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Technical and Allocative Efficiency of Rice Production in Yobe State, Nigeria

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Abstract
This study was designed to analyze the Technical and Allocative Efficiency of rice production in Yobe State, Nigeria. A multi stage sampling procedure was used to collect primary data from 110 rice farmers in the study area. The data was collected with the aid of well-structured questionnaire and analysed using descriptive statistics and stochastic frontier functions. The results indicated that over 97% of the farmers were within the productive mean age of 33years. Only 3% of the respondents had no formal education. Land acquisition was mainly (54.5%) through inheritance while the average farm size was 2 hectares. The years of rice production experience, years of schooling, years spent as member in farmers" cooperative, and farm size were statistically significant factors that influenced technical and allocative inefficiencies. The predicted technical efficiencies (TE) ranged between 0.60 and 1.00 with a mean TE of 0.9000 in the below. The wide variation shows possibility for improvement by some farmers. The result revealed that 40.0% of the respondents fell at the range of 0.80-0.89%, 28.2% at the range of 0.90-1.00%, 23.6% fell at the range of 0.70-0.79% and 8.18% fell at the range of 0.60-0.69%. The result revealed that majority of the respondent fell at the range of 0.80-0.89%. The major constraints that hindered rice farmers from achieving their full production potentials were low output prices, high cost of inputs, pests and diseases, inadequate credit facilities and marketing problems. The study therefore recommended among others that farmers" affordability and accessibility to fertilizer, improved rice seeds, extension services and credit facilities should be enhanced for effective achievement of self-sufficiency in rice production and for total import substitution.

Keywords: Rice, Technical, Allocative, Efficiency, Production

Introduction
Rice is grown primarily for human consumption and it has become an important strategic, daily staple food in Nigeria and the potential land for cultivation is between 4.6 and 4.9 million hectares. Out of this only 1.7 million or 35% of the available land area is presently cropped to rice (Willene *et al.,* 2014). According to FAO, the five highest rice producing countries are China (204285000 metric/tones), India (152600000 metric/tones), Indonesia (69045141 metric/tones), Vietnam (43061569 metric/tones) and Thailand (37000000 metric/ tones) (FAOSTAT, 2014). It is estimated that half of the world's population depends on rice as main sources of calories (IRRI, 2001). An average Nigerian consumes 24.8kg of rice per year representing 9% of calorie intake (FAO, 2001).

The demand for rice has been increasing at a much faster rate in Nigeria than in other West African countries (Moses and Adebayo, 2007). The increase in rice demand according to FAO (2001) is attributed to a consumer shift from traditional staples such as yam, gari to imported parboiled rice. FAO (2000) reports that as income of families increase, there would be a shift in consumption pattern from roots and tubers to rice. Akande (2002) sees urbanization as a major cause of the shift in consumer preferences towards rice in Nigeria. Rice is easy to prepare compared to other traditional cereals and therefore fit more easily in urban life style of rich and poor (Akande, 2002).

Rice therefore contributes a significant proportion of food requirement of the population. Because of the importance of rice in food and non-food uses and its position in Nigeria agriculture, it is imperative to examine the efficiency of the resources used in its production. The high dependence on importation of food including rice to meet the needs of Nigerians is remarkably an evidence of food insecurity in the country that can be addressed by articulated and realistic food production strategy. According to strategy report reported by Ogundari (2008) that Nigeria estimated annual rice demand is put at 5 million

metric tons while the annual production average is estimated to be 2.21 million tonnes. There exists a deficit of 2.79 million metric tons (about 57%) of demand which is covered by importation despite increasing hectares of land put into rice production annually in Nigeria.

Nigeria population was growing at 3.2 percent per annum while food production witnessed only between 1 to 2 percent (Oguntade, 2011). This is however not coming as a surprise to many as the sector faces many challenges, notably an outdated land tenure system that constrains access to land (1.8 ha/farming household), a very low level of irrigation development (less than 1 percent of cropped land under irrigation), limited adoption of research findings and technologies, high cost of farm inputs, poor access to credit, inefficient fertilizer procurement and distribution, inadequate storage facilities and poor access to markets have all combined to keep agricultural productivity low (average of 1.2 metric tons of cereals/ha) with high post- harvest losses and waste (Idiong, 2007).

