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Technical Efficiency of Rain-fed Lowland Rice Production in Niger State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author GB designed the study, wrote the protocol and supervised the work. Authors SA and OY performed the statistical analysis. Author AJT managed the literature searches and edited the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Aims of the study were to determine the technical efficiency of rain-fed lowland rice producers and factors influencing technical efficiency of rain-fed lowland rice producers in Niger State.
Study Design: Primary data were collected from rain-fed lowland rice producers through the use of structured questionnaires.
Place and Duration of Study: This study was carried out in three local government areas comprising nine villages in Niger State, Nigeria during 2014 cropping season.
Methodology: Multistage purposive and random sampling techniques were employed for data collection.
Results: The mean technical efficiencies were 63%. Findings further revealed that none of the sampled rice farms reached the frontier threshold. However, variables included in the model for the efficiency effects were seed, fertilizer, labour and agrochemical. The parameters of the stochastic

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frontier production function were estimated simultaneously with those of the model of inefficiency effects. Results indicated that farm size, fertilizer and labour were significant (p<0.01).
Conclusion: Findings further revealed that none of the sampled rain-fed lowland rice farms reached the frontier threshold. Also, household size, educational status, farming experience and cooperative membership were the socio-economic variables responsible for the variation in technical efficiency of the rain-fed lowland rice producers. It was therefore recommended that timely and adequate supply of fertilizer and labour should be made available to farmers at affordable price in order to enhance the production of rice in Niger State.

Keywords: Technical efficiency; rain-fed; lowland; rice; stochastic production frontier; Niger State.

1. INTRODUCTION

Agriculture provides employment opportunities for the teeming population, eradicates poverty and contributes to the growth of the economy [1]. Despite these however, the sector is thus characterized by low yields, low level of inputs and limited areas under cultivation [2,3]. It involves small scale farmers scattered over wide expanse of land area, with small holding ranging from 0.5 to 3.0 hectare per farm land. It is characterized by rudimentary farm systems, low capitalization and low yield per hectare [4]. The roles of agriculture remain significant in the Nigeria economy despite the strategic importance of the oil sector. Agriculture provides primary means of employment for Nigeria and accounts for more than one third of total Gross Domestic Product (GDP) and labour force [5].

The Contribution of agriculture to Nigeria's Gross Domestic Product (GDP), which stood at an average of 56% in 1960-1964 decline to 47% in 1965-1969 and further decline to 35% in 2002-2004 and with crop production accounting for an estimated 85% of this total, the agricultural sector provides a livelihood for the bulk of the rural population [6]; Provides up to 70% active labour force [7;8], supplies raw materials required by the industrial sector and generate foreign exchange through export. In spite of this, agricultural production has failed to meet the food needs of the country's rapid growing population [9].

According to [10], the Nigerian rice sub-sector witnessed a remarkable increased in output from 2.5 million metric tonnes in 1990 to about 4.2 million metric tonnes in 2008. This increase in output of rice over the years was as a result of increase in hectarage cultivated. However, there has been fall in yield of rice in Nigeria from 2069.54 kg per hectare in 1990 to 1754.40 kg per hectare in 2008 [10]. This fall in yield of rice led to supply deficit situation in the country.

The Nigerian government has embarked on an ambitious plan to make the country self-sufficient in rice production by 2015 under its current Agricultural Transformation Agenda, or ATA [11]. This initiative is in response to the perceived threat of larger volumes of milled rice imports into Nigeria since the 1990s, potentially displacing local production. According to [12], local production has not been able to meet a growing appetite for rice consumption, the share of domestic production having declined from 75 percent in the 1990s to 53 percent in 2012. By 2013, the import bill was close to US$2.2 billion [13]. As elsewhere in West Africa, the rice import bill rose sharply following the 2008 global food price hikes, and Nigeria, like many other countries, was left feeling vulnerable to future shocks in global rice prices.

