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COMPARATIVE ANALYSIS OF PRODUCTION EFFICIENCIES OF PARTICIPATING AND NON-PARTICIPATING RAINFED RICE FARMERS IN THE ANCHOR BORROWER'S PROGRAMIN KADUNA STATE, NIGERIA.

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Abstract *This study examined the comparative production efficiencies of participating and non-participating rainfed rice farmers in the Anchor Borrowers' Programme in Kaduna State. Primary data were collected during the 2019 cropping season from 263 rice farmers, comprising 143 ABP participants and 120 non-participants, selected through a two-stage sampling technique from four Local Government Areas of Kaduna State. Descriptive statistics, the Double Hurdle Model, Stochastic Frontier Production Analysis, and the Z-test were employed for data analysis.The findings revealed that participation in the programme significantly improved the technical efficiency of rice farmers. Double-Hurdleand Stochastic Frontier Production models were used in analyzing the data collected.Farmers who participated in the programme recorded a higher mean technical efficiency score of 76.88% compared to 61.81% for non-participants, indicating that participants utilized production resources more efficiently. The stochastic frontier analysis further revealed that a greater proportion of the variation in rice output among both groups was due to technical inefficiency rather than random factors, suggesting that output could still be increased through better use of available resources. The study also found that factors such as education, farming experience, extension contact, cooperative membership, access to credit, and market price significantly influenced farmers' participation and efficiency levels. The Z-test result confirmed that there was a significant difference in technical efficiency between participants and non-participants at 1% level. The study therefore concludes that participation in the Anchor Borrowers' Programme enhances*

rice farmers' efficiency and productivity. Based on the findings, the study recommends expansion of the programme to cover more farmers through improved access to credit, subsidized inputs, and timely support services. It also recommends strengthening extension services and cooperative membership to improve farmers' access to information, technology, credit, and better production practices.

Keywords Anchor Borrowers' Programme, Production, Efficiency, Rice, Rainfed Rice, Smallholder farmers

1. Introduction

Rice is one of the most important staple crops in the world and remains the second most widely cultivated cereal after maize (Food and Agriculture Organization Statistics/FAOSTAT, 2021). Its importance is reflected in its contribution to food security, calorie intake, and household nutrition, especially in developing countries where it forms a major component of daily diets (Kaka, Gindi, & Khalid, 2020). In Nigeria, rice is cultivated across different ecological zones, including upland, lowland, and irrigated systems, mainly by smallholder farmers who rely on traditional farming methods (FMARD, 2018). However, these farmers often face low productivity due to limited access to improved technologies and poor farm management practices (Tsado, Ojo, & Ajayi, 2014). Although the demand for rice in Nigeria is projected to reach 21.8 million tonnes by 2030 (Familusi& Chizoba, 2021), domestic production continues to lag behind consumption, with local output estimated at approximately 6.8 million tonnes against a national demand of 8.9 million tonnes, resulting in a substantial supply deficit (Kara et al., 2019). Consequently, Nigeria imported about 2.3 million tonnes of rice in 2021 to supplement domestic supply (USDA, 2021). This persistent production deficit, driven by demand consistently exceeding local supply, places considerable pressure on foreign exchange reserves through import dependence, underscoring the urgent need to enhance domestic rice production and bridge the supply gap (Zongoma*et al.* 2024).

Over the years, the Nigerian government and development agencies have introduced several interventions aimed at increasing domestic rice production and reducing dependence on imports. Despite these efforts, local rice production has remained inadequate relative to the growing demand driven by population increase and changing food preferences. The gap between actual yields and the attainable yields under improved practices remains substantial, with differences ranging from 2.5 to 6.5 metric tons per hectare (Mt/Ha). Furthermore, rice yield declined from 2069.54 kg/ha in 1990 to 1934.60 kg/ha in 2019 (NAERLS, 2020). This low productivity has been attributed to factors such as poor access to improved seed varieties, inadequate fertilizer application, weak extension services, limited access to credit, poor marketing systems, high production risks, and inadequate post-harvest management (Bitrus et al., 2021). These constraints continue to reduce the efficiency and profitability of rice farming among smallholder producers.

