice farmers without technology were male rice farmers, this indicates that majority of the rice farmers using technology and without technology were male rice farmers. This result is in line with Oladele et al. (2020) who reported that the male dominancy in agriculture could be expected especially due to the great energy required in carrying out farming activities. About 83.1% of the sampled rice farmers using technology were married and 83.3% of those without technology were also married implying that most of the sampled rice farmers from both categories have labour supply for rice production in the study area.

Furthermore, the results showed that majority of the sample farmers were literate, only 10.5% and sampled farmers with access to technology and 3.4% of farmers without access to technology has no formal education (Figure 2). The average household size of the sample rice farmers with and without technology was 7 and 9 persons, respectively. On average, the farmers without access to technology had a larger household than those with access to technology with a difference of 2 persons per household. The average length of years of rice cultivation by farmers with and without technology was 10 and 13 years, respectively. There was a difference of 3 years in the average years of farming experience between farmers with access to technology and those without access to technology. The length of years in rice cultivation makes farmers to accumulate experience and knowledge about rice cultivation which could maximize the profit. About 44.2% of the sampled farmers with technology were members of the cooperative association while majority (61.5%) of the sampled rice farmers without technology were also members of the cooperative association. The cooperative association makes farmers to organize themselves in such way that they can contribute their resources and pull it together which could enable them to purchase inputs in bulk at lower price rate.

Table 2. Socio-economic characteristics of the sampled small-scale rice farmers in the study area

	Variables	Rice Farmers with Technology n =1500		Rice Farmers without Technology n=1500	
		Frequency	**Percentage**	**Frequency**	**Percentage**
Age (Years)	21 – 30	300	20.0	250	17.7
	31 – 40	789	52.6	442	29.5
	41 – 50	363	24.2	596	39.7
	> 50	47	3.2	212	14.1
	Mean	36		46	
Sex	Male	1263	84.2	1250	83.3
	Female	237	15.8	250	16.7
Marital Status	Single	205	13.7	231	15.4
	Married	1247	83.1	1250	83.3
	Widow	47	3.2	19	1.3
Education Level	Quaranic	174	11.6	96	6.4
	Primary	253	16.9	269	17.9
	Secondary	615	41.1	500	33.3
	Tertiary	189	12.6	480	32.1
	Adult Education	110	7.4	96	6.4
	No Formal Education	158	10.5	58	3.8
Household Size (Number)	1-5	474	31.6	538	35.9
	6-10	805	53.7	480	32.1
	11-15	221	14.7	480	32.1
	Mean	7		9	
Length of Rice Cultivatio	1-5	174	11.6	404	26.9
	6-10	710	47.4	500	33.3
	11-15	410	27.4	154	10.3
	>15	205	13.7	442	29.5
	Mean	10		13	
	Member Cooperative				
	Members	663	44.2	923	61.5
	Not Member	837	55.8	577	38.5
	Access to Credit				
	With access	379	25.3	346	23.1
	No access	1121	74.7	1154	76.9
Source Finance	Personal	947	63.2	1019	67.9
	Bank	32	2.1	38	2.5
	Friend Relative	221	14.7	19	1.3
	Cooperative	300	20.0	423	28.2
Farm Size (Ha)	0.1-2	1105	73.7	1058	70.5
	2.1-4	221	14.7	250	16.7
	4.1-6	174	11.6	192	12.8
	Mean	1.5		1.4	

Source: Field Survey Data (2022)

