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Abstract

This study investigated the technical and scale efficiencies in rice production by rice farmers in Ebonyi State Nigeria using the data envelopment analysis (DEA). Data was collected from a sample of 180 farmers using multi-stage sampling technique. Data were analysed using descriptive statistics and Data Envelopment Analysis (DAE) approach. The result showed that majority of the rice farmers were operating with increasing returns to scale 77.2%, 18.99% decreasing returns to scale and only 3.9% with constant returns to scale. The result further indicated that only 5.56% of the farmers were 100% technically efficient in resource – utilization under variable returns to scale (VRS). Result of the analysis also showed that education level, farmers experience and extension agents visit significantly influenced the efficiency level of the rice farmers. Farm size was however negatively correlated and had no significant effect on resource use efficiency of the rice farmers. The variables having significant influences on technical and scale efficiencies of the farmers such as education and extension agents visit should be improved upon to enhance the farmers efficiency level and reduce resource wastage and increased cost of production.

Keywords: Data Envelopment Analysis, Resource Use, Efficiency, Nigeria

Introduction

Agriculture contributes about 40% of the Gross Domestic Product (GDP) and provides 88% non-oil earnings. The agricultural GDP is made up by crops (85%), livestock (10%, fisheries (4%) and forestry (1%). More than 90% of this agricultural output is provided by small-scale farmers with less than two (2) hectares under cultivation (FAO, 1997, FMA and WR (2008). Agricultural sector has performed far below expectation in providing cheap and affordable food in the table of average Nigerian despite all the productive potentials in terms of land, labour and capital resources that are available in abundance.

Rice is a staple food crops in Nigeria and the ecological nature of the Nigerian environment is aptly very much suitable for cultivation of different rice varieties. Rice is not only a key source of food but a major employer of labour and source of income (WARDA, 2004). The potential land area for rice production is between 4.6million and 4.9million hectares. However, only 1.7 million or 35% of this is cropped to rice, (Singh et al. 1997). Local rice production has not kept pace with domestic consumption demand (IRR, 1995). Declining productivity is begin witnessed in many countries and Farmers need new approaches and technologies to produ-ce more rice on existing or less land and water with limiting and or expensive inputs. Minimizing the yield gap between what is currently harvested by farmers and the achievable highest yield is possible through efficient resource utilization (IRRI, 1995). Efficiencies accounts for the effectiveness with which given resource inputs are used to produce outputs. It can be considered also in terms of the optimal combination of inputs to achieve a given level of outputs. According to Alimi (2000), resources must be available and efficiently used in order to achieve optimum production level. Helfand (2003) emphasized that the analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources, or certain level of output at least cost. The productivity of farmers has remained all time low leading to massive importation and depletion of the nations foreign reserve.

The few available resources are not perfectly applied and utilized in the production process. This scenario is witnessed in the over application or under utilization of these resources with consequent effect on poor productivity – yield per hectare and income of farmers. It becomes necessary therefore for an in depth examination of all factors of agricultural productivity especially as it concerns resource–use efficiency using Data Envelopment Analysis with a view at improving farmers productivity level. Hence, the specific objectives of this study are to:

1. examine the production characteristics of the rice farmers in the study area;
2. estimate the technical efficiency as well as ascertain the nature of returns to scale that exist in the rainfed rice production system.

Methodology

The research was conducted in Ebonyi State, Southeast Nigeria. The state is in tropical rain forest zone and the vegetation is a mixture of rich savannah and tropical rain forest (EBSMLS, 2001). Multi-stage random sampling technique was employed in this study. Three local government areas (LGAs) that produce rice in commercial quantity were purposively selected. The next stage was the random sampling of four communities per LGA and, fifteen rice farmers from each community, given a total sample size of 180 respondents. Data for the study was obtained through the use of well structured questionnaire. Data were analysed using descriptive statistics – mean, percentages and frequency distribution. Resource use efficiency was achieved using Data Envelopment Analysis approach.