In response to these challenges, the Central Bank of Nigeria introduced the Anchor Borrowers' Programme (ABP) in 2015 to improve agricultural productivity, enhance access to finance, and strengthen linkages between smallholder farmers and processors (Bitrus et al., 2021). The programme was designed to support farmers with farm inputs, labour, financing, and technical assistance in order to increase production and reduce the country's dependence on imported rice (CBN, 2019). In Kaduna State, which contributes about 4 percent of Nigeria's total rice output, the ABP was introduced in 2017 to improve the productivity and welfare of rice farmers. Despite the state's strong potential for rice cultivation, average rice yield remained relatively low at 3240 kg/ha in 2020 (NAERLS, 2020). This situation suggests the need to assess whether participation in the programme has improved the production efficiency of rice farmers in the state.

While Bitrus et al 2021 studied ABP in Adamawa, no study has compared TE of rainfed rice farmers in Kaduna using SFA and Double Hurdle models. This study therefore seeks to fill this gap by examining the differences in production efficiency between participating and non-participating farmers. Specifically, the study will;

i. determine the factors influencing the decision to participate and the intensity of participation in ABP in Kaduna State;
ii. evaluate the levels of production efficiencies among participating and non-participating rainfed rice farmers in Kaduna State.

2. MATERIAL AND METHOD

2.1 Study Area

The study was conducted in Kaduna State, which lies within the Northern Guinea Savannah ecological zone. The state is situated between latitude 9°N and 12°N and longitude 6°E and 9°E of the prime meridian. Kaduna State covers an estimated land area of about 68,000 square kilometres. Based on a projected annual population growth rate of 3.2 percent, the population of the state is estimated at 11,478,472 people in 2026. Agriculture remains the major occupation and backbone of the state's economy, with about 80 percent of the population actively involved in farming activities(John & Balogun, 2025).

2.2 Sampling Technique and Sample Size

A two-stage sampling technique was employed for the study. In the first stage, Makarfi Local Government Area and Sabon Gari Local Government Area were purposively selected because they are among the Local Government Areas participating in the Anchor Borrowers' Programme and also have a high concentration of rice farming activities in the state (KNARDA, 2019). In the second stage, three communities were randomly selected from each of the two LGAs, resulting in a total of six communities, namely Meyere, Gubuchi, Gimi, Bomo, Saka-Dadi, and Basawa.

To minimize spillover effects, two additional LGAs, Kudan Local Government Area and Ikara Local Government Area, were purposively selected from non-

participating areas. Thereafter, three communities were randomly chosen from each of these LGAs, namely Zabi, Hunkuyi, Doka, Furana, Auchan, and Rumi, making a total of six communities from the non-participating LGAs.

Finally, the Slovin formula was used to determine the sample size for each community, based on an assumed margin of error of 5 percent and a confidence level of 95 percent.

$$n_0 = \frac{N}{1 + (Ne^2)} \text{----------} \text{----------} \text{----------} 1$$

Where: n_0 is the required sample size; N is the sample frame and $e =$ the expected error.

The above gave a total number of 143 participants and 120 non-participants selected from the four LGAs. The non-participants were selected to serve as control group making a total of 263 rural farmers selected as the sample size for this study as shown below.