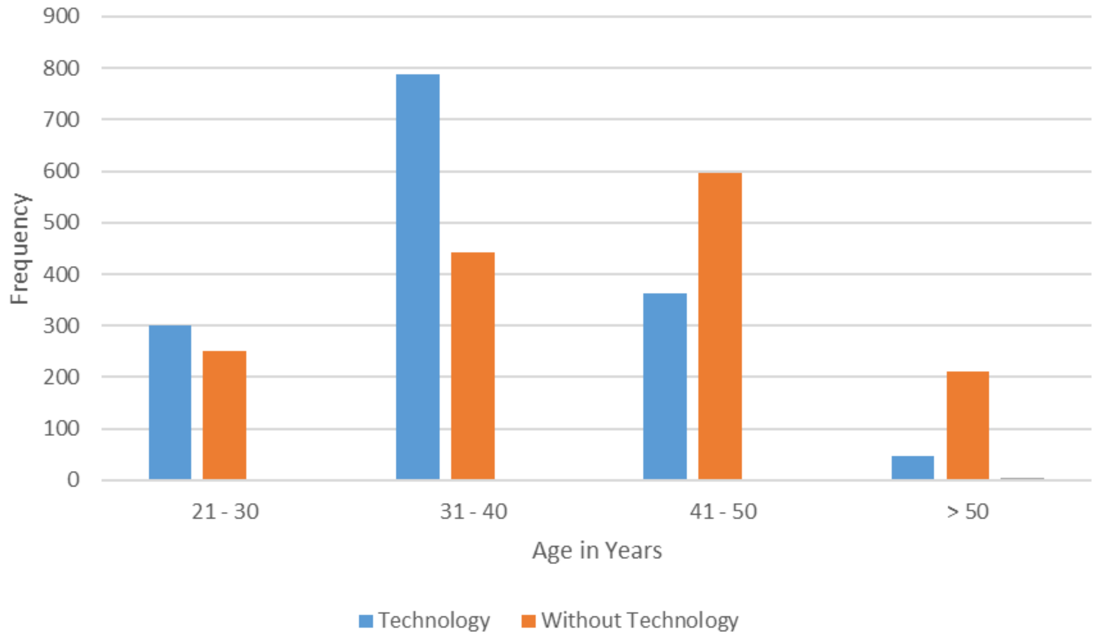

Figure 1. Age distributions of rice farmers

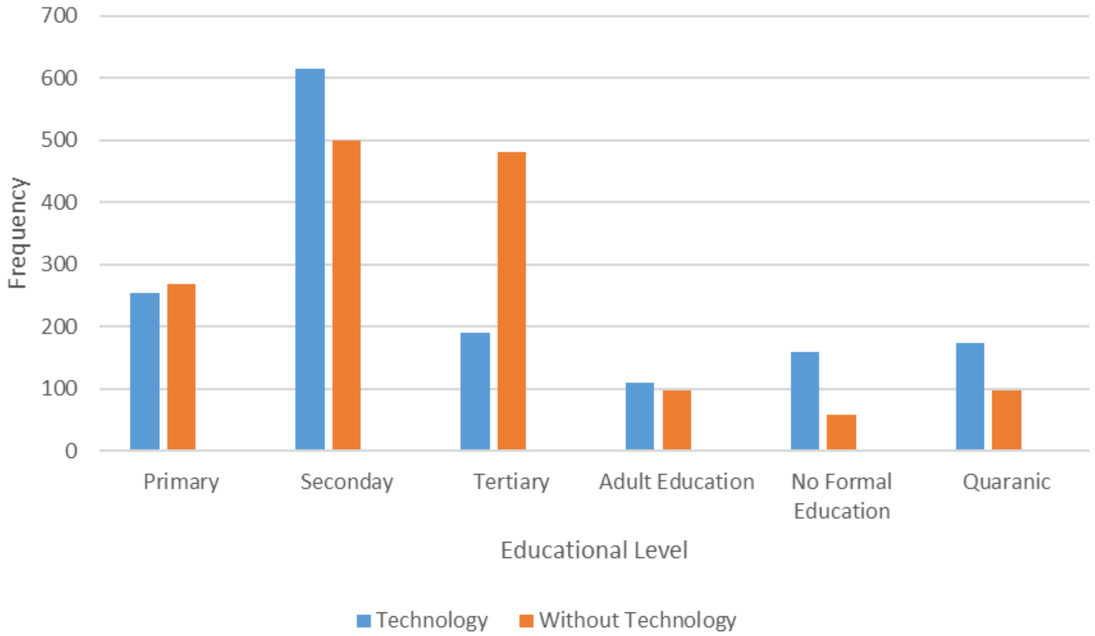

Figure 2. Educational level of rice farmers

The study also showed that majority 74.7% and 76.9% of the sampled rice farmers with and without technology had no access to formal credit facilities. More so, most of the rice farmers with technology (63.2%) and 67.9% of the farmers without technology have their capital or finance through personal savings. The majority of the sampled rice farmers with access (73.7%) and without access (70.5%) to technology has a land of less than 2 ha with average land size of 1.5 ha and 1.4 ha for farmers with access to technology and without technology respectively. This is in line with the findings of Abdulai et al. (2017) who reported farmers with similar farm size for farmers.