The rice production has increased in the last ten years in Yobe State but the rice production capacity is far below the rice requirement by populace. Yobe state inability to meet the rice consumption needs through local production has resulted in high cash outlays for importation. The local rice is imported from neighbouring states which include Gombe State, Taraba and Adamawa state. In Nigeria, the demand for rice has been increasing at a much faster rate than in any other African countries since the mid-1970s (WARDA, 2003).

Despite all the human and material resources devoted to rice production in Yobe state, the rice production efficiency is still low and the state rice output have persistently remained below market demand (Saka and Lawal, 2009). In a bid to address the domestic demand and supply gap, governments have at various times come up with policies and programmes. It is observed that these policies have not been consistent. The fluctuations in policy and the limited capacity of the Yobe state rice sector to match domestic demand have raised serious concerns especially with the abundant natural resources endowment suitable for commercial rice production in the state. This research work therefore analyses the efficiency and competitiveness of rice production systems in some selected local governments in the state. It will also border on how the various factors explain the efficiency and competitiveness in these systems can be examined so as to improve the rice production in Yobe state.

The productivity of farmers can be raised by adoption of improved production technologies or improvement in production efficiency or both (Idiong, 2007). But with the low rate of adoption of improved technologies by farmers in Nigeria (Saka and Lawal, 2009), improving farmers" production efficiency becomes the best alternative to productivity enhancement in the short run. Accordingly, the present Government, as part of its Agricultural Transformation Agenda (ATA), has set a goal to achieve complete sufficiency in rice production by the year 2015. This implies achieving a significant increase in yields of rice to substitute rice import. This target can only be achieved if efficiency at farm-level is improved; resources are used efficiently and deploy more modern rice production resources and systems in the best suited ecology. This however, requires empirical information on the efficiency and level of competitiveness in rice production systems and effects of policy intervention on rice production in the state. The specific objectives are to describe the socio-economic characteristics of the farmers, examine the farm level technical efficiency of the rice farmers, examine the farm level of allocative efficiency, and examine the constraints of rice production in the study area.

Theoretical Framework

Hussaini and Abayomi (2010) examine the technical and scale efficiency in vegetable crop production under Fadama in North central Nigeria, using DEA approach for a sample of 192 Fadama farmers. The result revealed a technical efficiency of 90% and 82 % for the scale efficiency. The result also showed that the average pure technical efficiency score of 93%.

Ogunwande *et al.* (2012) investigated the differences in the technical efficiency of small-scale farmers using organic fertilizer and otherwise in Oyo State, Nigeria. Stochastic Frontier Production was used to assess the efficiency differentials for the groups. The result showed that the mean efficiency score for organic fertilizer users (OFUs) and inorganic fertilizer users (IFUs) were 0.95 and 0.87 respectively. The results for the return to scale of the farmers were 0.67 and 0.33 for OFUs and IFUs, respectively which revealed that organic farmers operated at the stage II while IFUs at stage I of the production surface. They recommended that organic fertilizer should be used by all farmers in the rainforest, as it improves soil quality and

ultimately the crop yield. Many studies have applied frontier techniques (both DEA and stochastic frontier techniques) in agricultural production and few among them were reviewed in this study.

Ayinde *et al.* (2009) examined the technical efficiency and varietal-gap of rice production across three out of six geographical zones in Nigeria. Frontier approach was applied to a random sample of 675 rice farmers, in which the farmers were classified into three groups according to the variety of rice they planted. The three main varieties of rice planted were local (Ofada), improved (Mai-Nasara) and New Rice for African (NERICA). Estimates of the frontier were obtained assuming a translog functional form. Results revealed mean technical efficiency of 55%, 58% and 57% for Ofada, Mai-Nasara and NERICA varieties, respectively. Farm size, hired labour, fertilizer, seed, age, gender, household size and amount of credit are the determinants of technical efficiency of farmers in Nigeria rice production. The average values of varietal technology gap are more than 0.83 in all the varieties.