Table 1: Sampling Technique and Sample Size

PLGA	SV	SF	SS (33 %)	NPLGA	SV	SF	SS (33 %)
Makarfi	Meyere	31	20	**Kudan**	Zabi	32	20
	Gubuchi	34	22		Hunkuyi	42	27
	Gimi	40	26		Doka	33	21
Sabon Gari	Bomo	78	27	**Ikara**	Furana	69	35
	Saka-Dadi	40	26		Auchan	49	31
	Basawa	35	26		Rumi	34	22
Total		423	143			341	120

Note: PLGA=participants local government area and NPLGA=nonparticipants local government area, SV= selected villages, SF= sample Frame and SS=Sample Size
Reconnaissance Survey, 2019

2.3 Method of Data Collection

The study relied on primary data collected during the 2019 cropping season, covering the period from July to October. Data were obtained from selected farmers through the use of a structured questionnaire administered. Information collected included farmers' socio-economic characteristics such as age, sex, education, household size, farming experience, and farm size. Data were also obtained on extension contact, association membership, land rental, access to credit, labour use, input availability and prices, output and output prices, during the farming period.

2.4 Analytical Techniques

The analytical techniques that were used for this research to achieve its objectives include: Descriptive Statistics, which was used to describe the socio-economic characteristics rice production in the study area,Double Hurdle model to determine the decision to participate and the intensity of participation in the ABP, and Stochastic Frontier Production Analysis to evaluate the levels of production efficiencies among participating and non-participating rainfed rice farmers in the study area.

2.5 Model Specification

2.5.1 Double Hurdle Model

The double-hurdle model is a parametric generalization of the probit and truncated models, in which two separate stochastic processes determine the decision to participate and the intensity of participation in the project. The first-hurdle model was address by fitting a probit model and has an adoption (D) equation as specified below:

$$D_I = 1\ if\ D_i^* > 0\ and\ 0\ if\ D_i^* > 0$$

$$D_I = \alpha' Z_i + \mu_i \quad ---------- \quad 2$$

Where D is a latent variable which takes the value 1 if the farmer participates in the programme and zero otherwise. Z is a vector of household characteristics and α is a vector of parameters.

While the second hurdle was address by truncated model defined by:

$$Y_I = Y_i^*\ if\ Y_i^* > 0\ and\ D_i^* > 0$$
$$Y_I = 0 \text{ otherwise}$$
$$Y_I = \beta' X_i + \mu_i \quad ---------- \quad 3$$

Where:

Y_I = Intensity of participation (Quantity of output produced), X_i is a vector of the individual's characteristics and β is a vector of parameters, X_1 = Age of households (years), X_2 = Sex (1=male, 0= otherwise), X_3= Household size (Number), X_4= Year of schooling (years), X_5 = Farming experience (years), X_6 = Extension contact (Number of contact), X_7 = Membership of cooperative (years), X_8 = Marital Status (Persons), X_9 = Amount of credit received (Naira), X_{10} = Off farm income (Naira), X_{11} = Market price (Naira)

2.5.2 Stochastic Frontier Production Analysis

The stochastic frontier production function as used by Obianefo*et al.* (2021) applied in Mariko *et al.* (2019) was employed to achieve objective (iv) of the study. Therefore, the implicit functions were expressed as;

$$lnY_{it} = f(X'_{it}; \beta_4)\exp(e_{it}), i = 1,2 \ldots . N; t = 1, 2, \ldots . T ---------- 4$$

$$e_{it} = v_{it} - u_{it} ---------- 5$$

$$e_{it} = v_{it} - u_{it} ---------- 5$$

Thus, the explicit stochastic frontier production model that was used in this study is specified in a Cobb-Douglas functional form as follows:

$$lnY = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + (V_i - U_i) ------ 6$$

Where;

ln = The natural logarithm, Y = quantity of rice output (kg), β_0 = Constant term, β_i-β_5 = regression coefficients, X_1 = Farm size (ha), X_2= Quantity of seeds used (kg), X_3 =Quantity of fertilizer used (kg), X_4 = Total labour used (man days), X_5= Quantity of herbicide used (liters), V_i = assumed independently distributed random error or random shock having zero mean. It is associated with random factors such as measurement errors in production and weather which the farmer does not have control over.

