Efficiency and Profitability of Lowland Rice Production in Kogi State, Nigeria

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***Abstract*: This study examined the efficiency, profitability and constraints that confront lowland rice farmers in Kogi State, Nigeria. A multi-stage random sampling procedure was used to collect primary data for the study. The first stage involved a purposive selection of two local government areas based on predominance of lowland rice production. The second stage involved a random selection of 8 villages. The final stage involved the random selection of one hundred and forty-nine (149) lowland rice-producing households from the villages selected. Data were analysed using descriptive statistics, Cobb-Douglas stochastic frontier production function and Gross Margin Analysis. The stochastic frontier production function was estimated for technical, allocative and economic efficiency. The results revealed technical efficiency range of 0.19 to 0.95. The mean estimate was 0.83. The efficiency distribution had shown that, about 83 percent of the lowland rice farmers attained between 0.61 and 1.00 efficiency levels, while 17% of the farmers operate at less than 0.6 efficiency levels. The result also indicates that, the average lowland rice farmer would realize about 35.79 percent in cost savings, if he or she was to attain the level of the most efficient farmer in the sample. The result further shows that there are allowances for the farmers to improve their efficiency by about 17 percent. The allocative efficiency estimates revealed that, the allocative distribution ranged from 0.21 to 1.00; the mean allocative efficiency was 0.81. The result indicates that average lowland rice farmer in the State would enjoy cost saving of about 20 percent if he or she attains the level of the most efficient farmer among the respondents. The most allocatively inefficient farmer will have an efficiency gain of 84 percent in certified rice seed production if he or she is to attain the efficiency level of most allocatively efficient farmer in the state. The study therefore suggests intensive efforts at expanding the present scope of lowland rice farming, given the estimated technical efficiency in the production system.**

***Keywords*: Lowland rice, Technical, Allocative, Efficiency**

I. INTRODUCTION

Rice is one of the world's most important food crops, and the staple food of over 50 percent of the world's population (Abdullahi *et al.*, 2012). Globally, rice is increasingly preferred over many traditional cereals such as sorghum and millet and most root and tuber crops such as yam and cassava (Defoer *et al*., 2004).

On geographical zone basis, the central zone is the largest producer of rice in Nigeria, accounting for 44 per cent of the total rice output in 2000. This is followed by the northwest zone (29%), while the southwest zone is the least (4%) (Okoruwa *et al*., 2006). These zones, however, differ in terms of their competitive advantage in rice production (Okoruwa *et al*., 2006).

All efforts of government and other concern agencies were aimed at raising the low productivity of the Nigerian rice farms: either by raising the crop's productivities at the local farmer small-scale level or by encouraging rice farmers to wholly shift from small scale-farms production to large scale profitable ones. These measures to raising farm productivity suggest that rice farmers are not getting maximum returns from the resources committed to their rice enterprise. Therefore, it could be said that the productive efficiency for rice production in Nigeria is still low, far below expectations. The low productivity in rice production could indicate two things; first, that rice farmers are not getting the necessary inputs like improved rice seeds, improved management practices and relevant extension services as to ways to produce their crops. Secondly, that they are underutilizing existing production resources. The result is low productivity of resources. There is thus scope for increase in output from existing hectarages (Rahji, 2005).

II. RESEARCH METHODOLOGY

A. The Study Area

The study was conducted in Lokoja and Idah Local Government Areas of Kogi State of Nigeria. Kogi State is located between latitudes 6^0 33'and 8^0 44'North and longitudes 5^0 22' and 7^0 49' East of the Equator (Kogi State Government, 2007). The state has a total population of about 3,278,000, with an average of about 228,964 farm families (NPC, 2007). Based on 3.2 percent annual growth rate, the projected population of Kogi State as at 2021 was 4,217,000. About 70% of the people live in rural areas and are engaged in agricultural production. The average farm family is made up of 7 people, with an average farm size of about 2 hectares per farmer (Kogi State Government, 2007).