Despite rising global prices, domestic demand for rice has been growing at a rapid pace in Africa in general due to changing consumer preferences, rising incomes, and growing urban populations [14]. As a result, in no African country has production been able to keep pace with demand, and countries instead have come to rely on imports to make up the difference. The growing dependency on rice imports threatens to deplete a country's scarce foreign currency reserves, increases its vulnerability to global price shocks, and raises overall concerns about food insecurity.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in some selected Local Government Areas of Niger State, Nigeria. The State is divided into 25 Local Government Areas. It is located between latitude 80° to 11° 30 [1]North and Longitude 03° to 7° 40 [1] East [15]. It occupies a land area of approximately 76, 469.903 square kilometers or about 10% of Nigeria's land mass [15]. The state has an estimated population of

3,950249 [15]. This gives the state a population density of about 33 per square kilometer, the lowest in the country. The estimated projected population of the state at 3% growth rate per annum in 2014 is 4,898,309. The State has a tropical climate marked by dry and wet seasons. The rainy season commences in April and ends in October. The dry season begins from November and ends in March. It has a mean annual rainfall of 1000 mm and mean temperature of 33.5℃. The State is characterized by Guinea Savanna vegetation with trees like sheabutter and locust bean [16].

The State is endowed with fertile agricultural land and has the capacity to produce most Nigerian staple food (such as rice, maize, sorghum, soybean, groundnut, yam, pepper, tomatoes and livestock such as goat, poultry, cattle and sheep).

Niger state is popular for its brass work, particularly in Bida. It is also known for pottery, weaving and several cottage industries which can be found throughout the state. However, there are 3-prominent ethnic group, Nupe, Gbagi (Gwari) and Hausa. Other ethnic group includes, Kamberi, Kamuku, Gade, pangu and Ingwai [16].