U_i = is one sided component which captures deviation from frontier as a result of inefficiency of the farmer and ranges between zero and one. It is associated with farm-specific factors, which lead to the ith firm not attaining maximum efficiency.

The technical inefficiency of production U_i was modeled in terms of the factors that are assumed to affect the efficiency of production of farmers. Such factors were related to the socio-economic and institutional variables of the farmers. The determinant of technical inefficiency is defined by:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 ---------- 7$$

Where;

U_i = Technical inefficiency effects of the ith farmer; Z_1 = Age of the rice farmer (years); Z_2 = Sex (1 for male, 0 for otherwise); Z_3 = Marital status (1 for married, 0 for otherwise); Z_4 = Year of schooling (years of formal schooling); Z_5= Membership of cooperative (number of years); Z_6 = Household size (Number of people); Z_7 = Years of experience in rice production (years), Z_8 = Extension contact (number of extension contact), δ_0= constant, $\delta_1 - \delta_9$ = Parameters to be estimated.

2.5.3 The Z Test

The productive difference between participants and non-participants was determined using the Z - Test. This was used to test hypothesis of the study and the Z - Test is expressed as:

$$Z = \frac{\bar{U}_1 - \bar{U}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} ---------- 10$$

Where;

$\bar{U}_1$ = mean productivity of the participants group, $\bar{U}_2$= mean productivity of the non-participants group, σ_1^2= variance of the participants group

σ_2^2 = variance of the non-participants group, n_1 = number of the participants group, n_2= number of the non-participants group.

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

The farmers' characteristics were classified into continuous andcategorical variables.Continuous variables included age, household size, farming experience,and farm size, whilecategorical variables covered gender, marital status, education, extension access, and cooperative membership. These were summarized using frequencies, percentages, means, minimum and maximum values, while independent t-tests and chi-square tests were used to determine differences between the groups.

3.1.1 Distribution of Rice Farmers According to Age, Household Size, Farming Experience, and Farm Size

The findings showed that non-participants were generally older, had larger household sizes, and possessed more farming experience than participants, with these differences being statistically significant. Most farmers were within their productive age group and operated on a small scale, which is consistent with Ahmed et al. (2020), Kaka et al. (2021), Ahmed et al. (2021), Biswas et al. (2020), and NAERLS (2020).

Table 2: Distribution of Rice Farmers According to Age, Household Size, Farming Experience, and Farm Size

	Participant	Non- Participant	Pooled	
Variable	F(%)	F(%)	F(%)	^Difference Test
Age (years)				
Minimum	19	21	19	10.664***
Maximum	69	75	75	
Mean	45	53	42	
Household size (absolute number)				
Minimum	2	5	2	2.295**
Maximum	10	12	12	
Mean	7	11	8	
Farming experience (years)				
Minimum	5	7	5	4.059**
Maximum	20	40	40	
Mean	17	28	22	
Farm size (ha)				

Minimum	0.25	0.5	0.25	0.474
Maximum	7.5	9.5	9.5	
Mean	1.28	1.19	1.37	

*** p<0.01, ** p<0.05^*The independent t-test was used to test for difference in socio-economic characteristics between participants and non- participant. ^Difference Test: level of significance.*

3.1.2 Distribution of Rice Farmers According to Gender, Marital Status, Educational Level, Access to Extension services and membership of Cooperatives

The result from table 3 below showed that rice production in the study area was dominated by male farmers, as about 94 percent of the sampled farmers were male, with no significant gender difference between participants and non-participants; The predominance of male farmers could be attributed to the labour-intensive nature of rice production which could be very tedious, hectic and time consuming especially females who have to combine the farming activities with their domestic chores. Further, sex differences between participants and non-participant farmers were not statistically significant. This finding is consistent with Bitrus et al. (2021). Most farmers were married, although marital status differed significantly at 1 percent between the two groups, while the majority had no formal education, which may limit the adoption of improved technologies, contrary to Ahmed et al. (2020).