B. Sampling Technique and Sample Size

A multi-stage sampling technique was used for the selection of respondents. The first stage was purposive selection of two Local Government Areas in Kogi State, based on the predominance of lowland rice production in them namely, Lokoja and Idah Local Government Areas. Secondly, four villages were randomly selected from each of the two Local

Government Areas, Thirdly, random sampling method was used to select ten percent of the total (1493) of lowland rice farmers from the villages through the use of random numbers from the list of the sample frame.

C. Data Collection

For this study, only primary data were used. The primary data were collected for the 2021 cropping season with the aid of structured questionnaire. The information collected includes:

I. The socio-economic characteristics of the respondents such as age, lowland rice farming experience, household size, educational level, extension contact, amount of credit obtained and membership of farmers' group/associations
II. Input and output data: farm size used for lowland rice farming, quantity of seeds planted (kg) labour used for different farm operations(man-days), quantities of fertilizers applied (kg), quantity of agro-chemicals used (litres) and the cost(Naira) of these inputs; output of lowland rice (Kilogramme) and the sales (Naira), and
III. The constraints associated with lowland rice production in the study area.

D. Analytical Techniques

The analytical tools that were used to achieve the objectives of this study include descriptive statistics, gross margin analysis and stochastic frontier production model.

III. RESULTS AND DISCUSSION OF FINDINGS

A. Profitability of Lowland Rice Production in the Study Area

Summary statistics of inputs and output

The summary statistics of level of inputs used and output realized in the study area are reported in Table 1. The inputs that were used in rice production include; seed, fertilizer, agrochemical and labour. Table 1 reveals the mean farm size was 0.82 hectares. The minimum and maximum land areas were 0.1 ha and 3 ha, respectively. The average quantity of seed used by rice farmers was 30.20 kg/ha. The minimum and maximum seed used were 15.98 kg/ha and 56.76 kg/ha, respectively. Average fertilizer used by rice farmers was 90.47 kg/ha while the minimum and maximum were found to be zero and about 176 bags /ha, respectively. The mean labour recorded was 24.45 man-days while the minimum and maximum were observed to be 6.10 mandays/ha and 117.07 mandays/ha, respectively. This shows that agricultural production in the study area is of small scale and labour intensive. During the 2021 rice production season, an average of 90kg per hectare of fertilizer was applied. This fell below the recommended rate of 250-350kg per hectare, and this has serious effect on the yield. An average of 2.18 litre per hectare of agrochemical was applied by rice farmers. The high rate recorded among lowland rice farmers could be attributed to the susceptibility of rice varieties to disease infection as a result of their low level of disease resistance. The average yield of 1.0 tonne per hectare received, is far behind, compared to Niger State with average yield of about 1.8 tonnes per hectare (Abdullahi *et al.*, 2012).

Table 1: Summary of inputs utilized and output realized in lowland rice production

Variables	Mean	Std. Dev.	Min.	Max.
Seed (kg/ha)	30.20	26.60	15.98	56.76
Fertilizer (kg/ha)	90.47	81.10	0.00	8780.49
Labour (man-day/ha)	24.45	18.22	6.10	117.07
Agrochemical (litres/ha)	2.18	28.43	7.00	133.00
Yield (kg/ha)	1021.84	125.16	365.85	5853.59

Cost of rice production in the study area

Rice seed used by the farmers in the study area were mainly unimproved seeds taken from the last harvest. The quantity of rice seed was 30.2 kg/ha with an average market price of ₦100 / kg. This constitutes 9.1% of the total cost of production. The quantity of fertilizer was 90.47kg/ha with an average market price of ₦100 / kg was used. This constitutes 27.3% of the total cost of production.

Labour costs consisted of cost of land preparation, planting, fertilizer application, weeding, chemical application, replacement and harvesting. The cost of family labour was computed on the basis of opportunity cost. The wage rate varied according to farm operation performed. An average wage rate of ₦400 per man-day was used, giving the average labour cost per hectare to be ₦19,344 while the quantity of agrochemical was 2.18 litres/ha with an average market price of ₦800 per litre and this constitutes 5.3% of the total cost of production.

Returns to investment in rice production

Results presented in Table 2 indicate that the total revenue (TR) was ₦63,354.08/ha while the total variable cost (TVC) was ₦33,155/ha. The gross margin was therefore ₦30,199.08/ha. The average rate of returns on investment (return per naira invested) was 1.91, indicating that for every ₦1 invested in rice production in the study area; a profit of 91 kobo was made.

