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RESOURCE-USE EFFICIENCY OF RAIN-FED RICE FARMERS IN DASS LOCAL GOVERNMENT AREA

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ABSTRACT

A survey was conducted to estimate the resource-use efficiency using stochastic frontier model for rice farmers in Bauchi State, Nigeria. The population for the study consisted of all category of rice farmers in the area. A multi-stage sampling technique was used to select 400 farmers for the study. A semi-structured questionnaire was used to collect data from respondents. Descriptive statistics and Maximum Likelihood Estimation (MLE) method were used to analyzed the data. The average rice output for all categories was 1094.04kg per hectare. The result of the study further revealed that farm size, agrochemicals and quantity of rice seed planted all had significant influence on the output of rice at (P<0.001), whereas, quantity of fertilizer applied had significant influence on output at (P<0.01). Fertilizer and quantity of seed planted affected the rice output negatively. The study concluded that, farmers have not reached the maximum technical efficiency level.

Keywords: *Technical efficiency; stochastic frontier; resource use efficiency; rain-fed rice.*

Introduction

Rice production can be increased primarily through improving crop productivity, which can be achieved by making better use of available resources to the farmer. If farmers utilize inputs like land, capital and agrochemicals judiciously, optimal resource use could enhance greater yield and even increase profit margins. Nigeria has a great potential to produce rice both in the dry and wet seasons as reported by Adewuyi and Amurtiya (2021). The country's total arable land area is thought to be around 82 million hectares, of which 4.6 million hectares are cultivated for paddy cultivation. However, the country's existing production variations demonstrate how insufficient the Nigerian rice economy can produce to meet domestic demand. This is due to the fact that the country's rice farmers are unable to maximize the return on their investment in the enterprise. Low resource-use efficiency by farmers could be held responsible for the Nigerian rice sector's limited ability to meet domestic demand. Domestic rice production lags behind the demand for the commodity and central to this explanation is the issue of technical efficiency of the rice farmers in the use of resources (Ataboh *et al.*, 2014).

Rice production in Nigeria and also in Dass Local Government Area is mainly in the hands of small-scale resource farmers who are still using unimproved farming methods. As reported by Garba in Abdulhamid (2020),farmers in the area complain of unavailability and high cost of labour, and high use of crude implements in rice production. Lots of farmers conduct their farming activities based on habit and experience. This might be caused by several problems in farmer environment, such as lingering socio-economic condition and inefficiency in resource- use and poor access to inputs (high quality seed, fertilizing and crop protection products). This has declined the rice productivity in Nigeria and especially in the area.

Due to inefficient resource use, macroeconomic environment disincentives, and production being controlled by small-scale farmers who adopt traditional technologies, the Nigeria rice subsector's inability to meet domestic demand could be understood. (Angulu *et al*., 2012)

Making efficient use of the essential production factors, such as labour, land, and capital resources, is necessary for rain-fed rice production to continue to grow sustainably in Nigeria and in Dass Local Government Area. As a result, farmers can increase rice production if they use the resources at their disposal in an effective manner. (Ugwu *et al.*, 2017).

A study on the resource use efficiency of rice farmers is crucial due to the limited capacity of the Nigerian rice sector to meet domestic demand and some pertinent challenges. Therefore, the broad objective of this study is to determine the technical efficiency for rice production in order to investigate factors influencing resource-use of rain-fed rice farmers in Dass Local Government Area of Bauchi State.

Objectives of the Study

The main object of the study was to determine the resource-use efficiency of rain-fed rice farmers in Dass Local Government Area of Bauchi State.
Specifically, the study intends to:

i. Describe the socio-economic characteristics of rice farmers.
ii. Describe the quantity of variable inputs used per hectare of rice production.
iii. Determine the technical efficiency of resource used by rain-fed rice farmers.

