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Resource Use Efficiency among Fadama Crop Farmers in Ibadan/Ibarapa Agricultural Zone of Oyo State, Nigeria: A Stochastic Frontier Approach

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Abstract

The study investigated the resource use efficiency among Fadama crop soko (Celosia argentea), watermelon (Critullus lanatus), and maize (zea mays) farmers in Ibadan/Ibarapa agricultural zone of Oyo state, Nigeria. Data were collected from 120 respondents who were randomly selected and interviewed using both interview schedule and questionnaire. Data collected were analyzed using stochastic frontier model. The findings revealed that sigma square (δ^2) was 0.91397, and 0.678018 for soko and watermelon farmers, respectively, and were all significant at $\rho < 0.05$, while gamma for the three crops, soko, watermelon and maize were 0.985, 0.642 and 0.854, respectively, and significant at $\rho < 0.05$. Labour, fertilizer, insecticides and seeds influenced the technical efficiency of soko, while herbicides and insecticides influenced the technical efficiency of watermelon and labour, insecticides and seed influenced the technical efficiency of maize farmers. Age, educational levels and farming experience had significant effect on the level of technical inefficiency. The p values for soko, watermelon and maize were 0.694, 0.0261 and 0.0000, respectively. There was no significant difference in the productivity between Fadama and non Fadama (soko) farmers, while there was a significant difference between the productivity of Fadama and non Fadama (watermelon) farmers as well as Fadama and non fadama maize farmers.

Keywords: technical efficiency, productivity, floodplains, livelihood.

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1 Introduction

Nigeria is a food-deficit country that on many occasions has been dependent on food imports (Adeoye, 2010). Its agricultural sector has ceased to be an important contributor to foreign exchange earnings; even its contribution to employment has declined (Balogun, et al., 2012). According to Ojo and Akanji (1996), the growth index of agricultural production for crops has shown a decline from 7.4% in 1986 to 3.4% in 1995. Most studies show that aggregate food production in Nigeria has been growing at about 2.5% in recent years, but the annual rate of population growth has been at 3.5% (Ajibefun & Abdulkadir, 1999). This situation has not always been so and in fact; there is a great national optimism that the current predicament would be reversed and Nigeria return to full status of a major food basket in the region.

In Nigeria, various agricultural programs and policies have been instituted in the past, and were meant to improve sustainable productivity and farmers' income, consequently the quality of lives of the rural households. One of such projects is the National Fadama Development Project II.

Fadama is a Hausa name for wetlands. These are low-lying flood plains with easily accessible shallow ground water. Though the surfaces of these flood plains become dry during the dry seasons, appreciable amounts of water can be trapped around the plains. The water obtained from the tube wells dug in these plains is used for the development of small-scale irrigation schemes to boost dry season crop production. Fadama is an integrated approach which is designed by the government in order to achieve her rural development and food security objectives of government. Fadama farmers are those who utilize the Fadama resources on a sustainable basis. They benefit under the project by Community Driven Development approach, through the preparation of Local Development Plan. The Community Driven Development (CDD) approach is a bottom-top approach for the development of agricultural enterprise, there is a high sense of belonging by the beneficiaries because the communities take responsibility for designing, implementing, operating and maintaining sub-projects prioritized in their Local Development Plans.

The National Fadama Development Project is a major instrument for achieving the Government's poverty reduction objective in the rural areas of Nigeria. First National Fadama Development project (NFDP I) was designed in the early 1990s to promote simple and low-cost improved irrigation technology under the World Bank. The first phase of the National Fadama Development Project (NFDP1) was between 1993-1999.

Over the years the production pattern of crop has been fluctuating due to the environmental conditions under which production takes place. This fluctuation in production has had serious implications not only in farmers' income but also in the ability to use available resource efficiently. It is therefore necessary to examine and establish a trend in the use of farm inputs by Fadama farmers so as to be able to evolve policies that would help in increasing output and also ensuring stability in the farmers' income through an effective use of the limited farm resources. For economists productivity is about finding ways of increasing output per unit of input. Resource productivity is the therefore quantity of goods or services (outcome) that is obtained through the expenditure of unit resource. Agricultural productivity in general terms therefore means ratio of the value of total farm outputs to the value of total inputs used in farm production (Olayide & Heady, 1982).