Access to extension services was generally low, with most of the participants and the non-participants lacking contact with extension agents. The slightly higher proportion of non-participants who had contact with extension agents (15%) compared to participants (4%) may suggest that extension services were not a major factor influencing participation in the program. Instead, participation may have been driven by other factors such as peer influence, membership in farmer groups, personal initiative, or program-specific recruitment mechanisms, a finding similar to Ahmed et al. (2021). In addition, a large proportion of farmers belonged to cooperative societies, particularly among participants, and membership differed significantly at 5 percent, supporting the findings of Obianefo et al. (2021).

Table 3: Distribution of Rice Farmers According to Gender, Marital Status, Educational Level, Access to Extension services and membership of Cooperatives

	Participant	Non- Participant	Pooled	
Variable	F (%)	F (%)	F (%)	^Difference Test
Gender				
Male	136(95.10)	112(93.33)	248(94.29)	0.785
Female	7(4.89)	8(6.67)	15(5.70)	

Total	**143(100)**	**120(100)**	**263(100)**	
Marital Status				
Single	18(12.58)	21(17.50)	39(14.83)	2.669***
Married	118(82.52)	87(72.50)	205(77.85)	
Divorced	5(3.49)	8(6.67)	13(4.94)	
Widow	2(1.39)	4(3.33)	6(2.28)	
Total	**143(100)**	**120(100)**	**263(100)**	
Education level				
No formal education	85(59.44)	63(52.50)	148(56.27)	5.365***
Primary	35(24.48)	24(20.00)	59(22.43)	
Secondary	18(12.59)	25(20.83)	43(16.35)	
Tertiary	5(3.49)	8(6.67)	13(4.94)	
Total	**143(100)**	**120(100)**	**263(100)**	
Access to extension				
No Access	138(96.50)	102(85.00)	240(91.25)	0.533
Had Access	5(3.49)	18(15.00)	23(8.75)	
Total	**143(100)**	**120(100)**	**263(100)**	
Cooperative				
Member	125(87.41)	53(44.17)	178(67.69)	2.011**
Non member	18(12.59)	67(55.83)	85(32.31)	
Total	**143(100)**	**120(100)**	**263(100)**	

*** p<0.01, ** p<0.05

^*The Chi-square test was used to test for difference in socio-economic characteristics between participants and non- participants*

3.2 Factors Influencing Rice Farmers' Decision and the Intensity of participationin ABP

The Double Hurdle Model (DHM) was used to examine both the decision to participate in the Anchor Borrowers' Programme and the intensity of participation. The Probit model identified the determinants of participation, while the Tobit model estimated the intensity of participation. The model fit was confirmed by a Wald Chi-square value of 187.234 and a Log-likelihood of -310.417, indicating that the factors affecting participation were different from those influencing the intensity of participation. The findings revealed that age, sex, education, extension contact, cooperative membership, off-farm income, market price, and access to credit significantly influenced farmers' decisions to participate in the programme, while household size, farming experience, extension contact, cooperative membership, and market price significantly affected the intensity of participation.

Age positively influenced participation in ABP, suggesting that older farmers were more likely to participate due to their greater resource base and farming experience, although younger farmers may be more innovative. This finding agrees with Vabi et al. (2020) but contrasts with Kaliba et al. (2018), who found that older farmers were less likely to participate in agricultural programmes. Male-headed households were also more likely to participate than female-

headed households because of better access to land and resources, which supports the findings of Drabo et al. (2019). In contrast, higher educational attainment reduced the likelihood of participation.Educated farmers may have off-farm jobs, or perceive ABP bureaucracy as costly, a finding linked to Kaliba et al. (2018). Off-farm income and access to credit both increased the probability of participation because they improved farmers' ability to finance farm operations and acquire inputs, which is consistent with Siewe et al. (2021) and Vabi et al. (2020).