MATERIALS AND METHODS

The Study Area

According to Bose *et al.*, as cited by Abdulhamid (2020), Dass local Government Area (LGA) of Bauchi State lies in the Northern Guinea Savanna ecological zone of Nigeria, at about8^{O}40'–9^{O}30'North,and11^{O}–8^{O}50'East.The area of the LGA is approximately 456737 km², while the population is estimated at 86000 inhabitants, which represents only approximately 0.69% of that of the state .Due to geographical advantages, annual rainfall is relatively higher than in other parts of the state, ranging from

1000 to 1300mm.The weather consists of 5 months of humid season and 7 months of dry season. Major land uses are: agriculture, with frequent scattered or dense shifting/cyclic cultivation. Like other rural areas in Nigeria, the major livelihood activities include: farming, fishing, hunting, and carving. Farming practices and tools are pre-dominantly based on indigenous traditional knowledge .There is an established pattern of field crops cultivation and animal husbandry. The major crops include sorghum, rice (in commercial quantities), millet, cowpea, sweet potato, cassava, cotton, groundnut and vegetables.

Sampling Technique

This study's respondents were chosen using a multistage sampling process. First, the target population was determined and classified based on the farmers' agricultural production method (that is rain-fed rice farmers only). The following level of stratification was determined by the method of rice planting, which was either broadcasting, direct seeding, or sowing and transplanting. The districts where predominantly rain-fed rice is grown were the next level of stratification. Dass Local Government Area was purposefully chosen from among Bauchi State's twenty local government areas due to its comparative advantage in rice production over other local government areas in the state. Eight out of the twelve districts were selected as the sample list.

Method of Data Collection and Analysis

The study was a cross-sectional survey and involved the collection of primary data using semi-structured questionnaire. The information gathered covered the farmers' socioeconomic characteristics (age, gender, family size, years of formal education, farming experience, household size, land ownership system, accessibility to credit facilities, and so on), production inputs used such as farmland size (ha), labor (man-days and quantities), rice seed (kg), fertilizer (kg), and herbicide (litres), and paddy rice harvested output (kg).

The data was subjected to normality test in order to remove the outliers which reduced the number of respondents to 357 from 400. The study employed descriptive statistics and frontier production methods of analysis.

Model Specification

The Cobb-Douglas production function used in this study is specified in its line arized form as:

$$InY_{ij}=Inß_0+Inß_1X_{1ij}+Inß_2X_{2ij}+Inß_3X_{3ij}+Inß_4X_{4ij}+Inß_5X_{5ij}+V_{ij}–U_{ij} \quad ...(1)$$

where;

Y=Total farm output of paddy rice in (kg)

X_1= Farm size (hectares)

X_2= Labour input (man-days)

X_3= Quantity of fertilizer (kg)

X_4=Quantity of seed planted (kg)

X_5= Quantity of Agrochemicals (litres)

$ß_0 – ß_5$ = regression coefficients to be estimated.

V_{ij}= normal random error assumed to be independently and identically distributed, having$N^{\sim}(0,\delta^2)$.

RESULTS AND DISCUSSION

I. Socio-economic Status of Rain-fed Rice Farmers

Table 1: Distribution of the socio-economic characteristics of rain-fed rice farmers.

Variables	Frequency	Percent (%)	Chi-sq. n=357
Maximum Years of Formal Education			
None (Never been to school)	21	5.9	
1 – 4 years	14	4.0	
5 – 8 years	100	28.0	285.003***
9 –13 years	150	42.0	(9.78)
14 – 18 years	72	20.2	
Farming Experience (Years)	357	100	(8.163) 137.681***
Frequency of Extension Contact Per Production Season			
No Contact per season	109	30.5	
Once only	89	24.9	
Twice	93	26.1	
Three Times	55	15.4	342.742***
Four Times	09	2.5	
Five Times and above	02	0.6	
Household Size			
1- 4 persons	84	23.5	
5 - 9 persons	130	36.8	
10 - 14 persons	93	26.0	216.242***
15 - 19 persons	33	9.3	(8.0)