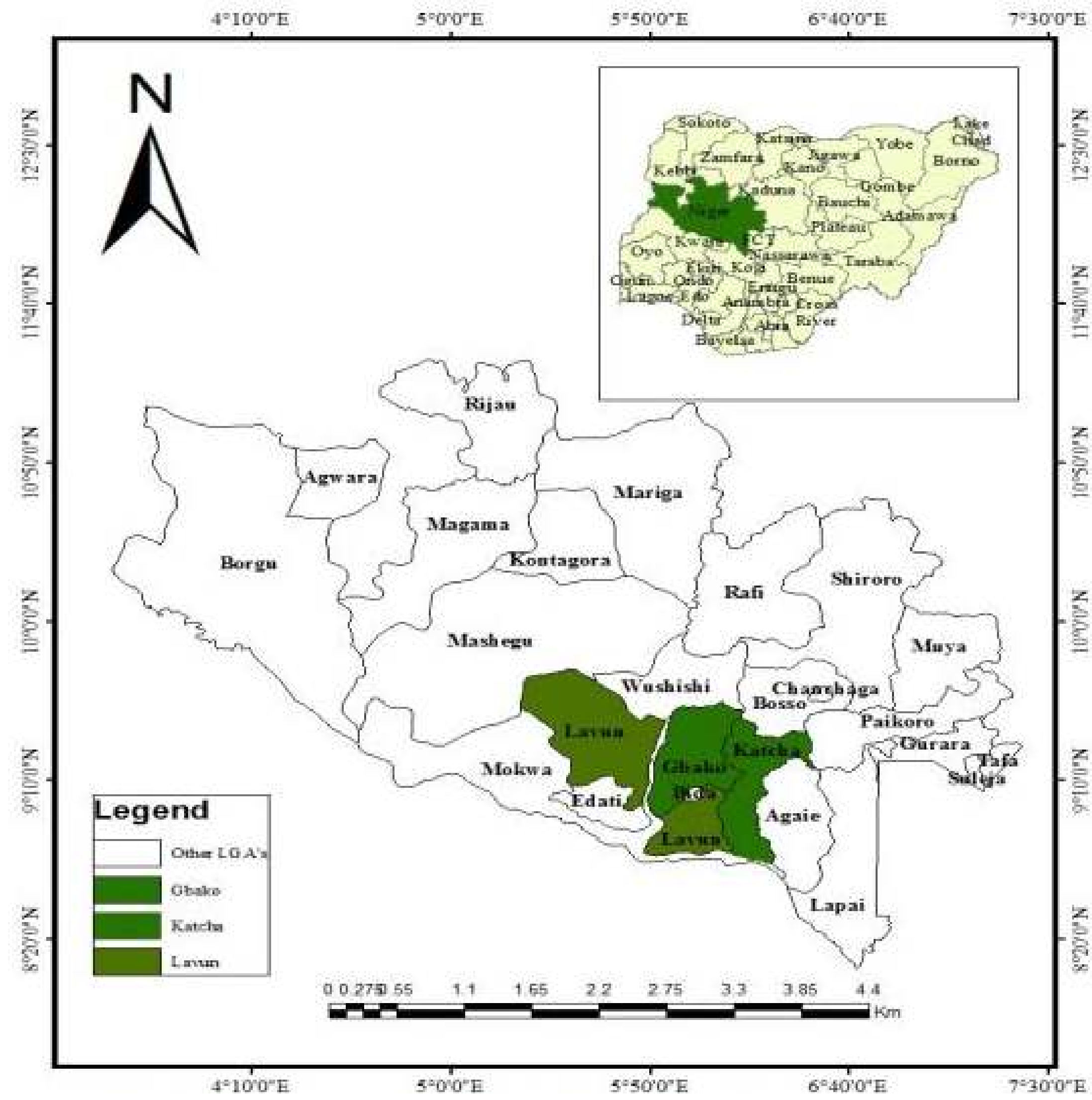

Fig. 1. Map of Niger State showing the study areas
Source: BBGIS consult, 2015

2.2 Sampling Procedure

A multistage sampling technique was used to select respondents for this study. The first stage involves a purposive selection of the three local governments based on dominance of rain-fed lowland rice production among the farmers. Secondly, nine villages was randomly selected, three from each local government area. Finally, a proportional sampling was employed in selecting farmers from each of the villages. Ten percent (10%) of the sample frame (1532) was used as the sample size. In all, 154 farmers were proportionally selected.

2.3 Data Collection and Analysis

Primary data were used for this study. These were collected with the aid of structured questionnaire, using interview method. The information was collected on (a) farmers' socio-economic characteristics such as age, household size, educational level, farming experience, amount of credit received, numbers of extension contact, cooperative membership, farm size and off-farm income. (b)Production data: input (seed (kg), fertilizer (kg), labour (man-days) and agrochemical (litres)) and output (rice (kg/ha)) data.

2.4 Model Specification

The production function of the model is specified as:

$$\ln Y = \beta o + \beta_1 \ln X_1 i + \beta_2 \ln X_2 i + \beta_3 \ln X_3 i + \beta_4 \ln X_4 i + \beta_5 \ln X_5 i + (Vi-Ui)$$

Where:

ln = the natural logarithm
Y = output of rice (kg)
βo = constant term
β_1- β_3 = regression coefficients
X_1 = farm size (hectares)
X_2 = quantity of seed (kg)
X_3 =quantity of fertilizer (kg)
X_4 = total labour used (man-days)
X_5 = quantity of agrochemical (litres)
Vi = random variability in the production that cannot be influenced by the farmer.
U_i = deviation from maximum potential output attributable to technically inefficiency.

The inefficiency of production, $U_{i,}$ was modelled in terms of the factors that are assumed to affect the efficiency of production of farmers. These factors are the socio-economic and management variables of the farmers. The determinants of technical inefficiency are defined by:

$$U_i = \delta_0 + \delta_1 1nZ_1 + \delta_2 \ln Z_2 + \delta_3 \ln Z_3 + \delta_4 \ln Z_4 + \delta_5 \ln Z_5 + \delta_6 \ln Z_6$$

Where:

U_i = inefficiency effect
δ_0 = constant
δ_1-δ_6 = Parameters to be estimated.
Z_1 = age of farmer (years)
Z_2 = household size (number of person in the household)
Z_3 = formal education (years)
Z_4 = amount of credit (Naira)
Z_5 = access to extension services (number of times of contact)
Z_6 = membership of cooperative (years)