Costs, returns and profitability of small-scale rice farmers with and without access to improved production technology

Table 3 presents the results of costs, returns and profitability of rice producers with and without access to improved rice production technology in the study area. The results showed that the total variable cost incurred by the small-scale rice producers with technology was ₦175,354.76 and those without technology incurred a total variable cost of ₦123,857.34. The cost incurred on labour having the highest proportion of 43% for farmers with access to technology and 49% for those without technology while the total variable cost incurred by the small-scale rice farmers without access to technology carries 79.3% proportion of the total cost of production. The total fixed cost incurred by the small-scale rice farmers with and without technology was ₦39474.28 and ₦22,427.42 respectively. The estimated total revenue realized by the rice farmers with access to technology was ₦830,244.75 while the revenue obtained by the small-scale rice farmers without technology was ₦350,287.55. The gross margin estimated for small-scale rice farmers with technology was ₦ 615,415.71 while those without technology obtained ₦194,002.79 and the net profit of about ₦575,941.43 and ₦171,575.37 for both small-scale rice farmers with access to technology and without technology, respectively. The obtained gross margin ratio was 0.75 and 0.55 for the small-scale farmers with and without technology, respectively while the operating ratio obtained by the small-scale producers with technology was 0.26 and small-scale producers without technology was 0.35. The rate of return on investment realized by farmers with technology was estimated to be 2.75 while the small-scale rice farmers without technology was 1.10. This study shows that the rice production with technology and without technology was profitable but rice production with access to technology was more profitable than those without access to technology. The rate of return on investment of 2.75 for small-scale rice producers with technology and 1.10 for those without access to technology implied that every 1 naira invested 2.75 kobo and 1.10 kobo was obtained as profit respectively, which covered the interest cost of capital, fees and commission. This is in line with Alabi et al. (2023) who reported that rice production is a profitable enterprise that worth investing in and undertaking.

Distribution of technically efficiency scores among rice farmers with and without access to improved production technology

Table 4 presents the results of summary distribution of the technical efficiency score of the sampled rice producers with and without access to technology in the study area. The results showed that the technical efficiency varies among the sampled rice farmers with and without access to technology. The study also revealed that about 42.1% of the rice producers with technology attained technical efficiency score between 0.81-1.0 while only 6.4% of the rice farmers without technology were able to attain 0.81-1.0 level of technical efficiency score (Figure 3). The minimum technical efficiency level attained by the rice farmers with access to technology and without those without access to technology were 0.001 and 0.011 respectively. The maximum technical efficiency level obtained by both category was 0.999 and 0.9821 respectively with average technical efficiency of about 81.1% for farmers with access to technology and 52.7% for farmers without access to technology. This indicated that the rice farmers with access to technology were technically more efficient than those without access to technology. This study is in line with the findings of Okello et al. (2019) who reported technical efficiency of 78% and asserted that rice farmers level of technical efficiency was less than 100%. Several other studies found similar result (Ahmed & Melesse, 2018, Aboaba (2020) and Biara et al. (2023).

Table 3. Average costs, returns and profitability per hectare of rice producers with and without access to improved production technology in the study area

Variables	**Rice Farmers with Technology**			**Rice Farmers without Technology**		
	Average Value (₦)/ha	**Financial Ratios**	**Proportion (%)**	**Average Value (₦)**	**Financial Ratios**	**Proportion (%)**
Variable Cost						
Seed	30,080.82		0.140	22,459.02		0.0.144
Fertilizer	48,000.00		0.22	6500.00		0.0142
Manure	**********		**********	4,857.14		0.031
Herbicide	19,236.30		0.089	6,830.34		0.044
Pesticides	3,926.80		0.018	*****		****
Cost of Labour						
Land preparation	24,722.41			13,103.33		
Planting cost	15,223.73			9,581.72		
First weeding	*****			3500.00		
Second weeding	11,279.63			18,124.39		
Fertilizer Application	18,72.34			8,831.71		
Harvesting	25,503.39			11,762.07		
Threshing/winnowing	14,272.41			12,012.05		
Total	**92,873.91**		0.432	**76,915.27**		0.492
Transportation	8,308.93			6,295.57		
Total Variable Cost	**175,354.76**		**0.816**	**123,857.34**		**0.793**
Fixed Cost						
Depreciation on Farm Implement	9,474.28			17,427.41		
Interest on capital	30.000			15,000		
Total Fixed Cost	39, 474.28		0.184	22,427.42		0.144
Total Cost	214,829.04			156,284.76		
Total Revenue	830,244.75			350,287.55		
Gross Margin	615,415.71			194,002.79		
Net Profit	575,941.43			171,575.37		
Gross Margin Ratio		**0.74**			**0.55**	
Operating Ratio		**0.26**			**0.35**	
RORI		**2.75**			**1.10**	