20 - 24 persons	10	2.8	
25-29 persons	05	1.4	
No Response	02	0.6	
Total Farm Size			
1.0-2.9 hectares	257	71.2	
3.0 – 4.9 hectares	64	20.0	614.118***
5.0- hectares and above	29	8.8	(2.29)

Source: Field Survey, 2015
Note: Figures in parenthesis ( ) are mean of the variables

Years of formal education

The average number of years of formal education as revealed by this study was 9.78 years. This shows that the average formal education level of rice farmers was lower than high school level. Understanding the knowledge level of farmers is vital because education improves the individual's quality of life and offers him/her access to employment and income. The chi-square value was statistically significant (P 0.001), indicating that there was a significant difference in the years of formal education frequency distribution variable under investigation.

Farmers' ability to adopt new technologies will be aided by the level of education they have attained. For a proper understanding of how most modern implements work, skilled training and manual reading are required. Oladimeji and Abdulsalam (2013) asserted that a farmer's chances of using more innovative inputs could be impacted by their education.

Years of farming experience

Most farmers who cultivate rice with rainfall are between the ages of 39 and 49. Considering this finding, most rice farmers will presumably be conservative, especially in areas without efficient extension services. It is postulated that farmers with more experience will have higher success rates. Farmers with more experience are more likely to accept innovations that would enhance their technical efficiency in resource use. The aforementioned conclusion is in line with that of Ugwu et al. (2017), who contended that it has long been common practice to distribute rice farmers according to one's level of farming knowledge and experience.

Frequency of agricultural extension contact

Thirty-five percent (30.5%) of the rain-fed rice farmers in the Dass LGA reported having no contact with agricultural extension agents. In the absence of effective and efficient extension services, farmers are compelled to rely solely on their personal farming experience as the best teacher. This can have a big impact on how efficiently resources are being used.

Household size

With regard to household size, 130 respondents' household size (36.8%) falls within the range of 5-9 persons while93 farmers (26.0%) had 10-14 persons per household. Those farmers who had less than five persons per household were only (23.5%). 33 respondents (9.3%) had 15-19persons per household. Furthermore, the result indicated that 15 respondents (4.2%) had 20 and above persons per household. The mean household size was approximately eight.

The cost of employing labourers for every stage of the rice production process, from land clearing to harvesting it, is indeed a significant factor in operating costs. Thus, according to Ugwu et al. (2017), more household members partake in labour. This is consistent with Umeh et al. (2013) study, which found that farm households generally maintain large family sizes.

Farm size

Based on the research authors' estimates, as shown in Table 2, 71.2% of farmers have farms that are smaller than five hectares. The fact that so many farmers cultivate only small plots of land in such a situation does not encourage mechanization or subsistence agricultural production. However, most of the farm families in the study area had small farms of up to 2.5 hectares in size. Agricultural policies are typically implemented in favor of large-scale farmers due to the assumption that they are more technically proficient than small-scale farmers. Abdullahi *et al*(2012) observed that, the size of farmland determines the extent to which other resources (capital, labour and so on) are used for optimum productivity. But the majority of farming families in their study area had small farm holdings of 2.5 ha or less.

II. Inputs Used for Rain-Fed Rice Production

Table 2: Distribution of inputs used for rain-fed rice production

Source: Field Survey, 2015

	Factors of Production	Min.	Max.	Mean	Std. Dev.	Percentiles 25th	50th	75th	Chi-Square n=357
a.	Total Farm Size (ha)	1	9	2.29	1.508	1.00	2.00	3.00	614.118***
b.	Quantity of rice seed planted (kg) per hectare	45	200	127.73	70.014	99.00	105.00	150.00	1766.134***
c.	Quantity of herbicides, insecticides & pesticides applied (litres)	3	7	4.36	3.822	2.50	2.50	4.00	1849.373***
d.	Quantity of fertilizer used (kg) per hectare	50	175	100.69	6.208	50.0	100.00	130.00	1069.555***
e.	Labourers used per production season	85	183	123.87	4.580	91.20	118.00	122.34	270.815***