Table 2: Average costs and returns per hectare of rice production

Variables	Values/ha (₦)	% Contribution
A. Variable cost		
i seed (kg)	3,020	9.1
ii fertilizer (kg)	9,047	27.3
iii labour (man-days)	19,344	58.3
iv agrochemical (litres)	1,744	5.3
B. Total variable cost	33,155	100
C. Total Revenue	63,354.08	
D. Gross Margin (C -B)	30,199.08	
E. Return per Naira Invested (C/B)	1.91	

B. Efficiency of Lowland Rice Production

Data Envelopment Analysis (DEA) and stochastic frontiers are two alternative methods for estimating frontier functions and thereby measuring efficiency of production (Coelli *et al*., 1998). Data envelopment analysis involves the use of linear programming methods to construct a non-parametric piece-wise surface (or frontier) over the data. Efficiency measures are then calculated relative to this surface. Comprehensive reviews of the methodology are presented by Seiford and Thrall (1990), Lovell (1993), Ali and Seiford (1993), Lovell (1994), Charnes *et al* (1995) and Seiford (1996).

Estimated technical efficiency of lowland rice farmers

The ML estimates and inefficiency determinants of the specified frontier are presented in Table 3. The study revealed that the generalized log likelihood function was -188.465. The log likelihood function implies that inefficiency existed 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) was estimated to be 81% and it was highly significant at $p<0.01$. This is consistent with the theory that true γ-value should be greater than zero. This implies that 81% 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 (**σ^2**) was also highly significant at 1% 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 made significant contribution to the technical inefficiencies of lowland rice farmers.

Table:3 Results of maximum likelihood estimates of stochastic frontier production function of lowland rice production

Variables	Parameters	Coefficients	Std. error	T-Value
Production				
Constant	β_0	6.034	0.542	11.132***
Seed	β_1	0.135	0.056	2.399**
Fertilizer	β_2	0.123	0.046	2.656***
Agrochemical	β_3	-0.758	0.111	-0.680
Labour	β_4	0.396	0.146	2.716***
Inefficiency model				
Constant	Z_0	0.194	0.519	3.741
Age	Z_1	-0.289E-03	0.902E-02	-0.032
Household size	Z_2	0.0575	0.051	1.122
Education	Z_3	-0.193	0.094	-2.053**
Farming experience	Z_4	-0.024	0.098	-2.487**
Extension contact	Z_5	0.0069	0.0152	-0.456
Membership of Cooperative	Z_6	-0.705E-05	0.710E-06	-10.992***
Diagnostic Statistic				
Sigma-squared	(σ^2)	0.6188	0.0950	6.513***
Gamma	(γ)	0.8144	0.2641	3.083***
Log likelihood function	*L/f*	-188.465		
LR test		33.091		
Total number of observation		149		
Mean efficiency		0.83		

***P< 0.01
** P< 0.05
* P<0.10

The estimated coefficient for fertilizer was 0.123 which is positive and statistically significant at 1% level. This implies that a 1% increase in fertilizer will increase lowland rice output by 0.12%. Fertilizer is a major land augmenting input because it improves the quality of land by raising yields per hectare. The estimated coefficient for agrochemical was -0.758 which is negatively signed and statistically not different from zero. The coefficient of labour was 0.396 which is positive and statistically significant at 1% level.

Estimated Stochastic Frontier Cost Functions

The Maximum Likelihood (ML) estimates of the stochastic frontier cost parameters for lowland rice are presented in Table 4. For the cost function, the sigma squared ($\sigma^2 = 0.30$) and the gamma (γ=0.71) are quite high and highly significant at 1% level of probability. The high and significant value of the sigma squared (σ^2) indicate the goodness of fit and correctness of the specified assumption of the composite error terms distribution (Idiong, 2005). The gamma (γ = 0.71) shows that 71% of the variability in the cost of lowland rice farmers that are unexplained by the function is due to allocative inefficiency. The results of stochastic frontier cost function for lowland rice are shown in Table 4. The estimated coefficients of the parameters of the cost function are positive except that of agrochemical which is negative. The cost variables seed, fertilizer and labour are significant at 1% level while agrochemical is not significantly different from zero. The coefficient of the cost of seed was positive and statistically significant at 1%. The coefficient of the cost of fertilizer was positive and statistically significant at 1%. This implies that fertilizer is important in crop production in lowland rice farms. This indicates that if there is an increase in cost of fertilizer, the total cost of production will increase. The estimated coefficient of labour was positively signed and statistically significant at 1% level, indicating that if there is an increase in labour cost the total cost of lowland rice production will increase.