3. RESULTS AND DISCUSSION

The model specified was estimated by the maximum likelihood (ML) method using FRONTIER 4.1 software developed by [17]. The ML estimates and inefficiency determinants of the specified frontier are presented in Table 1. The study revealed that the generalized log likelihood function was -130.759. The log likelihood function implies that inefficiency exist in the data set. The log likelihood ratio value represents the value that maximizes the joint densities in the estimated model. Thus, the functional form that is, Cobb-Douglas used in this estimation is an adequate representation of the data. The value of gamma (γ) is estimated to be 30% and it was highly significant at ($p<0.01$) level of probability. This is consistent with the theory that true γ-value should be greater than zero. This implies that 30% of random variation in the yield of the farmers was due to the farmers' inefficiency in their respective sites and not as a result of random variability. Since these factors are under the control of the farmer, reducing the influence of the effect of γ will greatly enhance the technical efficiency of the farmers and improve their yield. The value of sigma squared ($\boldsymbol{\sigma^2}$) was statistically significant at ($p<0.01$) level of probability. This indicates a good fit and correctness of the specified distributional assumptions of the composite error terms while the gamma γ indicates the systematic influences that are unexplained by the production function and the dominant sources of random error. This means that the inefficiency effects make significant contribution to the technical inefficiencies of rice farmers.

Table 1. Results of maximum likelihood estimates of stochastic frontier production function of rice production

Variables	Parameters	Coefficients	Std. error	T-value
Production function				
Constant	β_0	6.565	0.269	24.339***
Farm size	β_1	0.296	0.051	5.760***
Seed	β_2	-0.336	0.033	-1.000
Fertilizer	β_3	0.156	0.095	1.651*
Labour	β_4	0.233	0.074	3.128***
Agrochemical	β_5	0.197	0.137	1.438
Inefficiency model				
Constant	Z_0	-30.073	11.197	2.686***
Age	Z_1	0.175	0.110	1.585
Household size	Z_2	0.556	0.159	3.487***
Educational status	Z_3	-1.283	0.339	-3.775***
Farming experience	Z_4	-0.534	0.143	-3.725***
Cooperative membership	Z_5	-0.813	0.221	-3.681***
Extension contact	Z_6	-0.336	0.223	-1.506
Diagnostic statistic				
Sigma-square	($\boldsymbol{\sigma^2}$)	0.146	0.038	3.820***
Gamma	**(γ)**	0.301	0.097	3.105***
Log likelihood function	*L/f*	-130.759		
LR test	171.92			
Total number of observation	153			
Mean efficiency	0.63			

****= P<0.01, **= P<0.05 and *= P<0.1%.*

However, the estimated coefficients of farm size, fertilizer and labour were positive and significant at 1% and 10% level of probability and hence play a major role in rice production in the study area while the estimated coefficients of seed and agrochemical was statistically not significant. The average technical efficiency for the farmers was 0.63 implying that, on the average, the respondents are able to obtain 63% of potential output from a given mixture of production inputs. Thus, in a short run, there is minimal scope (37%) of increasing the efficiency, by adopting the technology and techniques used by the best rice farmer.

The estimated coefficient of farm size was 0.296 which is positive and statistically significant at 1% level. The implication of the positive coefficient of farm size is that it contributes positively to technical efficiency in rice farming in the study area and a unit increase in farm size will increase rice output. This is in line with findings of [18], who revealed that there is a positive and significant relationship between farm size and farmers' efficiency in production.

The estimated coefficient for seed was -0.336 which is negative and statistically not different from zero. The estimated -0.336 elasticity of seed implies that increasing seed by 1% will decrease rice output by less than 1% which means, all things being equal the output is elastic to changes in the quantity of seed used. The significance of seed quantity is however, due to the fact that seed determines to a large extent the output obtained. If correct seed rates and quality seeds are not used, output will be low even if other inputs are in abundance. This is at variance with the findings of [19] who observed that the estimated coefficient of seed and labour inputs were positive as expected and significant at 1% level which implies that the more seed is applied and the more labour employed the better the output of rice.