Total farm size cultivated (ha)

Seventy-five percent of the rain-fed rice farmers cultivated 1-3 hectares of land. The difference between the actual and expected farm size was significantly different, as per chi-square analysis. The amount of land that farmers cultivate is crucial because it affects the crop population and harvest yield. This implies that the farm units were generally economically viable for mechanization. The adoption of new farming techniques and the amount of farmland that farmers own are significantly correlated, as lamented by Mustapha et al. (2012).

Quantity of rice seed planted (kg)

Rice farmers usually planted 85 to 150 kg of rice per hectare; 25 to 75 % of them broadcast 99 to 150 kg of rice per hectare. Broadcasting, transplanting, and direct seeding are the three main types of sowing. The first two methods that allow straight-row planting are recommended practices. Kijima *et al.* (2011) found for large sample rice farmers that the average seeding rates of four groups of farmers ranged from 85 to 150 kg ha^{-1}. According to Haneishi *et al.* (2011), rain-fed rice producers sowed their fields with an average of 80 kg/ha. Farmers must plant twice as much seed if the recommended rate is desired and their seed germinates at a rate of 50%. The chi-square result showed a significant difference between observed and expected quantity of seed planted ($P<0.001$).

Quantity of herbicides, insecticides and pesticides applied (litres)

The table clearly showed that the minimum, maximum, mean, and standard deviation of the quantity of pesticides used to manage weeds, pests, and other insects were, respectively, 3 liters, 7 liters, 4.34 liters, and 3.82 liters. The first and second quartiles of rice farmers, or 25% and 50%, used 2.5 liters of various insecticides and herbicides per hectare, while the third quartile, which included 75% of rice farmers and below, utilized 4 liters of various chemicals. It was also found that the chi-square result was significant (P 0.001). The expansion and growth of rice seeds can be greatly impacted by the agrochemicals employed by the sampled farmers. This is because the plant is affected by either an overdose or an underdose.

The chemicals sampled by farmers are classified into three groups: herbicides for weeding and insecticides and pesticides for insect and pest control. According to a study by Sanzidur and Chidiebere (2018), Pesticides are used by farmers to reduce the amount of labour required for various farm operations and ploughing activities. Farmers treat pesticides as substitutes for labour and tillage services. An increase in the price of rice would lead to a significant increase in pesticide use.

Quantity of fertilizer dosage applied per (ha)

The row section in the table for quantity of fertilizer applied per hectare indicated that 50kg, 175kg, and 100.69kg and 6.208 were the minimum, maximum, mean and standard deviation respectively. The percentile result showed that 75% of the farmers and below applied 130kg of fertilizer and below against the 250kg per hectare recommended. The chi-square results also indicated a significant difference between observed and expected on quantity of fertilizer applied. Both over and under dosage can affect output of rice cultivated. The implication of the quantity of fertilizer applied by the farmers is that quantity of rice output will be affected negatively. Djomo *et al.* (2017) on a study carried out on the effect of different rates of NPK fertilizer on the growth and yield of rice revealed that the different doses of NPK fertilizer significantly improved the output of rice compared to the control. Thus, with proper fertilization of the rice variety, a better yield will be achieved. Comparing varietal performance, the best yield was obtained with NERICA3 at a dosage of 200 kg of the fertilizer N-P-K (20-10-10) and N-P-K (23 10 05) per hectare while, that of NERICA7 was obtained at a dosage of 220 kg of the two fertilizers. Yields of 6.08 t/ha with N-P-K (20-10- 10) and 5.95 t/ha with N-P-K (23- 0-05) were also obtained. However, at a dosage of 220 kg with N-P-K (20-10-10), NERICA36 had an output of 4.47 and 3.90 t/ha with N-PK (23-10-05). NERICA 42 on the other hand had its best output of 6.36 t/ha with N-P-K (20 10 10) and 5.19 t/ha with N-P-K (23 10 05) at a dosage of 220 kg/ha.