Model Specification

Data Envelopment Analysis (DEA) is a performance measurement technique which employs linear programming techniques to measure efficiency as the distance of each firm from a non-parametric production frontier constructed from convex combinations of observed input-output combinations. The DEA frontier technology is formed as a non-parametric, piece-wise linear combination of observed "best-practice" activities. Data points are enveloped with liner segments, and efficiency scores are calculated relative to the frontier (Coelli et al. 1998). One of the limitations of the DEA is that efficiency is measured relative to this frontier, where all deviations from the frontier are assumed to be inefficient (Johanson, 2005). Coelli (1996) reported that where all Decision Making Units (DMUs) are not operating at optimal scale, due to a number of constraints limiting their ability to do so, the use of variable returns to scale (VRS) to characterize the production process is ideal. The use of VRS specifications permits the calculation of technical efficiency devoid of scale efficiency effects. The input oriented model measures how much the *i*th DMU's input can be proportionally reduced without any loss in output. In order to derive the economic efficiency (EE) of the *i*th firm following from Coelli (1996), the following input-oriented DEA model was applied:

$$\min_{\lambda x_i^*} P_i x_i^*$$
$$\text{subject to } -y_i + y\lambda \geq 0,$$
$$X_i^* - X\lambda \geq 0,$$
$$N1\lambda = 1$$
$$\lambda \geq 0$$
$$\theta \in (0, 1)$$

where P_i represents a vector of input prices for the ith DMU and X_i^* which is calculated by the LP is the cost-minimizing input bundle faced by the firm.

Scale efficiency occurs when the firm is operating at constant returns to scale (CRS). Scale efficiency varies between zero and one in value. Scale efficiency scare of one indicates that the firm is operating at an optimal scale that is CRS. Scale inefficiency is usually a result of increasing or decreasing returns to scale (Sharma et al. (1999). The specification of non-increasing returns model is given as

$$\min_{\theta\lambda} \theta,$$
$$\text{st } -y_1 + Y\lambda \geq 0,$$
$$\theta_{Xi}^* - X\lambda \geq 0,$$
$$N\lambda \leq 1$$
$$\lambda \geq 0$$

The specification of non-decreasing returns model is given as

$$\min_{\theta}\lambda\, \theta,$$
$$\text{st } -y_1 + Y\lambda \geq 0,$$
$$\theta X_i - X\lambda \geq 0,$$
$$N_1\lambda \geq 1$$
$$\lambda \geq 0$$

The influence of different factors on technical and scale inefficiencies of the rice farms was explained by employing Tobit regression model. This involves the relation of efficiency measures to sets of explanatory variables presumed to account for differences in efficiencies.

Results and Discussion

The result of the frequency distribution on production characteristics are shown in Table 1. The result indicates that greater percentage (50%) of the farmers had their personal farm land and, 22% cultivate rice on their family land. This implies that the farmers had no restrictions and engage in farm practice suitable to them. Under the cropping system, sole cropping (90%) dominate in the study area. The prominent varieties grown are 306 (27%), Iron (19%), BG (16%) and, R5 (14%). Other varieties cultivated include 14.16, farrow and mass. The land preparation practice is mostly done manually or tractor and manual method. About 39% and 49% of the farmers use hired labour and, family and hired labour respectively in their farm operation. The high percentage of this category of labour is expected to have a positive effect on efficiency due to stronger incentives for technical efficiency in small subsistence farming (Alamder and Oren (2006). Family labour alone does not provide adequate labour force sufficient for all the needed farm operations. Also, the cost implication of hired labour and the farmer's financial limitations makes it difficult for them to adequately finance all the labor requirements of their farm hence; they combine family and hired labour.