Source: Field Survey Data (2022)

Table 4. Distribution of technically efficiency scores among rice farmers with and without technology

Technical Efficiency Score	**Farmers with Technology**		**Farmers without Technology**	
	Frequency	**Percentage**	Frequency	**Percentage**
0.0-0.20	16	1.1	58	3.8
0.21-0.40	300	2.0	134	8.9
0.41-0.60	395	26.3	1096	73
0.61-0.80	158	10.5	115	7.7
0.81-1.00	632	42.1	96	6.4
Minimum	0.001		0.011	
Maximum	0.999		0.9821	
Mean TE	0.8129		0.5270	

Source: Field Survey Data (2022)

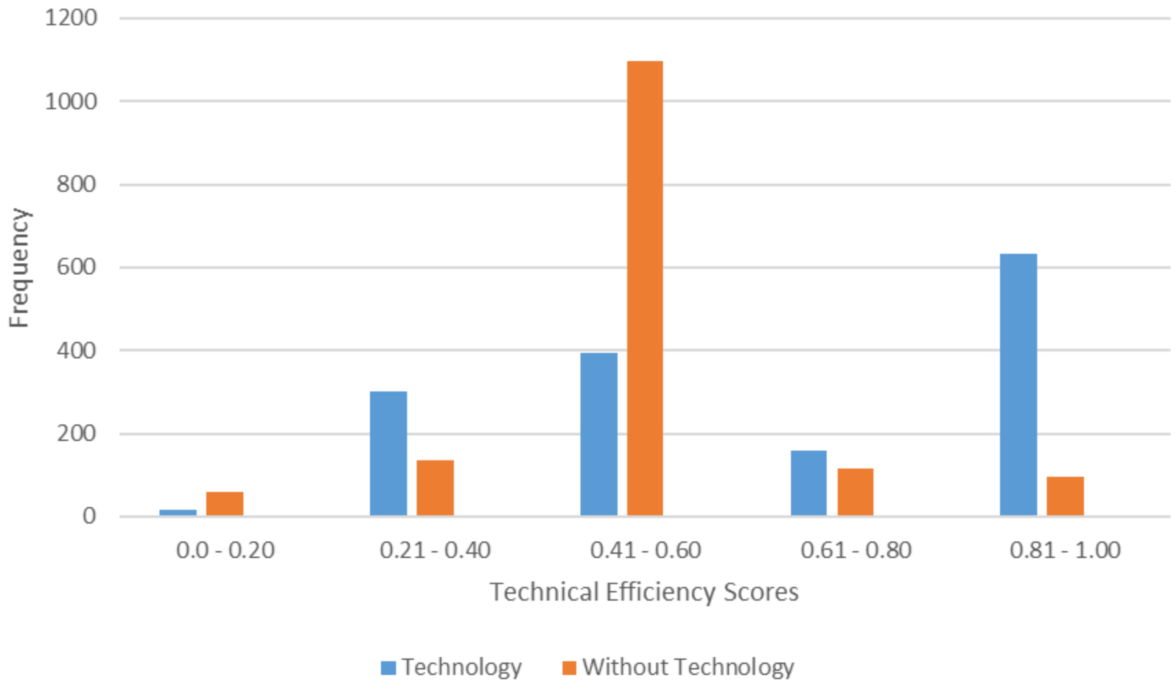

Figure 3. Technical efficiency scores of rice farmers

Estimates of the factors influencing total output and the technical efficiency of rice production among small-scale rice farmers with and without access to improved production technology