Muhammad (2016), said that although the application of fertilizers, nitrogen fertilizers in particular, is of critical importance to attain higher yields from rice, farmers in sub-Saharan Africa use very little of them, mainly because of high prices of chemical fertilizers relative to rice. In their study area, 47% of sample farmers applied some kind of fertilizers and the rate of application in terms of nitrogen applied was estimated at 11kg ha^{-1} for the total area planted to rice or 23kg ha^{-1} for the area with fertilizer application. There was significant difference in the fertilizer intensity used between small and large-scale farmers: Small farmers applied nearly three times more than large farmers did.

Labour use per production season

The average labour use for the sample rain-fed rice farmers was 123 man-days hour per hectare and per production season. The minimum, maximum and mean of the labour used for rain-fed rice production were 85 and 183 man-days per production season with a standard deviation of 4.58. The percentile range indicated that 25% of the rain-fed rice farmers used 91.2 man-days hour per hectare and per production season with 50% of the farmers using 118.0 man-days hour per hectare and per production season. Majority of the farmers 75% used 122.34 man-days hour per hectare and per production season. There was significant difference in the chi-square analysis ($P<0.001$). this shows that labour input resource-use varies significantly across rain-fed rice farmers in Dass LGA. The farmers' labour is expected to have positive and contributory influence on the level of farm resource-use which can equally affect rice output efficiency. It ranges from 250 to 410 person-days ha^{-1} as reported by (Kijima *et al*., 2011), and from 200 to 430 person-days ha^{-1} in a nation-wide upland rice farmer survey (Haneishi *et al*., 2011).

III. Estimate the Technical Efficiency of Rain-Fed Rice Farmers in the Study Area.

Table 3: Maximum likelihood estimate for parameters of the efficiency stochastic frontier Cobb-Douglas production model for rice farmers.

Variables	Parameters	Coefficient	Std. Err.	t-sig.
Log Farm size (ha)	$ß_1$	0.9094	0.0899	10.12***
Log Labour (man-days)	$ß_2$	-0.3445	0.2022	-1.67^{NS}
Log Fertilizer (kg)	$ß_3$	-0.1569	0.0486	-3.23**
Log Seed planted (kg)	$ß_4$	-0.2412	0.0675	-3.57***
Log Agro-chemicals (litres)	$ß_5$	0.3505	0.0600	5.84***

Source: Field Survey, 2015

Note: ^{NS} not significant, ** = significant at (P<0.01), *** = significant at (P<0.001)

The stochastic frontier Cobb-Douglas production function for rice based on the Maximum Likelihood Estimates (MLE) for the efficiency (Table 6) shows that farm size, agrochemicals have positive coefficients (0.9094 and 0.3505), quantity of rice seed planted had negative coefficient (-0.2412) and all had significant influence on the output of rice (P<0.001), whereas, quantity of fertilizer (-0.1570) applied had significant negative influence on output (P<0.01). The positive coefficient indicated that for efficiency variables, as the quantity of inputs applied increases by a unit, the quantity of rice produces increases by the coefficient of that variables. For example, for every one-unit increase in the quantity of agro-chemical applied, quantity of rice output increases by 0.9094 unit. Whereas, for the negative coefficient, as the quantity of inputs applied increases by a unit, the quantity of rice produces decreases by the coefficient of that variables. The negative coefficient of fertilizer is against a priori expectation as the sign indicates that increase in fertilizer quantity will reduce the level of rice output.