Little effort has been made to determine the productivity differentials between beneficiaries and non-beneficiaries of the fadama programme interventions. Such study on productivity differentials is needed, in order to evaluate success or otherwise of the programmes in the agricultural sector. The paper thus analyse resource productivity of fadama farmers vis-a-vis non fadama farmers, as well as estimate the cost and returns to crop farming in the study area.

2 Conceptual Framework

The conceptual framework guiding this study is the body of work known as the livelihood approach or framework (Scoones, 1998; Bebbington, 1999; Carney et al, 1999; Ellis and Freeman, 2005). A livelihood comprised of the capabilities, assets (including both material and social resources) and activities required to make a living (Chambers & Conway, 1992). Livelihoods are based on income (in cash, kind, or services) obtained from employment, and from remuneration through assets and entitlements. Different members of a household engage in different types of livelihood activities and each household member above a certain age attempts to procure different sources of food, fuel, animal fodder and cash; these sources are likely to vary according to the month of the year. In water sector, livelihoods analysis is essential because it assesses gains and losses of the rural or urban poor from irrigation activities (Lankford, 2005). It improves the knowledge of the context from the local level upwards and helps to analyze opportunities and constraints of the rural or urban poor to benefit from the changes within the given context (Nicol, 2000). It helps to identify what options have better potential to reduce poverty within the given context and what enabling conditions, policies and incentives are needed for the poor to increase the range of better livelihood options (Scoones, 1998; Ellis, 2000; Moriarty et al, 2004; Lankford, 2005). Some of the distinctive features of the livelihoods framework are that it takes an 'all-round' view of people's means of gaining a living, including the social and institutional circumstances in which people's livelihoods are embedded. At the centre of the approach is a relationship between the assets or resources that people own or can obtain access to, including land, irrigation water, skills and education levels of family members, which are categorised as natural, human, social, financial and political capitals (Scoones, 1998; Nicol, 2000; Ellis & Freeman, 2005). The households utilise these assets in their productive activities in order to create income and satisfy their consumption needs, maintain their asset levels and invest in their future activities. The access to the assets is strongly influenced by the vulnerability context and policies and institutions.

3 Research Methodology

3.1 The Study Area

The study was carried out in Ibadan/Ibarapa agricultural zone of Oyo state which is one of the four administrative zones of the Oyo State Agricultural Development Programme. The zone is made up of eight local government areas. Oyo State is located in the South West Region of Nigeria. Latitude 8^o and Longitudes 4^o East bisect the State into four nearly equal parts.

The State is bounded in the South by Ogun State and in the North by Kwara State. To the West, it is bounded partly by Ogun State, and partly by Benin Republic while in the East, it is bounded by Osun State.

Three vegetation regions are marked out in the State. These are Forest, Derived Savannah and Savannah regions. The forest region has a much higher relative humidity and rainfall pattern that supports tree crops cultivation while the savannah region with low humidity and rainfall pattern support mainly arable crops such as maize, cowpea and sorghum. The weather for most parts of the State follows a tropical rain forest type with an annual rainfall ranging from 1,000mm to 1,400mm and fairly high temperature (Agboola, 1979). The main occupation of the inhabitants is farming and both men and women are involved. Arable crops cultivated in the zone include maize, melon, soy-bean, cassava, cowpea, yam and vegetables while tree crops are cocoa, oil palm and cashew.

3.2 Materials and Method

Systematic and simple random sampling techniques were employed in the study. Of the eight Local Government Areas in Ibadan/Ibarapa agricultural zone, three Local Government Areas were randomly selected. From each of these local government areas two communities were randomly selected. Ten Fadama crop farmers and ten non Fadama crop farmers were randomly selected from each community to have twenty farmers from each community. This made a total sample size of 120 respondents. Primary data collection involved the administration of structured questionnaires on the respondents. The data focused on production activities of the farmers.

Quantitative analytical tool in form of Cobb-Douglas production function was used to determine the extent to which the inputs used explained the variability of crop output.