Table 5 shows the results of the maximum Likelihood estimates of the factors influencing technical efficiency of the small-scale producers with and without technology. The first stage of the stochastic frontier production function showed that the statistically significant factors influencing total output of the rice production for small-scale rice producers with technology were land size, labour, seed, fertilizer, and agrochemical while the factors influencing the total output of rice producers without technology were land size, labour, and fertilizer. This is consistent with Amaechina & Eboh (2017) who reported that land size, labour and fertilizer had positive influence on rice production in Anambra State, Nigeria. The land size influenced the total output of rice production positively for rice producer with and without access to technology and was statistically significant ($p<0.01$). The coefficient of land size for rice producers with technology (0.2076) and 0.3177) for rice producers without access to technology implied that a unit change in the land size would result in the increase in the total output of rice producers with access to technology and without technology by 20.8% and 31.8%, respectively. This result is consistent with Abdulai et al. (2018) and Amaechina & Eboh (2017) who reported that farm size has a positive influence on total output of rice production. The labour influenced the total output of rice production positively for both small-scale rice farmers with access to technology and those without access to technology and it was statistically significant ($p<0.01$). The magnitude of the coefficient of labour for the small-scale rice farmers with technology was 0.9695) and 0.1764 for the small-scale rice farmers without access to technology. This implied that a percentage change in labour supply for rice production would result in the increase in the total output of rice production by 96.9% and 17.6% for the small-scale rice farmers with access to technology and without technology, respectively. The rice seeds influenced the total output of rice positively for small-scale rice farmers with access to technology and was statistically significant (p<0.01) but was not significant for farmers without access to technology. The coefficient of rice seed for rice farmers with access to technology was 0.3033 implying that a percentage change in the quantity of the rice seed planted by the small-scale rice farmers would result in the increase in the total output of rice production by 30.3% for rice farmers that has accessed to technology. An access to improved seed variety could be the reason why seed influenced the total output of rice production among the farmers that had access to technology. A fertilizer has a positive influence on the total output of rice production among small-scale rice farmers that had access to technology while for farmers without access to technology the fertilizer influenced the total output of rice negatively and it was statistically significant at p<0.01 and p<0.10, respectively. The coefficient of fertilizer for farmers with access to technology was 0.2102, while for farmers without access to technology was -0.1002. This signified that a percentage change in the quantity of fertilizer applied to the rice farm by rice farmers with technology would result in the increase in the total output of rice production by 21.1% and those without access to technology would experience a decrease in the total output by 10.1%. This finding conforms to the results of Amaechina & Eboh (2017) and Mabe et al. (2018) who found that the fertilizer had a positive effect on the total output of rice production. This finding is on the contrary to the result of Abdulai et al. (2018) who reported a negative influence of fertilizer on rice production output and was a confirmation to the results of the farmers without access to technology. The agrochemical was statistically significant and influenced the total output of rice production positively for farmers with access to technology only. The magnitude of the coefficient of agrochemical (0.3053) implied that a percentage change in the use of agrochemical by the small-scale rice farmers with access to technology would result in the increase in the total output of rice production by 30.5%. The technical inefficiency component of the stochastic frontier which was the second stage of the production function showed that the statistically significant factors which influenced the technical inefficiency of the small-scale rice farmers with access to technology and without technology were as follows: the age of the farmers as seen in Table 4 influenced the technical inefficiency of the small-scale rice farmers with access to technology negatively and positively for rice farmers without technology and it was statistically significant at p<0.01) and p<0.10, respectively. The estimated coefficient of the age of the small-scale farmers with access to technology (-57.1175) and those without access to technology (0.0718) implied that a unit change in the age of the farmers with access to technology would result in the decrease in the technical inefficiency of the small-scale rice farmers by 57.1% while for those without access to technology the increase in technical inefficiency was 0.7%. The result connoted that the younger farmers were more technically efficient than the old farmers because the younger farmers were risk takers and adopt a new innovation. This conforms to the finding of Ishiaku et al. (2017). The education of the sampled small-scale rice farmers had a negative influence on the technical inefficiency of the small-scale rice farmers that had access to technology while the small-scale farmers without access to technology education had a positive influence on the technical inefficiency and was statistically significant at p<0.01 for both small-scale farmers with access to technology and without. The coefficient of education level of the rice farmers with access to technology was -0.2024 and for those without access to technology was 0.0213. This result revealed that a unit change in the level of education of small-scale rice farmers would result in the decrease in technical inefficiency for farmers with access to technology by 20.2% and increase in technical inefficiency (decrease in technical efficiency) for rice famers without access to technology by 2.1%. The implication of the positive sign for farmers without technology was that they were not well educated and as a result, they did not consider the technology as a means that would improve their productivity. They prefer to stick to their traditional method of rice production thereby resulting in technical inefficiency. This is in line with Dominic et al. (2019) who reported a negative association of education with technical inefficiency. This means that an increase in the year of education of farmers increases the level of technical efficiency in production. The results also conform to the finding of Danso-Abbeam et al. (2015) who also found that the access to education affected the technical inefficiency negatively.