Table 4: Maximum likelihood estimates results of frontier cost function (Allocative Efficiency) of lowland rice production

Variables	Parameters	Coefficients	Std. error	T-Value
Cost				
Constant	β_0	8.493	0.429	19.752***
Seed	β_1	0.116	0.041	2.823***
Fertilizer	β_2	0.038	0.125	3.024***
Agrochemical	β_3	-0.009	0.025	-0.341
Labour	β_4	0.223	0.071	3.150***
Inefficiency variables				
Constant	Z_0	0.284	0.595	0.477
Age	Z_1	-0.031	0.018	-1.697*
Household size	Z_2	0.673	0.027	2.454**
Education	Z_3	-0.167	0.101	-1.643
Farming experience	Z_4	-0.004	0.016	-0.249
Cooperative association	Z_5	0.074	0.240	0.307
Extension contact	Z_6	0.070	0.037	1.889*
Amount of credit borrowed	Z_7	-0.34E-05	0.62E-05	-0.551
Diagnostic Statistics				
Sigma-square	(σ^2)	0.301	0.128	2.355***
Gamma	(γ)	0.7065	0.164	4.309***
Log likelihood function	*L/f*	-67.789		
LR test		44.707		
Total number of observation		149		
Mean efficiency		0.81		

***P< 0.01
** P< 0.05
* P<0.10

Frequency distribution of TE, AE and EE estimates of lowland rice farmers

Distribution of technical efficiency estimates of lowland rice farmers

The frequency distribution of the technical efficiency estimates for lowland rice farmers in the study area as obtained from the stochastic frontier model is presented in Table 5. The mean technical efficiency is 0.83. It was observed from the study that 83% of the farmers had technical efficiency (TE) of 0.61 and above while 17% of the farmers operate at less than 0.6 efficiency level. The farmers with the best and least practice had a technical efficiency of 0.98 and 0.19 respectively. This implies that on the average, output fell by 17% from the maximum possible level due to inefficiency. The study also suggests that for the average farmer in the study area to achieve technical efficiency of his most efficient counterpart, he could realize about 17 percent (1-0.83/0.98*100) cost savings while on the other hand, the least technically efficient farmer will have about 83 percent (1-0.19/0.98*100) cost savings to become the most efficient farmer.

Distribution of allocative efficiency estimates of lowland rice farmers

The allocative efficiency estimates presented in Table 5, indicate that it ranged from 0.21 to 1.00; the mean allocative efficiency was 0.81. The result indicates that average lowland rice farmer in the state would enjoy cost saving of about 20 (1-0.81/0.95*100) percent if he or she is to attain the level of the most efficient farmer among the respondents. The most allocatively inefficient farmer will have an efficiency gain of 81 (1-0.2/0.95*100) percent in rice production if he or she is to attain the efficiency level of most allocatively efficient farmer in the study area.

Distribution of economic efficiency estimates of lowland rice farmers

The frequency distribution of the economic efficiency estimates for lowland rice farmers in the study area as obtained from the stochastic frontier model is presented in Table 5. It was observed from the study that 10% of the farmers had economic efficiency (EE) of 0.81 and above while 90% of the farmers operate at less than 0.81 efficiency level. The mean economic efficiency of the 149 sampled farmers in the study area was 0.67. The farmers with the best and least practices had economic efficiencies of 0.82 and 0.15, respectively. This implies that on the average, output fell by 33% from the maximum possible level due to inefficiency. The study also suggests that for the average farmer in the study area to achieve economic efficiency of his most efficient counterpart, he could realize about 40 percent (1-0.67/0.82*100) cost savings while on the other hand, the least economic efficient farmer will have about 98 percent (1-0.2/0.82*100) cost savings to become the most efficient farmer. However, the average economic efficiency of lowland rice farmers was 67 percent. This indicates that lowland rice farms were moderately economically efficient.