The Cobb-Douglas production function is expressed as follows:

$$Q = AXi \; b_I \text{ (where i ranges from 1 to 4)} \quad (1)$$

The specification is log linearised to obtain an estimating equation as:

$$\text{Ln } Qi = LnA + b_1LnX_{1i} + b_2LnX_{2i} + b_3LnX_{3i} + b_4LnX_{4i} + LnU_i \quad (2)$$

Where,

Qi is the output of the ith farms (kg)

X_1 = labour used on the ith farm in man-days

X_i = fertilizer in kg

X_3= herbicide in litres

X_4 = insecticide in litres

X_{5i}= seed in kg

A, is the intercept term which represents the average physical product (A measure of the efficiency of technology adopted by the ith farmer);

b_1, b_2, …,$b_{5,}$ are the slope terms representing the elasticity's of production for the different inputs used by the ith farm;

Ui is the error term.

3.3 Maximum Likelihood Estimates (Mle) for Parameters of Cobb-Douglas Model.

The analysis of the data for the technical efficiency estimates was achieved through the Maximum Likelihood Estimation (MLE) of the Stochastic Frontier Function. The estimated Stochastic Frontier Model is given in Table i while the results of the estimates of the parameters of the stochastic frontier of the inefficiency model are presented in Table ii. Sigma square (δ^2) 0.91397 and 0.678018 for soko and watermelon farmers, respectively, were large and statistically significant at $\rho < 0.05$. This indicated a good fit and the correctness of the specified distribution assumption of the composite error term. δ^2 (ratio of farm specific technical efficiency of the total variance of output) 0.2378018 for maize was significant at $\rho < 0.05$ level. These suggest that the technical efficiency effect were a momentus component of total variability of the yield.

The gamma which measures the effect of technical inefficiency in the variations of observed output had values 0.985, 0.9642, 0.854 for soko, watermelon and maize, respectively, and significant at $\rho < 0.05$. This suggests that the systematic influences that are unexplained by the production function are the dominant sources of random errors. This means that about 99%, 96% and 85% of the variation in output of crop production among soko, watermelon and maize farmers, respectively, were due to differences in technical efficiency, that is, the existence of technical inefficiency among the sampled farmers accounts for about 99%, 96% and 85%, of the variation in the output level of the crops grown, for soko, watermelon and maize, respectively. It therefore implied that 1.5%, 3.6% and 14.6% of the differences between the observed and maximum production frontier output were due to differences in farmer's level of technical efficiency and not related to random variability. These factors are under the control of the farm and the influence of which can be reduced to enhance technical efficiency of crop production. In the specified model therefore, there is the presence of a one-sided error component and that a classical regression model of the production function based on the OLS (Ordinary Least Square) estimate would be an inadequate representation of the data. The result also confirmed the relevance of the stochastic parameters of the production frontier and maximum likelihood estimation.

The Maximum Likelihood estimates of parameters were presented presented in Table 1, the coefficient of labour ($\beta_{1)}$ was significant and had positive sign for soko. This shows the importance of labour in soko farming in the study area. Several other studies (Okike 2000; Awoyemi, 2000) have shown the importance of labour in farming, particularly in developing countries where mechanization is only common in big commercial farms. In this study, farming is mainly on a small scale which involves the use of traditional farming implement such as hoe and machete. Human power plays a crucial role in virtually all farming activities. It appears that labour will continue to play important role in crop production, affecting its efficiency, until these factors constraining mechanization are addressed. While the coefficient for maize (-0.0869) had a negative sign implying that increase in labour by 100% will decrease output by 86%.

The production efficiency of output with respect to quantity of fertilizer ($\beta_{2)}$ for soko and maize were about 0.13 and 0.647 respectively. By increasing the quantity of fertilizer by 100%, output level will improve by a margin of 13.9% and 64.7% for soko and maize, respectively. The estimated coefficient is statistically significant at 5% level.

The estimated elasticity of the inputs shows that coefficient for insecticide β_3 were 0.074, 0.444 and 0.0259 for soko, watermelon and maize respectively, meaning that for a 100%

increase in the use of insecticides will increase output by about 7.4%, 44% and 2.6% respectively, for the three crops.
Seed β_4 among the watermelon farmers, the coefficient for seed is not significant unlike for soko and maize which was 0.080 and 0.389 respectively, meaning that 100% increase in seed will improve output by 8% and 38% for soko and maize respectively.