The intensity of participation was significantly influenced by household size, farming experience, access to extension services, cooperative membership, and market price. Larger households were more likely to intensify the level of consumption which brings about less surplus for participants to pay the ABP loan, as contrary toMbavai et al. (2019). Farming experience also increased participation intensity because experienced farmers are better able to assess and adopt improved technologies, which agrees with Vabi et al. (2020) and Manda et al. (2020). Farmers who had access to extension services and belonged to cooperative societies were more likely to participate more actively in ABP because they had better access to information, training, and improved production practices. This result is consistent with the findings of Vabi et al. (2020), Siewe et al. (2021), and Mbavai et al. (2019). In addition, higher market prices for rice encouraged both participation and greater intensity of participation, as farmers were motivated to expand production in order to take advantage of better returns.

Table 4: Determinants of farmers' decision to participate and intensity of participation in ABP (Double Hurdle Model)

Explanatory Variables	**Probit**				**Truncated**			
	Coeff	**SD**	**t-ratio**	**ME**	**Coeff**	**SD**	**t-ratio**	**ME**
Constant	0.0526	0.1213	0.4336	-	0.3247	1.7308	0.1876	-
Age	-0.0647***	0.0213	-3.0375	-0.0317	0.0182	0.0287	0.6341	0.0070
Gander	0.3868***	0.1236	3.1295	0.0145	0.0253	0.0369	0.6856	0.0127
Household size	-0.3064	0.4443	-0.6896	0.0398	-0.0262**	0.0114	-2.2982	-0.0957
Education	-0.2658***	0.0975	-2.7262	-0.0063	0.6429	0.4262	1.5084	0.0836
Farming experience	0.0274	0.0204	1.3431	0.1249	0.0849***	0.0314	2.7038	0.0688
Extension visit	0.0623***	0.0236	2.6398	0.0746	0.8197*	0.4521	1.8130	0.0539
Cooperative membership	0.0648***	0.0154	4.2078	0.0367	0.1153***	0.0425	2.7129	0.1367
Marital status	0.0805	0.1108	0.7265	0.0251	0.1382	0.1385	0.9978	0.0561
Off farm income	-0.0373***	0.0123	-3.0325	-0.0097	-0.2374	0.5583	-0.4252	0.1729
Market price	0.0424**	0.0196	2.1633	0.0236	0.0352*	0.0198	1.7778	0.0415
Access to credit	0.5518***	0.1932	2.8561	0.0032	0.7054	0.6356	1.1099	0.0632
Goodness of fit:								
Log-likelihood		**-310.42**			**-436.62**			

Wald Chi^2 (11)	**187.23**	**252.91**
Pseudo R^2	**0.5467**	**0.2367**
Prob.> chi^2	**0.0000**	**0.0023**

Note: SD=Standard deviation and ME= Marginal effect: it refers to the marginal measured effect of the variable on the probability of participation

*** p < 0.01, ** p < 0.05

Determinants of Technical Efficiency in Rice Production

The stochastic frontier estimates showed that the sigma square values were significant for both participants and non-participants, confirming that the models were well specified. The gamma values of 0.7942 for participants and 0.9307 for non-participants indicate that about 79.42 percent and 93.07 percent of the variation in rice output among the two groups was due to technical inefficiency rather than random factors. The higher gamma estimate for non-participants suggests that there is greater scope for improving their productivity through interventions aimed at reducing technical inefficiency, whereas participants appear to have benefited from programme-related support that narrowed efficiency gaps.This also implies that non-participants have less control over random shocks.

For participants in the Anchor Borrowers' Programme, rice output was significantly influenced by seed, labour, fertilizer, and herbicide use. Seed had a significant effect at 1 percent, labour and fertilizer at 5 percent, and herbicide at 10 percent. For non-participants, farm size, seed, labour, and fertilizer significantly influenced rice output, with fertilizer significant at 1 percent and the other variables at 10 percent. In both groups, the coefficients of these inputs were positive, implying that increased use of these inputs would lead to higher rice output. This finding is consistent with Kaka et al. (2020), who identified farm size, seed, labour, fertilizer, and herbicide as important determinants of rice production among smallholder farmers in Nigeria.