The estimated coefficient for quantity of fertilizer was 0.156 which is positive and statistically significant at 10% level. This implies that a 1% increase in fertilizer will increase rice output by 15.6%. Fertilizer is a major land augmenting input because it improves the quality of land by raising yields per hectare. This study is in agreement with the findings of [20,21].

The coefficient of labour was 0.233 which is positive and statistically significant at 1% level. This shows that labour is an important variable in rice farming in the study area. This is in line with several studies by [22] and [23] which show the importance of labour in farming, particularly in developing countries where mechanization is rare on small scale farms. In the study area, human power plays a crucial role in virtually all farming activities. This situation has variously been attributed to the practice of split-plot cropping on small scattered land holdings and lack of affordable equipment [22].

The estimated coefficient of agrochemical was 0.197 which is positive and statistically not different from zero. This implies that an increase in agrochemical to a certain level will increase technical inefficiency by 19.7%. This study is in agreement with the findings of Maurice [20].

The estimated result of the inefficiency model is contained in Table 1. Generally, a negative sign on a parameter means that the variable reduces technical inefficiency, while a positive sign increases technical inefficiency. The results show that all the technical inefficiency variable except age and extension contacts were statistically significant at 1% level of probability.

The coefficient of household size was positively signed with technical inefficiency and statistically significant at 1% level of probability. This implies that a unit increase in household size of rice farmers will leads to increase in technical inefficiency, thereby reducing the rice output. The implication of large household size is that it will increase household consumption expenditure which would compete with production for limited financial resources within the household.

Years of education showed a negative relation with technical inefficiency and are significant at 1% level for rice farmers. The negative coefficient of education reveals that a high level of education results in a reduction in technical inefficiency of rice farmers. [24] noted that education is one of the socio–economic variables that greatly affect farmers' decision to accept and adopt modern farm technologies. Also, [24] observed that education sharpens managerial input and leads to a better assessment of the importance and complexities of good decisions in farming. It also implied that education widens the scope of farmer's horizon towards adoption of technological innovation, thereby moving him away from traditional practices to adopt technological concepts.

Experience in rice production was negative and significant at 1% for rice farmers. This shows that increase in experience in rice production would reduce technical inefficiency. Farmers' experience could be associated with skill accumulation which could enhance productivity and resource allocations thereby reduce technical inefficiency.

Membership of cooperative was negative and significant at 1% level of probability for rice farmers. The negative coefficient for membership imply that membership of association reduces technical inefficiency in rice production. Membership of association could affords the farmers the opportunity of sharing information on modern farming practices by interacting with other farmers. [24] noted that the reduction of inefficiency effects through farmers belonging to cooperatives is linked to cooperatives being a source of good quality inputs, information and organized marketing of products. This implied that rice farmers can market their produce through cooperative societies for higher profit and income.

4. FREQUENCY DISTRIBUTION OF RAIN-FED LOWLAND RICE FARMERS ACCORDING TO TECHNICAL EFFICIENCY ESTIMATES

The frequency distribution of the technical efficiency estimates for rice farmers in the study area as obtained from the stochastic frontier model is presented in Table 2. It was observed from the study that about 64% of the farmers had technical efficiency (TE) of 0.61 and above while 36% of the farmers operated at less than 0.6 technical efficiency levels. The farmer with the best and least practice had technical efficiencies of 0.85 and 0.32 respectively. This implies that on the average, output fell by 38% from the maximum possible level attainable due to inefficiency.