3.4 Determinants of Technical Efficiency among Fadama and Non Fadama Farmers

Table 2 shows the result of the analysis of the factors that determine or influence technical efficiency among the crop farmers in the study area. Table 2 presents the result of the inefficiency model for the three crop farmers (soko, watermelon and maize).
For soko farmers; age, educational level, and farming experience had significant effect on the level of technical inefficiency. Age had positive relationship with technical inefficiency, the positive coefficient implies that the variables have the effect of increasing the level of technical inefficiency. Any increase in the value of such variables would lead to an increase in the level of technical inefficiency. Educational level, farming experience had negative relationship with technical inefficiency. The negative coefficient implies that increase in the value of the variable would lead to a decrease in the level of technical inefficiency (or increase technical efficiency) level of farmers.
For maize farmers; gender had significant effect on the level of technical inefficiency and had negative relationship with technical inefficiency. Implying that increase in household by one male will decrease technical inefficiency. The negative coefficient implies that this variable has the tendency of reducing the technical inefficiency (or increasing the technical efficiency) level of the farmers.

3.5 Technical Efficiency Estimate for Fadama and Non-Fadama Farmers.

Table 3 presents the frequency distribution of technical efficiency estimates for the fadama and non fadama crop farmers in the study area. The distribution of technical efficiency shows a wide distribution across the crop farmers. For soko farmers, Table iii suggests that there is high variability in technical efficiency in the farmers with a mean of 0.7653. This variation in the level of technical efficiency in the soko fadama farmers implies that ample opportunities exist for this group of farmers to raise the current level of technical efficiency by 23.5%. Also for non fadama soko farmers, there is variability in technical efficiency in farmers with a mean value of 0.7221. This suggests there is still opportunity for increased efficiency by 27.8 percent given the present state.
Also, Table 3 shows that there is difference in technical efficiency between the two groups of farmers; when efficiency level was 0.91-1.0, 14(70%) and 20(100%) for Fadama and non fadama watermelon farmers respectively. Table 3 shows that about 80% and 15% of Fadama and nonfadama maize farmers respectively had technical efficiency between 0.91 and 1.0. Also, at the technical efficiency range of 0.8-0.9; about 20% and 0% of the Fadama and non-fadama maize farmers respectively fell within this range.
The forgoing analysis has indicated a wide variation in technical efficiency of the Fadama and non-fadama crop farmers, within each group, between the two groups and between the crops. From Table 1 the p values for soko, watermelon and maize are 0.694, 0.0261 and 0.0000 respectively. This implies that among soko farmers, there is no significant

difference in the technical efficiency between the Fadama and non fadama farmers, while there is a significant difference in the technical efficiency between Fadama and non fadama of watermelon and maize farmers at 95% confidence interval.

4 Conclusion

The study examined resource use efficiency among Fadama crop farmers in Ibadan /Ibarapa agricultural zone of Oyo state. The finding of this study revealed that there was no significant difference in the productivity between Fadama and non-Fadama (soko) farmers, while there was a significant difference between the productivity of Fadama and non-Fadama (watermelon) farmers and as well as Fadama and non-fadama maize farmers. The findings also revealed that labour, fertilizer, insecticides and seed influenced the technical efficiency of soko farmers. Herbicides and insecticides influenced the technical efficiency of watermelon farmers, while labour, insecticide and seed influenced the technical efficiency of maize farmers. The positive coefficient for age variable implies that the older farmers were more technically inefficient than the younger ones. Older farmers tend to be more conservative and less receptive to modern and newly introduced agricultural technology. Also negative coefficient for education implies that the farmers' level of technical inefficiency declined with more education. These results are in conformity with previous works by Parikh et al. (1995).With regards to farmer-specific factors, especially education, there is the need for policy to promote formal education as a means of enhancing efficiency in production over the long-term period. This is because it would enable farmers to make better technical decision and also help in allocating their production inputs effectively. In the short-term, informal extension education could be effective, especially when targeted at farmers who have had limited formal educational opportunities