The resource – use efficiency, measured in terms of returns to scale, classified into increasing, decreasing and constant returns to scale (IRS, DRS, CRS) is shown in Table 2 and figure 1. The percentage of farmers operating with IRS, DRS and CRS were 77.2%, 18.9% and 3.9% respectively. This shows that majority of the rice farmers are operating with IRS. The result implies that only 3.9% of the rice farmers were operating at their optimal scale, while 18.9% were operating above their optimal resource utilization. The result is consistent with Orefi, (2011). The distributions of technical efficiency under variable returns to scale (VRS) is presented in Table 3 and Figure 2. About 32.78% of the farmers were 40-59% efficient in resource utilization, 21.67% between 60-79% and 11.10% 80 – 99% efficient. Only 5.56% of the rice farmers were 100% technically efficient in resource utilization. Since economies of scale is usually a consequence of better and more efficient use of production resources. (Sharma et al, 1999), by operating with CRS, these categories of farmers could be more competitive since their reduced costs would probably translate to increased profit.

The explanatory variables presumed to affect the rice farmers efficiency include education, experience, farm size and expansion agent visit. Education, experience and extension visit have significant impact on the resource use efficiency of the rice farmers in the study area. The positive sign on the coefficient of these variables indicates that they tend to increase efficiency. The coefficient of farm size was negative and not signed, showing that farm size did not significantly influence the farmers' level of resource utilization.

Conclusion and Recommendation

The technical and scale efficiency estimates were made for the rice farmers in Ebonyi State Nigeria. The result showed low level of efficiency in resource utilization by the farmers. Majority of the farmers were experiencing increasing returns to scale. By operating on an optimal scale (CRS), input wastage could be reduced. There is need to improve the farmers education level as well as their contact with extension agents to enhance their productivity through adoption of improved production practices.

Table 1: Production characteristics of the rice farmers

Variable	Frequency	Percentage
Source of farm land		
Personal level	90	50
Family level	39	22
Communal land	24	13
Rent	27	15
Gift	0	0
Total	**180**	**100**
Cropping system		
Sole cropping	162	90
Relay cropping	16	9
Inter cropping	1	0.5
Inter planting	1	0.5
Total	**180**	**100**
Varieties grown		
14.16	17	9
Farrow	11	6
Mass	16	9
BG	28	16
306	49	27
Iron	34	19
R5	25	14
Total	**180**	**100**
Land preparation method		
Use of tractor	13	7
Manual tillage	125	70

Tractor and manual	40	22
Other methods	2	1
Total	180	100
Labour use		
Family labour	17	10
Gang work	3	2
Hired labour	71	3.9
Family and hired labour	89	4.9
Total	180	100

Source: Field Survey, 2011

Table 2: Types of Returns to scale

Types of returns	Frequency	Percentage
Increasing returns to scale	139	77.2
Decreasing returns to scale	34	18.9
Constant returns to scale	7	3.9
Total	**180**	**100**