Table 2. Frequency distribution of technical estimates from the stochastic frontier model of lowland rice farmers

Technical efficiency	Frequency	%
<0.2	14	9.15
0.21-0.40	13	8.50
0.41-0.60	28	18.30
0.61-0.80	55	35.95
0.81-1.00	43	28.10
Total	**153**	**100**
Mean	0.63	
Minimum	0.32	
Maximum	0.85	

The study also suggest that for the average farmer in the study area to achieve technical efficiency of his most efficient counterpart, he could realize about 48% (1-0.62/0.85*100) cost savings while on the other hand, the least technically efficient farmers will have about 80 percent (1-0.24/0.84*100) cost savings to become the most efficient farmer. This finding is in line with (2) who observed that average farmer in Kaduna State would enjoy cost saving of about 20% if he or she attains the level of the most efficient farmer among the respondents in the study area.

5. CONCLUSION

Based on the findings of this study, the estimated mean technical efficiency was 0.63 and it is evident here that, the rain-fed lowland rice production systems in the study area did not reach the frontier of production. The mean technical efficiency estimates was 0.63 with about 64% of the farmers having an efficiency level above 0.60. This implies that about two-third of the sample rice farmers had technical efficiency above 0.60. This result agrees with the finding of [25]. Who in their studies Technical Efficiency of Rice Production at the Tono Irrigation Scheme in Northern Ghana revealed mean technical efficiency was 0.81 with the majority of the farmers recording efficiency levels above 0.60. Education level, farming experience, extension contact and access to credit are major socio-economic determinant of technical efficiency in lowland rice production. These factors tend to reduce inefficiencies as we improve on them. The implication of the study is that technical efficiency in farm production among the farmers could be increased by 39% through better use of available resources given the current state of technology. This can be achieved through improved farmer-specific factors.

6. RECOMMENDATIONS

It was observed from the result that no single rice farm is able to attain the frontier of rice production; hence there is the presence of inefficiency. In other to raise efficiency level, there is need for the commitment of non-governmental organization and government in the provision of inputs such as agrochemicals, seeds and farm implements at affordable rates.

Fertilizer is one of the inputs that positively and significantly influence rice production in the study area. Therefore, government should ensure timely and adequate supply of fertilizer to farmers through its e-wallet (GESS) programme at affordable prices in order to enhance the production of this crop.

Extension service should be intensified to educate and encourage farmers to adopt modern cultural practices in order to reduce cost of inputs and promote efficient utilization of existing knowledge and skills to increase their yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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ECONOMIC ANALYSIS OF RAIN-FED LOWLAND RICE PRODUCTION INSELECTED LOCAL GOVERNMENT AREAS, NIGER STATE

Dear Respondent,

This questionnaire will be used by a student of Department of Agricultural Economics and Rural Sociology, Faculty of Agriculture, Ahmadu Bello University, Zaria. Please, respond or tick where necessary. All information will be treated with utmost confidentiality and will strictly be used for the purpose of research only. Thanks for your cooperation.

Instruction: Kindly tick (√) or fill in the blank spaces as appropriate

SECTION A

Background Information of the Farmer

Questionnaire No……………..….. Name of Respondent……………………………
Village…………………………………… L.G.A…………………… Date……../……../2015.

SECTION B

Socio-economic Characteristics of the Farmer

1. Sex: Male ( ) Female ( )
2. Age of respondent (years): ………………………………………………….
3. Marital status: (a)Single ( ) (b) Married ( ) (c) Widow ( ) (d) Widower ( ) (e) Divorce ( )
4. Household size: ……………………………………………………………….
5. Family Size (All the number of the people depending on you for living)…………….
6. (a) No of Adult Male ( ) (b) No of Adult female ( ) (c) Children >15yrs ( ) (d) Children <15yrs ( )
7. Highest level of Education: (a) No Formal Education ( ) (b) Primary Education ( ) (c) Secondary Education ( ) (d) Tertiary Education ( ) (e) Quranic Education ( )
8. How long have you been in rice farming? (Years of experience)…………………….
9. Do you belong to any co-operative/Association?

   Yes ( ) No ( )
10. If yes, (Years of participation) ------------------------
11. What benefit did you derive as a member? …………………………………..
12. What is your major source of capital for rice farming?