Villano *et al.* (2010) adopted frontier approach to estimate technical efficiency and the technology gap using farm-level data on the production of three different varieties of pistachio trees in Kerman Province of Iran. Results show that, on average, very little difference exists in technical efficiency between farms growing the different tree varieties. But they indicate that farms growing the three varieties differ in the use they make of inputs as measured by the technology gap ratio. Ignoring the limits placed on increasing technical efficiency because of constraints imposed by variety choice could lead to incorrect conclusions about the scope for farmers to improve their technical performance by adopting better farming practices. Being the first study to estimate a frontier in agricultural production based on crop variety in Iran, they concluded that it is misleading to compare the performance of different tree varieties on the basis of yield per hectare alone.

Otieno *et al.* (2011) analysed farmers" technical efficiency and willingness to comply with Disease Free Zones, across three main cattle production systems in Kenya. They applied the stochastic frontier model to estimate TE and technology gaps across three main cattle production systems in Kenya and the determinants of TE were assessed using a Tobit model. Results show that there is significant inefficiency in both the nomadic and agro-pastoral systems, but less in ranches. Further, in contrast with the other two systems, ranches are found to have higher meta-technology ratios (MTRs). The average pooled TE with respect to the frontier is estimated to be 0.69, which suggests that there is considerable scope to improve beef production in Kenya. The main factors that are he found to have a positive influence on TE include: use of controlled cattle breeding method, access to market contract, presence of farm manager, off-farm income and larger herd size.

Methodology

Study Area

The study was conducted in Yobe State, Nigeria. Yobe is located in the North East zone of Nigeria and mainly an agrarian state with its headquarters at Damaturu. It was created in August, 27th 1991, with a total of seventeen (17) Local Government Areas (LGAs). It lies between latitude 120 00"N and longitude 11.300 E, covering a land area of about 45,502 square kilometres (km2), with an estimated population of two million, three hundred and twenty-one thousand, five hundred and ninety-one (2,321,591) people (NPC, 2006). The projected population of the State for 2014 using an annual growth rate of 3% is therefore two million, nine hundred and fourteen thousand, one hundred and eighty-four (2,914,184). The State shares boundaries with Borno State to the East, Bauchi to the South and Jigawa to the West. It also, shares international borders with the Republic of Niger to the North. Yobe State lies mainly in the dry savannah belt; it is therefore, dry and hot for most part of the year except in the southern part of the state which has a milder climate. The soil type is generally sandy and the annual temperature ranges between 390C to 400C. The rainy season begins in June, with mean annual rainfall between 900mm - 1500mm which spread up to October, depending on the year and the hot season is between February to May.

The climate favours the production of a wide variety of crops, which include legumes (groundnuts and beans); Cereals (maize, millet, sorghum and rice), solanaceous crops (peppers, tomato, garden eggs). The State was said to have one of the largest cattle markets in West Africa. Animals like; camel, sheep, goats, and poultry are also kept. Yobe, apart from its agricultural orientation, it has a rich fishing grounds and mineral deposits of gypsum, kaolin, and quartz. The major ethnic groups living in the State were Fulani, and other ethnic communities include: Kanuri, Kare-Kare, Bolewa, Ngizim, Bade, Hausa, Ngamo and Shuwa (YSGHP, 2012).

Sampling Procedure and Sample Size

The target population for the study was the rice producing farmers. The selection of the sampling was based on the basis of the type of dominant rice producing village in each local government area. The study was carried out in all the three senatorial zones of the State namely Northern Senatorial, Central and South Zones; a multistage sampling technique was employed to get the respondents. In the first stage, three Local Government Areas were selected purposively; out of the nine-rice producing LGAs in Yobe state.