The land size influenced the technical inefficiency negatively for small-scale rice farmers with and without access to technology $p<0.01$ and $p<0.10$, respectively. The coefficient of the land size for both categories of small-scale rice farmers implied that a unit change in the land size would result in the increase in the technical efficiency of rice production among small-scale rice farmers by 63.3% and 62.5%, respectively. The experience influenced the technical inefficiency of rice production for small-scale rice farmers with access to technology negatively and was statistically significant ($p<0.01$) while for farmers without access to technology it was positive. The coefficient of farming experience for both small-scale rice farmers was -1824 and 0.0394 respectively, meaning that a unit increase in the years of farming experience would result in the decrease in technical inefficiency for small-scale farmers with access to technology by 18.2% while those without technology would lead to decrease in technical efficiency by 3.9%. This is in conformity with the Nwahia et al. (2020) who reported that farmers with more experience tended to be technically efficient than those that has less farming experience.

The household size influenced the technical efficiency of small-scale rice farmers with access to technology positively and negatively for farmers without technology and it was statistically significant at $p<0.05$ and $p<0.01$, respectively. The coefficient of household size for farmers with access to technology was 0.0269 and those without technology was -0.0628. This showed that a unit change in the number of household size per person for farmers with access to technology would result in the decrease in technical efficiency (increase in inefficiency) of rice production by 2.7. The number of persons in the household could have negative relationship with technical efficiency in the sense that available resources may be diverted for solving family problems rather than for farm activities. This is in line with Okello et al. (2019) who reported that a larger household size could result in decline in the technical efficiency in rice production while for farmers without access to technology would result in the increase in technical efficiency by 6.3%.

The extension contact influenced the technical efficiency for small-scale rice farmers with access to technology negatively and it was statistically significant at $p<0.01$ probability level, it was not significant for farmers without access to technology. The coefficient of extension contact for smallholder rice farmers with access to technology was -0.0307 that signified that a unit increase in access to extension contact for services would result in increased technical efficiency of rice production by 3.1% for farmers with access to technology. These results indicated that the rice farmers with access to technology who have access to extension service were more technically efficient than their counterparts that did not have access to technology. This result is in consonance with the findings of Dominic et al.

(2019), Danso-Abbeam et al. (2015), Abdulai et al. (2018).

The cooperative association influenced the technical efficiency for small-scale rice farmers with access to technology negatively and was statistically significant at $p<0.05$ and $p<0.10$ probability level. The coefficient of cooperative association for small-scale rice farmers with access to technology was -0.3051 while for farmers without technology was -0.2575. This finding implied that a unit change in the possibility of being a member of cooperative association by small-scale rice farmers would result in the increase in technical efficiency of rice production among small-scale rice farmers by 30.5% and 25.7%, respectively. This is in line with Alabi et al. (2023) who reported that the cooperative membership increased the access to farm inputs at a low cost because they may purchase the inputs in bulk at a lower price and to be more efficient and to maximize the profit.