The factors influencing technical inefficiency among participants included age, education, gender, cooperative membership, household size, farming experience, and extension contact, while for non-participants, age, education, household size, farming experience, and extension contact were significant. In both groups, farmers who were more educated, more experienced, had access to extension services, and actively participated in cooperative societies were more technically efficient than others. This finding agrees with Obianefo et al. (2021), who reported that education, farming experience, extension contact, and cooperative membership positively influence agricultural productivity among small-scale farmers in Nigeria.

Overall, the participants' outcome equation appears to fit the data better than the non-participants' outcome equation, as evidenced by the higher and more statistically significant sigma-square t-ratio (t=2.33 for participants and t=1.75 for the non-participants). Nevertheless, the significance of both sigma-square estimates

supports the appropriateness of the estimated model for both groups.

Table 5: Maximum Likelihood Estimates of the stochastic Frontier

	Part.			Non-Part.		
Variable	**Coeffi.**	**SE**	**t-ratio**	**Coeffi.**	**SE**	**t-ratio**
Constant (β_0)	-2.2085	-2.2714	0.9723	3.5389	3.2586	1.0860
Farm size(β_1)	0.0017	0.0084	0.2024	0.2092**	0.1243	1.6830
Seed(β_2)	0.3474*	0.1909	1.8198	0.5066**	0.2803	1.8073
Fertilizer(β_3)	0.4056**	0.1654	2.4522	0.2359***	0.0152	15.519
Labour(β_4)	0.2462***	0.0751	3.2782	0.3587**	0.1935	1.8537
Herbicide(β_5)	0.5780*	3.2908	1.9876	0.0456	0.4293	0.1062
Inefficiency Model						
Constant	1.7044	1.8981	0.8979	-1.1292	2.2523	-0.5014
Age	-0.4330***	0.1718	-2.5203	-0.4437**	0.2179	-2.0362
Education	-0.3489***	0.0887	-3.9233	-0.2392	2.3170	-0.1032
Gender	-0.5534*	0.3057	-1.8102	1.4716***	0.2785	5.2840
Membership of cooperation	-0.4483**	0.2061	-2.1737	0.1881	0.2072	0.9078
Family size	-0.6442***	0.2431	-2.6499	-0.7556*	0.4178	-1.8124
Farming experience	-0.3365***	0.0583	-5.8017	-0.2243**	0.0922	-2.4295
Marital Status	0.4742	0.8351	0.5678	-0.5531	0.7384	-0.7494
Number of Extension Visit	0.0742**	0.0351	2.1139	-0.1531***	0.0382	-4.0289
Model Summary						
Sigma Squared. (σ^2)	0.0632**	0.0271	2.3321	0.0558*	0.0319	1.74921
Gamma (γ)	0.7942***	0.2527	3.1428	0.9307**	0.3957	2.35203
Log-Likelihood	58.73			54.67		

Note: Part. = participant, non-Part=non-participants and SE=Standard error.
*** p < 0.01, ** p < 0.05, *p< 0.1

3.2.1 Frequency Distribution of Technical Efficiency Scores

The technical efficiency distribution in Table 4.6 indicated that the T.E. of the participants group ranges between 0.12 and 0.96 or 12 % and 96 % while the non-participants group had technical efficiency ranges between 0.10-0.88 or 10 % and 88 %. Furthermore, the mean technical efficiencies of the participants and non-participants group were 76.88 % and 61.81 % respectively. This means in the short run there are opportunities, among the groups, for reducing input used for rice production proportionally by 23.12 % and 38.19 % to produce the current level of output. If the average farmer of the participants and non-participants group in the sample was to achieve the technical efficiencies level of its most efficient counterpart, then the average farmer, among the group, could realize 23 % and 38 % reduction of inputs use to produce the output of the most efficient counterpart.