Source: Field survey 2011

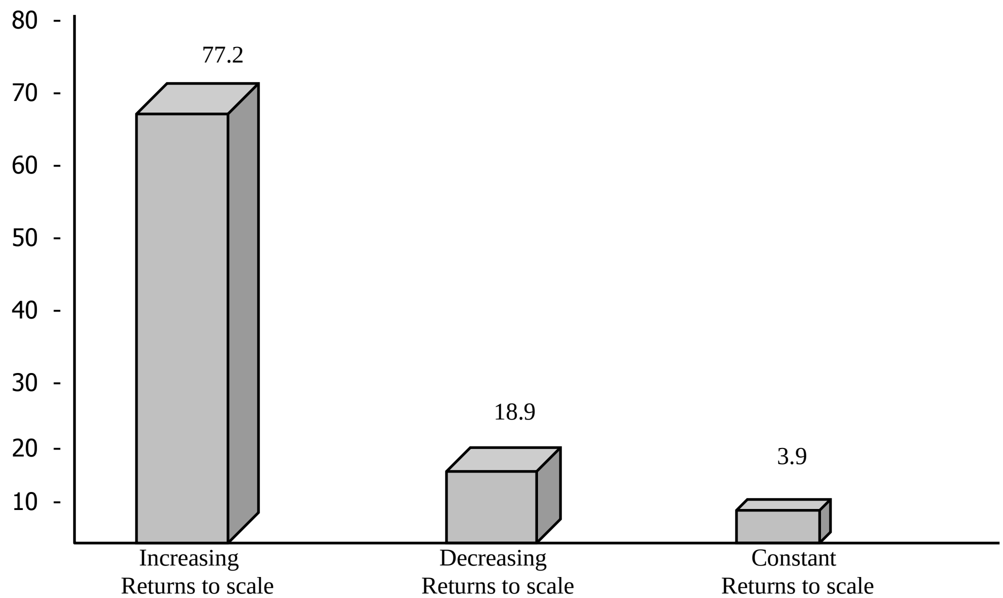

Figure 1: Types of Returns to scale

Table 3: Variable returns technical efficiency

Technical Efficiency	Frequency	Percentage
Less than 20%	0	0.00
20 – 39%	52	28.89
40 – 59%	59	32.78
60 – 79%	39	21.67
80 – 99%	20	11.10
100%	10	5.56
Total	**180**	**100**

Source: Field survey 2011

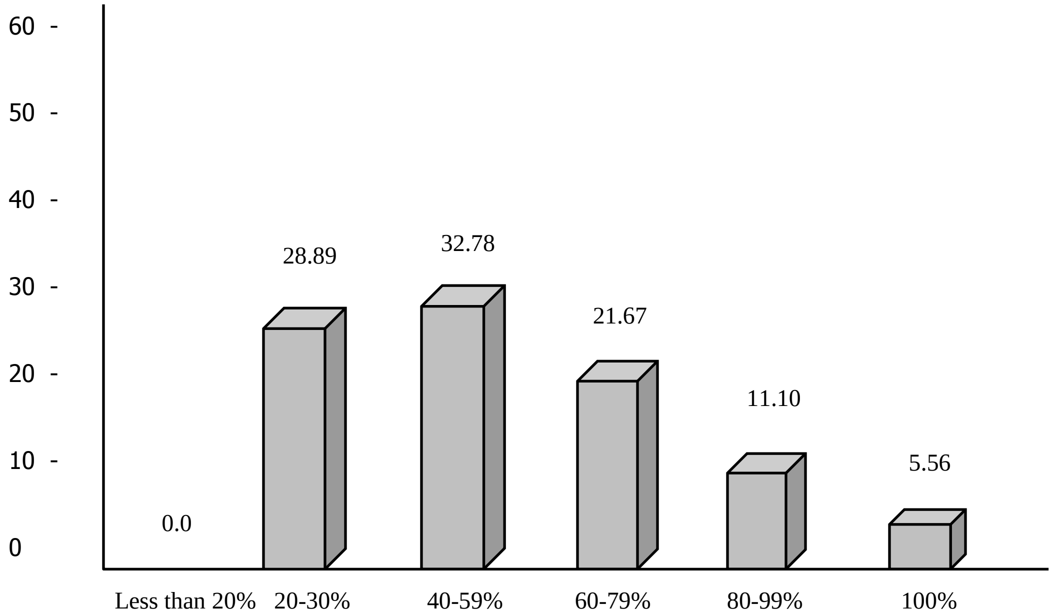

Figure 2: Technical efficiency of farmers

Table 4: Determinants of technical efficiency

Variable	Coefficient	Std. error	z-statistic	Probability
Education	0.022221	0.001587	13.99976	0.0000*
Experience	0.004869	0.000815	5.971015	0.0000*
Farm size	-0.075114	0.014042	-1.694103	0.0000
Extension visit	0.098749	0.004401	11.07756	0.0000*

Source: Field survey data, 2011

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