    (a) Personal savings ( ) (b) credit (borrow) ( ) (c) Friends and family ( ) (d) Money Lenders (Borrow) ( ) (e) Association/Co-operative society ( )

13. If you borrow, what were the sources of the credit?

    (a) Commercial bank ( ) (b) Bank of Agriculture ( ) (c) Cooperative Society ( ) (d) Money Lenders ( ) (e) Friends and Family ( ) (f) others (specify) …………………………….

14. How much did you borrow to finance last production? (Fill for the source you indicated in the question above)

Source of loan	Amount(₦)	Interest Rate (%)
Commercial Bank		
Bank of Agriculture		
Cooperative Societies		
Money Lenders		
Friends And Family		
Others (Specify)		

15. Have you been visited by an extension agent? Yes ( ) No ( )

16. If Yes, How many times in last one year? ……………………..

17. What activities did the agent teach you from the visit? ....

18. Of what benefit were the techniques learnt to you to the success of your farm? ....

19. Have you been trained on rice farming?

    Yes ( ) No ( )

20. If yes, which organization conducted the training? ………………………

21. Was the training beneficial to you?

    (a) Not beneficial ( ) (b) somehow beneficial ( ) (c) beneficial ( ) (d) very beneficial ( )

22. How many rice farm plots do you have? .... Please indicate the size in the table below.

Plot no	Plot size (Ha)
1	
2	
3	

23. How did you acquire your land? *(Please Tick below)*

    (a) Inheritance………. (b) Lease …………… (c) Borrowed………… (d)Purchased……….. (e) Gift…..

24. What does it cost to rent one Hectare of land per season in your village? .... Naira

25. What is the quantity of seed you used?

Plot no	Quantity of seed (Kg)	Cost (₦)
1		
2		
3		

26. What is the quantity and type of fertilizer you used?

Plot no.	Fertilizer type	Quantity (kg)	Cost (₦)
1			
2			
3			

27. What is the quantity and type of agrochemical used?

Plot no	Agrochemical type	Quantity(Litres)	Cost(₦)
1			
2			
3			

28. Please indicate the cost and type of labour for Land preparation

Plot no	Hire labour			Family labour		
	No of people	No of hours	Cost (₦)	No of people	No of hours	Cost (₦)
1						
2						
3						

29. Please indicate the cost and type of labour for Planting

Plot no	Hire labour			Family labour		
	No of people	No of hours	Cost (₦)	No of people	No of hours	Cost (₦)
1						
2						
3						

30. Fertilizer Application

Plot no	Hire labour			Family labour		
	No of people	No of hours	Cost (₦)	No of people	No of hours	Cost (₦)
1						
2						
3						

31. First Weeding

Plot no	Hire labour			Family labour		
	No of people	No of hours	Cost (₦)	No of people	No of hours	Cost(₦)
1						
2						
3						

32. Second Weeding

Plot no	Hire labour			Family labour		
	No of people	No of hours	Cost(₦)	No of people	No of hours	Cost (₦)
1						
2						
3						

33. Harvesting

Plot no	Hire labour			Family labour		
	No of people	**No of hours**	**Cost (₦)**	**No of people**	**No of hours**	**Cost (₦)**
1						
2						
3						

34. How much do you pay to transport rice output per bag? …………………………

35. Rice output

Plot no	No. of output produced (Kg)	Total qty sold (₦)	Price/unit (₦)
1			
2			
3			

36. Information on other crops

Plot no	Types of crop grown	Number of output produced in (Kg)	Total Qty sold (₦)	Price/Unit	Total cost incurred (₦)	Profit (₦)
1						
2						
3						

37. Where do you sell your produce?

(a) At the Farm ( ) (b) Rural market ( ) (c) Urban market ( )

38. When do you sell your produce?

(a) Immediately after harvesting ( ) (b) Few months after harvest ( ) (c) Off season ( ) (g) what are the constraint faced and coping strategy used during the production of rice?

S/n	Constraints	Ranking according to severity 1=least severe, 2=moderately severe, 3= severe, 4= more severe, 5= most severe.	Coping strategy
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Thank you for your attention.

Peer-review history:
The peer review history for this paper can be accessed here:
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