These were Bade in Northern zone, Bursari in Central and Fune in South. The selection was based on easy accessibility, familiarity and spread. In the second stage, simple random sampling technique was used to select one rice producing villages from each Local Government Area, making a total of three villages. These are Zango in Bade LGA, Garin-gada in Fune LGA, and Dumburi in Bursari LGA. Thirdly, 10% of the total household heads was randomly selected from each village, which forms the sample size of 110 for the study

Method of Data Collection

The study made used of primary and secondary data. The primary data was collected through the administration of a structured questionnaire with the aid of verbal interview to the respondents. The secondary information includes those sourced from journals, bulletin, and other literature materials from the international network (internet) to augment the farmer's response.

Methods of Data Analyses

The following analytical and statistical tools such as: Descriptive statistics and inferential Statistics were utilized to capture the stated objectives of the study.

Descriptive Statistics

Descriptive statistics such as the mean, standard deviations, frequency distribution and percentages were used to describe the socio-economic and institutional variables of the sampled rice farmers and the level of inputs and output of the rice production as well as constraints faced by rice farmers.

Inferential Statistics

Data was analysed using the stochastic frontier model. The stochastic production frontier as an econometric method of efficiency measurement in production systems is built round the premises that the production system is bounded by a set of smooth and continuously differential concave production transformation functions for which the frontier offers the limit to the range of all production possibilities. It has the advantages of allowing simultaneous estimation of individual technical efficiency of the respondent farmers as well as determinants of technical.

Stochastic frontier models

As a first stage in the productivity analysis, Ordinary Least Square (OLS) estimation was made on the Cobb-Douglas production function. Based on the significance of the parameter estimates, information was gained on which variables should be included in the stochastic frontier analysis. In the production function five inputs of production, farm size (ha), Seed quantity (kg), Agrochemical quantity (litter), labour (man-day), and fertilizer quantity (kg) were included. The choice of the variables was made because these inputs are the conventional inputs used in rice production in the study area.

The model of the stochastic frontier production for the estimation of the TE was specified as:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + V_i - U_i \quad \text{..... (1)}$$

where subscript i refers to the observation of the ith farmer, and

Y = Rice output (kg)
X_1 = Farm size under rice cultivation (ha)
X_2 = Seed quantity (kg)
X_3 = Fertilizer quantity (kg)
X_4 = Agrochemical Quantity (litre)
X_5 = Labour (man-days)
β_i's = the parameters estimated
ln's = natural logarithms
V_i = the two-sided, normally distributed random error
U_i = the one-sided inefficiency component with a half-normal distribution.

The Inefficiency Model

In this study, the technical inefficiency was measured by the mode of the truncated normal distribution (i.e., U_i) as a function of socio-economic factors (Yao and Liu, 1998). Thus, the technical efficiency was simultaneously estimated. The determinants of the technical efficiency were defined by:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where:

U_i = Technical inefficiency of the ith farmer
Z_1 = Age of farmer (years)
Z_2 = Farming Experience (number)
Z_3 = Year of Education (years)
Z_4 = Household size (number)
Z_5 = Association membership (Yes = 1, No =0)

Accordingly, technical efficiency (TE) of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the firm. Technical inefficiency is therefore defined as the amount by which the level of production for the farmer is less than the frontier output. This is shown in equation (3.3)

$$\mathrm{TE_i} = \frac{\mathrm{Y}*2}{Yi} + \frac{f(Xi\beta)\exp(Vi-Ui)}{f(Xi\beta)\exp(Vi)} = \exp(-Ui) \ldots\ldots (3)$$

The translog stochastic cost function which is the basis for estimating the allocative efficiency (AE) of the farms is specified as follows:

$$\ln Ci = \alpha_0 + \sum_{k=1}^{4}\sum_{j=1}^{4} P_{ji}\ln P_{ji} + V_i + U_i \ldots\ldots\ldots\ldots(4)$$

where,

C_i stands for the total cost of production of the rice yield of *i*th farm on per hectare basis (N);
P_1 indicates cost of seed per hectare (N);
P_2 indicates cost of total quantity of family (opportunity cost) and hired labour man-days required to perform various farming activities on the *i*th farm (N per hectare);
P_3 shows cost of quantity of inorganic fertilizer used on *i*th farm (N per hectare);
P_4 represents the total cost of irrigation and water management on *i*th farm (N per hectare) and
αs are vector of unknown parameters to be estimated

$$U_i = \delta_0 + \sum_{i=1}^{4} \delta n Zi \ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