The Cobb-Douglas stochastic production function for rice based on the Maximum Likelihood Estimates (MLE) can also be directly interpreted as elasticities of production as reported in table 6. The table shows an increase return to scale because the total elasticities with respect to the summation of the five production variables was (0.8272), meaning that the values of inputs used in the production of rice should be reduced. Farm Labour (-0.0345), Fertilizer applied (-0.1570) and quantity of seed planted(-0.2412) all had negative coefficients. This implied that a unit increase in farm labour, fertilizer applied and quantity of seed input planted will lead to a decrease in quantity of paddy rice production by (3%, 15% and 24%) respectively. Whereas, farm size (0.9094) and agrochemicals (0.3505) had positive effect on paddy rice production in the area.

Kadiri *et al.* (2014) estimates the Maximum Likelihood (ML) of the stochastic frontier production parameters for rice farmers where coefficients of seed (X_1), labour (X_2), and fertilizer application (X_3) have the desired positive signs and are statistically significant (P<0.001) showing direct relationship with rice output. Also, the parameter estimates by Enwerem and Ohajianya, (2013) of the MLE related to quantity of planting materials (X_1), total quantity of labour used (X_2) and land or farm size (X_4) were statistically significant (P<0.001) for the two farm types. The coefficients for quantity of fertilizer (X_3), and agro-chemicals (X_6) were not statistically significant (P<0.05), implying that these variables are not important factors affecting output of rice farmers in Imo State as reported by the authors. Labour and seed contributed significantly to the output of rice, while the coefficients of fertilizer and agro-chemicals were not significant. The results indicate that the estimated coefficient for labour is positive as expected and significant ($P<0.05$). The positive coefficient and significance of the labour input implies that its availability is determined to a great extent by the level of output that can be obtained from the farm, (Abdullahi *et al.,* 2012). These studies are contrast to the current findings in Dass LGA.

Table 4: Distribution of technical efficiency estimate for rice farmers

Efficiency-Level	Frequency	Percent (%)	Cumulative (%)
0.56-0.60	1	0.3	0.3
0.61-0.65	0	0.0	0.0
0.66-0.70	0	0.0	0.0
0.71-0.75	0	0.0	0.0
0.76-0.80	1	0.3	0.6
0.81-0.85	7	2.0	2.6
0.86-0.90	73	21.4	24.0
0.91-0.95	151	44.3	68.3
0.96-0.10	108	31.7	**100**
Total			
Mean	0.92		
Std-dev.	4.54		
Minimum	0.57		
Maximum	0.98		

Source: Field Survey, 2015

The frequency distribution for the technical efficiency of rice farmers in table 8 indicates that majority 99.4% of the rice farmers' technical efficiency falls within the range of 0.81- 1.00, with a minimum of 0.57, mean of 0.92 and maximum of 0.98. The standard deviation of 4.54 shows a wide variability gap in the technical efficiency of farmers in the study area. The cumulative percentage column indicates that (68.3%) of the paddy rice farmers technical efficiency falls within the range of 0.95 and below. The average technical efficiency of rice farmers in the study area was 0.92 or 92% as shown in table 8. This indicates that in spite of the low yield obtained by farmers in Dass, as compared with their counterparts in other African countries such as Côte d'Ivoire and Senegal as reported by Olorunfemi and Victor (2006) in their study of technical efficiency differentials in rice production technologies in Nigeria. There is opportunity for increased technical efficiency with about 8%. The present efficiency levels of rice farmers in Dass in particular and Nigerian in general, may be too low to ensure self-sufficiency in rice production.

Conclusion

The study concluded that small scale farmers dominate rice production in Dass LGA. The average literacy level among respondents was secondary school which may not be adequate enough to increase rice production and influence technology adoption and skill acquisition. Frequency of agricultural extension services were poor and farmers had to depend on their farming experience as their teacher. Farmers had little or no access to credit facilities.

Yields per hectare was still below optimal and are not achieving their maximum attainable potential not because of a lack of improved seeds but due to limited use of the inputs. The study concluded that, there is still room for rain-fed rice farmers in the area to move to the frontier level.

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