Table 5: Frequency distribution of technical, allocative and economic estimates from the stochastic frontier model of lowland rice farmers

Class	Technical Efficiency		Allocative Efficiency		Economic Efficiency	
	Frequency	%	Frequency	%	Frequency	%
≤0.2	1	0.74	0	0	10	7.46
0.21-0.40	5	3.73	30	20.39	16	11.94
0.41-0.60	16	11.94	36	26.87	24	17.91
0.61-0.80	71	52.99	60	44.78	72	53.73

0.81-1.00	41	30.60	8	5.97	14	10.45
Total	149	100	149	100	149	100
Mean	0.83		0.81		0.67	
Minimum	0.19		0.21		0.15	
Maximum	0.98		0.95		0.82	

Constraints Faced by Lowland Rice Farmers in the study area

The problems faced by rice farmers in the study area were ranked according to their magnitude as stated by the farmers (Table 6). About 65% of the rice farmers indicated that pests and diseases were most serious constraint reducing the quality and quantity of rice output in the study area. Unavailability of improved seed is ranked second (56.4%) by rice farmers in the study area. According to the respondents they make use of seeds from their previous harvest which is not reliable and can jeopardize improved and sustainable productivity. This finding is in line with Zulu (2004), who opined that most farmers have little or no access to improved seeds and continues to recycle seeds that have become exhausted after generations of cultivation. About 48% of the rice farmers indicated inadequacy of capital and credit facilities which rank third. This affects rice production in the study area, because the meager savings the farmers might have made or the funds generated from relatives is not sufficient to satisfy various activities in rice production. Most of the farmers also complained of not having enough money to purchase chemicals to combat the diseases, although the economic advantage of spraying could lead to increased yield thereby justifying the costs invested. Also, the efficacy of spraying may not be quickly obtained as there are a lot of fake chemicals in the market. This emphasizes the need for more extension activities on integrated pest management that will reduce the number of spray. Marketing of rice is another constraint identified by 43.6% of the respondents. This problem is compounded as a result of polished rice which seems to be more preferred by the consumers. About 22% of the rice farmers indicated short of labour as constraints in the study area. According to the farmers, during active period of production, every household would have been engaged in their family farm work. The demand for labour is normally very high and expensive during the peak period of land clearing, ridging, harvesting, processing and weeding in the study area. These led to labour shortage in rice farming in the study area . High cost of fertilizer was perceived to be serious constraint which rank sixth with about 12.8% of the farmers attesting to this fact. According to the respondents, fertilizer was made available when farmers were far into the production period, sometimes at the middle of the rainy season.

Table 6: constraints associated with rice production

Variable	*Frequency	Percentage	Rank
Pest and disease	97	65.1	1st
Lack of improve seed	84	56.4	2nd
Lack/Inadequate capital	71	47.7	3rd
Marketing	65	43.6	4th
Lack of Labour	32	21.5	5th
Hight cost of fertilizer	19	12.8	6th

*****multiple responses was allowed

IV. CONCLUSION

This study has revealed that lowland rice farmers were not fully technically efficient and therefore there is allowance of efficiency improvement by addressing some important policy variables that negatively and positively influenced farmers' levels of technical efficiency in the study area. Based on the findings of this study, it could be concluded that lowland rice production in the study area was profitable by returning 91 kobo to every ₦1.00 spent.

V. RECOMMENDATIONS

From the findings of this study, the following recommendations are made:

i. Farmers' membership of association was positively related to efficiency, implying that policies that would encourage farmers to form cooperatives/farmers' organizations or join existing ones will be a step in the right direction. Lowland rice farmers should join cooperative societies, so as to be able to benefit from the government and non-governmental organization.
ii. Majority of the farmers sourced their credit from personal savings and relatives which are mostly not adequate for appreciable production and is an important factor which significantly influences the production. Agricultural loan facilities should be made accessible to rice producers by the government so as to ensure timely and adequate utilization of agricultural inputs for improvement in farm production efficiency.
iii. 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.

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