The coefficient of farming experience was estimated to be negative as expected and statistically significant at the 5% level. The implication is that farmers with more years of farming experience tend to be more efficient in crop production. This conforms with the findings of Coelli and Battese (1996) who reported a negative production elasticity with respect to farming experience for farmers in two villages in India, thus suggesting that older farmers are relatively more efficient, and vice versa. It is possible that such farmers gained more years of farming experience through "learning by doing," and thereby becoming more efficient. The study also found that farmers under Fadama harvested more per unit of land of output of crop than non-fadama farmers for soko and maize and this confirms the hypothesis that programme intervention has the capacity to succour farm production problems while accruing more income to farmers

Table 1: Maximum Likelihood Estimates (MLE) For Parameters of Cobb- Douglas Model

Variables	**parameter**	**Soko**		**Watermelon**		**Maize**	
		Coefficient	**p>/z/**	**Coefficient**	**p>/z/**	**coefficient**	**p>/z/**
Ln(labour)	β_1	0.7133401	0.000	0.1093376	0.075	-0.086948	0.000
Ln(Ferterlizer)	β_2	0.138827	0.000	0.607084	0.536	0.6465244	0.000
Ln(herbicide)	β_3	-	-	0.2118934	0.006	-	-
Ln(insecticide)	β_4	0.740641	0.000	0.4445842	0.016	0.0259636	0.000
Ln(seed)	β_5	0.803923	0.000	0.1291471	0.471	0.3894236	0.000
Constant		5.144691	0.000	4.042719	0.000	3.832601	
Variance parameter							
Sigma squared	δ^2	0.91397	0.000	0.678018	0.002	0.2378018	0.001
Gamma	γ	0.9850900	0.000	0.9642311	0.000	0.8542311	0.004
Log likelihood function		11.643602		34.188582		18.459219	

Source: Field Survey 2011

Table 2: Inefficiency Model

Inefficiency Model		**Soko**			**Water Melon**			**Maize**		
Variable		**Coefficient**	**Std Error**	**z-ratio**	**Coefficient**	**Std Error**	**z-ratio**	**Coefficient**	**Std Error**	**z-ratio**
Family Size	(Z_1)	0.0796482	0.2422113	0.742	48.29954	1818.962	0.979	-0.596246	0.67157	0.929
Gender	(Z_2)	1.116273	0.7697634	0.147	-67.48011	2717.465	0.980	-1.636471	0.7554439	0.030
Age	(Z_3)	1.195704	0.3620083	0.001	-47.28231	1818.975	0.979	0.1338651	0.5123251	0.794
Educat Level	(Z_4)	-1.629576	0.4791069	0.001	18.15383	901.2148	0.984	0.1472564	0.4435617	0.740
Farming Esp	(Z_5)	-1.349679	0.4332656	0.002	41.85451	1808.668	0.982	0.2419975	0.3977894	0.543
Fadama	(Z_6)	-0.5622628	0.6423462	0.381	39.66775	1802.430	0.982	-6.569314	1.146846	0.000
Constant		1.092306	1.793365	0.542	-158.4699	7214.414	0.982	0.333042	3.301906	0.920

Source: Field Survey 2011

95% Confidence Interval

Table 3: Technical Efficiency Estimate For Fadama And Nonfadama Farmers.

Efficiency Level	**Frequency** Fadama	**Frequency** Nonfadama	**Total**
Soko Farmers			
Up to 0.5	2(10.0)	1(5.0)	3(7.7)
0.51-0.6	6(30.0)	2(10.0)	8(20.0)
0.61-0.7	0(0.0)	5(25.0)	5(12.5)
0.71-0.8	4(20.0)	7(35.0)	11(27.5)
0.81-0.9	0(0.0)	2(10.0)	2(5.0)
0.91-1.0	8(40.0)	3(15.0)	11(27.5)
Total	20(100.0)	20(100.0)	40(100.0)
Watermelon farmers			
0.71-0.8	3(15.0)	0(0.0)	3(7.5)
0.81-0.9	3(15.0)	0(0.0)	3(7.5)
0.91-1.0	14(70.0)	20(100.0)	34(85.0)

Total	20(100.0)	20(100.0)	40(100.0)
Maize farmers			
Up to 0.5	0(0.0)	17(85.0)	17(42.5)
0.81-0.9	4(20.0)	0(0.0)	4(10.0)
0.91-1.0	16(80.0)	3(15.0)	19(47.5)
Total	20(100.0)	20(100.0)	40(100.0)

Source: Field Survey 2011

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