Table 5. Maximum likelihood estimates of the stochastic frontier of rice production function for producers with and without access to technology in the study area

Variable	Farmers with Technology			Farmers without Technology		
	Coefficients	**Std Error**	**Z-Score**	**Coefficients**	**Std Error**	**Z-Score**
Land Size	0.207577*	0.0359482	5.77	0.3177182*	0.1221348	2.60
Labour	0.9694883*	0.3839501	2.53	0.1764158*	0.1127985	6.78
Rice Seed	0.3033543*	0.0186010	16.31	0.153018	0.2862165	0.53
Fertilizer	0.2109786*	0.0309272	6.28	-0.170330***	0.1001697	-1.70
Agrochemical	0.3052799*	0.0422674	7.22	-0.3556807	0.2018589	0.76
Constant	4.099452	5.895435	0.70	0.3712768	0.6059639	0.61
Inefficiency Model						
Education	-0.202436*	0.0072075	-28.09	0.0212888***	0.0432501	2.93
Age	-57.11753*	19.18636	-2.98	0.0717677***	0.0072658	1.66
Land Size	-0.6330422*	0.2192555	-2.89	-0.624897***	0.3553213	-1.76
Experience	-0.1823747*	0.0381327	-4.78	0.0393537***	0.0206194	1.91
Household Size	0.0268977**	0.012722	2.11	-0.0628044*	0.0193691	-3.24
Extension Contact	-0.030728***	0.0159691	-1.92	-0.0663106	0.0495128	-1.34
Cooperatives	-0.3051075**	0.0139493	-2.19	-0.257457***	0.129831	-1.98
Sex	0.0037830	0.0143900	0,26	-0.028159	0.0178288	-1.58
Diagnostic Statistics						
Log likelihood	-95.8000			834.7854		
Sigma square	71.5117			0.05654		
Gama	0.544071			0.22177		

Source: Field Survey Data (2022)

*Significant at the 1%, ** Significant at the 5%, *** Significant at the 10% Probability Levels

Constraints faced by the small-scale rice producers with access to improved production technology

Table 6 presents the constraints faced by the sampled small-scale rice farmers with access to technology. The results showed that majority 95.8% of the sampled small-scale rice farmers with access to technology encountered a poor access to credit facilities as the major constraints faced in rice production and it was ranked first based on the rice farmer's opinion. Also, most of the farmers with access to technology encountered a shortage of farm input as a challenge and it was ranked second while 91.6% of the rice farmers were faced with the challenge of inadequate rainfall season and high cost of labour respectively. The results also revealed that about 90.1% of the sampled small-scale rice farmers with access to technology encountered instability in planting calendar as a major constraint militating against rice production in the study area and it was ranked 4th in the order of severity. Other constraints encountered by the small-scale farmers with access to technology were ineffectiveness of agricultural chemicals (83.2%) due to delay in rainfall and the attitude of farmers towards adoption of innovation. Furthermore, about 81% of the sampled small-scale rice farmers with access to technology faced the challenges of the farm land small size while 76.8% of rice farmers encountered a poor soil fertility and poor access to market centers due to bad roads in the study area. This result is in line with Parveen et al. (2016); Coker et al. (2018) and Alabi et al. (2023) who reported similar problems of rice production faced by farmers in their respective study areas.

Table 6. Constraint faced by rice producers with access to improved production technology

Constraints Faced by Farmers With Technology	**Frequency**	**Percentage**	**Rank**
Poor credit facilities	1437	95.8	1st
Shortage of farm input	1405	93.7	2nd
Inadequate rain fall season	1374	91.6	3rd
High cost of labour	1374	91.6	3rd
Instability in planting calendar	1358	90.1	4th
Ineffectiveness of agricultural chemicals used due to delay in rainfall	1247	83.2	5th
Attitude of farmers towards adoption of innovation	1247	83.2	5th
Small Farm Size	1167	81.0	6th
Poor soil fertility	1153	76.8	7th
Poor access to market centers due to bad roads	1153	76.8	7th
Problem of land ownership	1026	68.4	8th
Inadequate extension contact	458	30.5	9th
Total	1500	100	

Source: Field Survey (2022)

Constraints faced by the small-scale rice producers without access to improved production technology

Table 7 presents the constraints faced by the small-scale rice farmers without access to technology in the study area. The results showed that the majority (97.4%) of the sampled rice farmers ranked 1st and identified the poor soil fertility and attitude of farmers towards adoption of innovation while 96.2% of the respondents ranked the poor access to credit facilities as 2nd. The high cost of labour was the 3rd most important constraints to rice production in the order of severity. This result is in line with Alabi et al. (2020) and Alabi et al. (2023).