The sources of technical and allocative inefficiency effects in equations (1) and (3) is modelled in terms of the farm's and farmer's characteristics and specified as:

Where,

U_i = technical and allocative inefficiency effects of the equations (3.1) and (3.3) respectively;
Z_1 = Cost of seed;
Z_2 = Cost of agro-chemical;
Z_3 = Cost of fertilizer;
Z_4 = Cost of labour;
Z_5 = Cost of Land;

These were included in the models (3.1 and 3.3) to indicate their possible influence on the technical and allocative efficiencies of the farmers.

The maximum – likelihood estimates of the β, and δ coefficients in equations (3.1), (3.3) and (3.4) respectively were estimated simultaneously using the computer program FRONTIER 4.1 (Coelli, 1996) and the results obtained were used to achieve part of objective 2 and objective 3 and also tested the hypotheses 1 and 2.

Results and Discussion

Technical and Allocative Efficiencies Estimations

Maximum Likelihood Estimates of the Determinants of Efficiency of Rice Farmers

The Table below showed the maximum likelihood estimates of the determinants of technical efficiency for the rice farmers considered in the study. The results revealed that all the estimated coefficients of the variables of the production function were positive except seed. The positive coefficient of farm size, labour used, fertilizer used and agrochemicals used implies that rice output increases with increase in these variables. Seed quantity used did not exert any significant effect on rice output as shown by their t-ratio values. The implication of this is that increase in the level of use of seeds will not increase output of rice in the study area.

The parameter estimates from the inefficiency model included in the stochastic production frontier estimation revealed that association membership have significant negative effect on inefficiency.

Table 1: Maximum likelihood estimates of the determinants of efficiency of rice farmers

Inefficiency variables	Parameters	Coefficient	Standard Error	T-ratio
Constant	β0	2.1191	0.4090	5.1809
Age	β1	0.1354	0.8489	1.5953*
Farming Experience	β2	0.3648	0.5586	0.6531
Year of Education	β3	0.3180	0.6197	5.1327***
Household size	β4	0.5899	8.1612	7.2280***
Association membership	β5	-8.62	8.6924	-0.9926
Efficiency variables				
Constant	δ0	7.3860	0.1598	0.4620
Farm size	δ1	22.702	11.4563	1.9816*
Seed quantity	δ2	99.5567	66.7418	1.4977
Fertilizer used	δ3	0.1315	36.4342	3.6111***
Agrochemical Used	δ4	62.3624	11.5253	5.4108***
Labour Used	δ5	8.6370	1.8746	4.6072***
Diagnostic Statistics				
Sigma square	δ^2	0.1053	42.5459	24.7606***
Gamma		5.1570	0.1424	0.3619
Log likelihood	¥	84.2935		

Source: Computed from Field Survey Data, 2020
**Significant at 10%* ***significant at 5%* ****Significant at 1%*

Technical Efficiency Range of Rice Farmers

The predicted technical efficiencies (TE) ranged between 0.60 and 1.00 with a mean TE of 0.9000 in the below. The wide variation shows possibility for improvement by some farmers. The result revealed that 40.0% of the respondents fell at the range of 0.80 - 0.89%, 28.2% at the range of 0.90 - 1.00%, 23.6% fell at the range of 0.70 - 0.79% and 8.18% fell at the range of 0.60-0.69%. The result revealed that majority of the respondent fell at the range of 0.80 - 0.89%.