Similarly, the most technically inefficient farmer of the participants and non-participants group were to achieve the technical efficiency level of his most efficient counterpart; then the least efficient farmer could realize 88.49 % and 90.44 % reduction of inputs use to produce the output of the most efficient counterpart. Based on the result of the analysis, it can be inferred that the technical efficiency of the participants group was found to be relatively higher than that of the non- participants group. The overall implication is that, the participants group is more technically efficient than the non- participants group, and therefore there is still room for doing much better.

The results also revealed a standard deviation of 0.127 for participants group and 0.186 non-participants group respectively. This indicates that on average, deviation of technical efficiency scores from the mean value is about 32.71 % for the participants and 28.62 % for the non- participants group respectively. This implies that technical inefficiency among non- participants group is more spread out compared to the participants group. The results are in line with similar studies of Bitrus et al. (2021), who obtained a mean technical efficiency estimate of 74 % with minimum and maximum values of 12 % and 98 % respectively in a study into the technical efficiency of rice production in Northern Nigeria.

Table 6: Distribution of Technical Efficiency Estimates for Rice Farmers

Class Interval	Technical Efficiency Score			
	Participants		Non-Participants	
	Freq.	%	Freq.	%
≤ 0.20	5	3.49	12	10.00
0,21-0.40	23	16.08	16	13.33
0.41-0.60	15	10.49	19	15.83
0.61-0.80	33	23.08	32	26.67
0.81-1.00	67	46.85	41	34.17
Total	**143**	**100**	**120**	**100**
Minimum	**0.1151**		**0.0956**	
Maximum	**0.9583**		**0.8774**	
Mean TE	**0.7688**		**0.6181**	
SD	**0.3271**		**0.2862**	

Note: Freq. = Frequency and SD = Standard deviation

3.2.2 Test of Hypothesis

The result in Table 6 shows the result of the hypothesis test comparing the difference in technical efficiencies between the participants and non-participants of rice farmers. The result proved that there is a significant difference in the mean efficiencies between participants and non-participants group from the results of the

hypothesis testing. However, the result of the Z-test revealed that the mean difference in technical efficiency score of sample rice farmers in the study area was statistically significant at 1 % level. This suggests that the mean TE score for participants group was significantly greater than the mean score for the non-participants.

Table 7: Test of Hypothesis

Null hypothesis	Test statistics	Decision rule
There is no significant difference in the level of technical efficiency between the participant and non-participants group $H_0: TE_P - TE_{NP} = 0$	Z – statistics 7.829***	Reject There are significant differences at 1 %

4. CONCLUSION AND RECOMMENDATION

The study concludes that participation in the Anchor Borrowers' Programme significantly improved the technical efficiency of rainfed rice farmers in Kaduna State. This is because participants in the programme recorded a higher mean technical efficiency score of 76.88% compared to 61.81% for non-participants, indicating that farmers who participated in the programme utilized their production resources more efficiently. The stochastic frontier results further showed that most of the variation in rice output among both groups was due to technical inefficiency rather than random factors, implying that output can still be increased through better use of available resources. In addition, factors such as education, farming experience, extension contact, cooperative membership, access to credit, and market price played important roles in influencing participation and efficiency levels among farmers. The Z-test result confirmed that there was a statistically significant difference in technical efficiency between participants and non-participants at 1 percent level, leading to the rejection of the null hypothesis.

Based on the findings, it is recommended that;

I. The Anchor Borrowers' Programme should be expanded to cover more rice farmers through improved access to credit, subsidized inputs, and timely support services.
II. Extension services and cooperative membership should be strengthened to improve farmers' access to information, technology, credit, and better production practices.

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