Chow Test

Chow Test result to determine the difference between rice producers with and without access to improved production technology. The results of Chow-test are presented on Table 8. The residual sum of square for pooled sample was 5818.887, while the residual sum of square for farmers with access to technology was 923.600 and that of famers without technology was 4858.988 with calculate F* value of 26.44 and the table F-Value of 2.495. In the Chow test, if there is no significant statistical difference between two sub-samples (i.e., if $\sigma_I^2 = \sigma_R^2$), then the regression test statistic in Equation (11) follows an F(K, T-2K) distribution. However, if the test statistic (F*) is greater than the respective F-statistic at 5% level of significance (as in this study), the null hypothesis should be rejected. Consequently, the relevant conclusion is that the sub-samples are significantly different. This was the statistical evidence which justifies the decision to estimate separate models for the sub-samples. The coefficients of the rice farmers with access to technology were more significant than those without access to technology.

Table 7. Constraint Faced by Rice Producers without Access to Improved Production Technology

Constraints Faced by Farmers	**Frequency**	**Percentage**	**Rank**
Poor soil fertility	1462	97.4	1st
Attitude of farmers towards adoption of innovation	1462	97.4	1st
Poor credit facilities	1442	96.2	2nd
High cost of labour	1385	92.3	3rd
Instability in planting calendar	1365	91.0	4th
Ineffectiveness of agricultural chemicals used due to delay in rainfall	1327	88.5	5th
Inadequate rain fall season	1250	83.3	6th
Shortage of farm input	1134	75.6	7th
Problem of land ownership	1115	74.4	8th
Small Farm Size	1115	74.4	8th
Poor access to market centers due to bad roads	769	51.0	9th
Inadequate extension contact	711	47.4	10th
Total	1500	100	

Source: Field Survey Data (2022)

Table 8. F-Chow Test Outcome

RSSP	RSS1	RSS2	F*	F(K, T-K) at 5% significance level	Decision
5818.887	9323.600	4858.988	26.44	2.495	There is Significant Impact on Productivity of Rice Farmers with Access to Improved Technology in the Study Area

Source: Field Survey Data (2022)

CONCLUSION

The general conclusion drawn from this study is that the access to improved rice production practices increases yield, profit and technical efficiency of the farmers. Farmers with access to technology have Return on Naira Investment and the mean technical efficiency was significantly higher than that of rice farmers without access to technology. The average technical efficiency obtained by the small-scale farmers with access to technology was 81.1% while those without access to technology obtained 52.7% indicating that the farmers with access to technology were more technically efficient than the small-scale rice farmers without technology. The factors influencing the total output of rice production for small-scale farmers with access to technology were land size, labour, fertilizer and agrochemical while the statistically significant factors influencing the total output of rice production for small-scale farmers without access to technology were land size, labour and agrochemical. The current study found that the statistically significant factors that influenced the technical inefficiency of the farmers with access to technology were education, age, land size, experience, household size and extension contact. The statistically significant factors influencing technical inefficiency for farmers without access to technology were education, land size, experience, household size and cooperatives. The major challenges faced by the small-scale rice farmers with access to technology were the poor credit facilities, shortage of farm input, and inadequate rainfall. The small-scale rice farmers without access to technology faced the major constraints such as poor soil fertility, attitude of farmers towards adoption of innovation, and poor credit facility. Therefore, the study recommends the following policy implications: The need to expose all small-scale rice farmers to improved production practices. The inputs such as mechanization of land predation use of improve seed varieties, precision planting, fertilizers and agro-chemical inputs. These inputs should be provided to farmers by government of Nigeria or Non-Governmental Organizations at affordable price or subsidized rate and timely. The extension services should be provided to small-scale rice farmers for improved rice production. The technologies utilization advices should be provided to farmers with training and farm demonstration on how to use technology appropriately. The workshops, seminars including media broadcasting through television, radio and internet/social media and symposium should be properly organized for adequate training of small-scale farmers in order to understand the technicalities of rice production using technology. Farmers should be encouraged to join cooperative organizations, to have access to credit facilities in order to boost their production capacity that will provide them with the ability to adopt rice production technologies which will in turn increase their output, income and improve their livelihood and welfare in the study area. Future research can be conducted in North West, North East, North Central, South West and South-South Regions of Nigeria.

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