Table 2: Technical efficiency range of rice farmers

Efficiency level	Frequency	Percentage
0.60-0.69	09	8.18
0.70-0.79	26	23.6
0.80-0.89	44	40.0
0.90-1.00	31	28.2
Total	**110**	**100.0**
Mean = 0.9000		
Minimum = 0.6094		
Maximum = 0.9899		

Source: Computed from Field Survey Data, 2020

Maximum Likelihood Estimate of Cobb-Douglas Frontier Production Function for Allocative Efficiency of Rice Farmers.

The below table showed the maximum likelihood estimates of Cobb-Douglas frontier production functions for allocative efficiency of rice farmers. The results revealed that some independent variables conform to the a priori expectations as some of the estimated coefficients (Ln cost of land and Ln cost of seed) gave positive coefficients. These means that as these factors increased total production cost increased ceteris paribus. The other estimated coefficients (Ln cost of agrochemicals, Ln cost of fertilizer, and Ln cost of labour) gave negative results. This means that as these factors increased total production cost will reduced. The result of the t-ratio test shows that

some variables were positive and different from zero at 1%level of significant. The cost of agrochemicals, cost of fertilizer and cost of labour were negative. This means that increase in the cost of these variables would not increase the total cost of production significantly.

The analysis revealed that there was economic inefficiency effect as shown by the gamma value of 0.9932 in the cost function which was significant at 1% level. This implies that about 99.32% of the total variation in total cost of production incurred by each farmer was due to differences in their cost inefficiencies.

Table 3: Maximum likelihood estimate of Cobb-Douglas frontier production function for allocative efficiency of rice farmers.

Variables	Parameter	Coefficient	Standard Error	T ratio
Constant	β0	27.9596	4.7860	5.8418
Ln cost of seed	β1	0.8637	1.8746	4.6072
Ln cost of agro-Chemicals	β2	-0.8473	0.2359	-3.5909
Ln cost of fertilizer	β3	-7.7564	1.9951	-3.8876
Ln cost of labour	β4	-0.1773	0.4744	-3.7372
Ln cost of land	β5	0.5197	0.2099	2.4753
Diagnostic statistics				
Sigma square	δ^2	3.8263	40.4486	9.4598
Gamma	ɣ	0.9932	46.5579	0.02133
Log likelihood		211.5840		

Source: Computed from Field Survey Data, 2020

Conclusion

Based on the findings of this study, it is concluded that the rice farmers in rice producing area of Yobe State were technically and allocatively scale inefficient. The significant factors that increased rice farmers" technical and allocative efficiencies in the production were the years of rice production experience, years of education, years spent as member in farmers" cooperative, and farm size.

The wide gap between the frontier and the relative frontiers is due to inefficiency in rice production and this gap can be reduced by adopting superior rice production techniques and enhancing efficiencies of farmers. All the rice production was both privately and socially profitable. Low output prices, high cost of inputs, pests and diseases, inadequate credit facilities and marketing problems were the main constraints facing rice farmers in Yobe State.

Recommendations

In order to sustain and improve efficiency of rice production in the study areas, the following suggestions and policy recommendations are drawn from the study's results:

An analysis of the factors affecting efficiency indicated which aspects of the farms" human and physical resources might be targeted by public investment to improve farm efficiency. Farming experience and years of schooling are both significant variables for improving efficiency. Policies should be designed by Yobe State government to formally educate farmers especially the more experience rice farmers which will have a great impact in increasing the level of efficiency and productivity.

Farmers should be encouraged to form farmers" cooperative or group through which government and relevant agencies could find ease in reaching large number of rice farmers at a time and at a cost. Other benefits of grouping can be reaped by the farmers like group lending and group marketing.

Since increase in farm size reduces both technical and allocative inefficiencies and the most common type of scale inefficiency among the rice production system is increasing return to scale (IRS), a policy to prevent land fragmentation into smaller uneconomic sizes should be enforced. There is need to promote consolidation of farm lands into large commercial sizes as this will encourage mechanization and afford the farmers opportunity for access to credit facilities.

Government should continue to protect domestic rice industry by strictly enforcing and increasing import tariff on rice import and as well as reducing the production cost in domestic rice production.

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