Efficiency and productivity of farmers in Nigeria: a study of rice farmers in north central Nigeria.

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Introduction

Nigeria's rice sector has witnessed some remarkable developments particularly in the last ten years

❖**Demand:** Rice demand is growing faster than for any other major staples, with consumption broadening across all socio-economic classes, including the poor. The periods,1961 – 1992 demand rose at annual rate of 5.6% (Osiname, 2002). Projected demand by FAO (2003) for Nigeria beyond year 2000 remained as high as 4.5 per cent per annum

❖**Production:** Rice is cultivated in virtually all the agro-ecological zones in Nigeria despite this, domestic rice production has not increased sufficiently to meet the increased demand (see Fig 1) Estimate of locally produced rice for year 2002 was 2.9 million tonnes (FAOSTAT, 2003). In the 90s/200 while output increased yield of rice declined. increased output was traced to expansion in area cultivated. Nigeria's ave yield for both upland and lowland rainfed rice is 1.8 tonnes/ha and irrg. system is 3.0 tonnes/ha. For Cote d' Ivoire and Senegal, upland and lowland systems yields about 3.0 tonnes/ha while yield in irrg system is 7.0 tonnes/ha (WARDA and NISER, 2001).

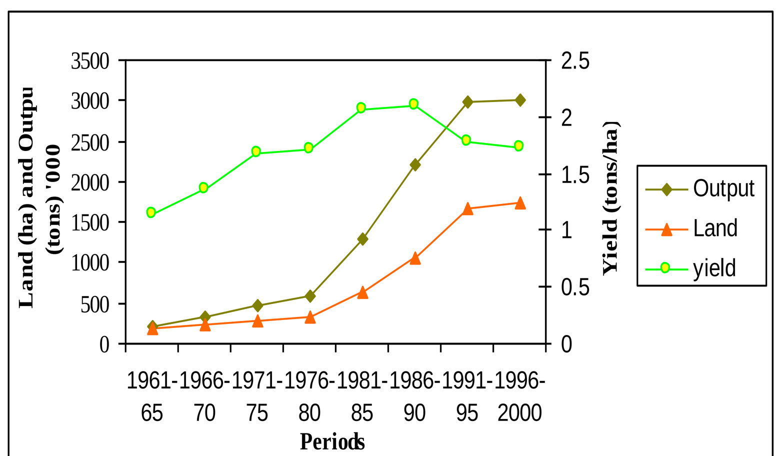

Fig 1: Rice production trend in Nigeria (1961-2000)

The Question often raised in policy and research circles is what factors explains why domestic rice production lag behind the demand for the commodity in Nigeria? Central to the explanation for this is the issue of efficiency in resource use. It does appear that rice farmers in Nigeria are not getting maximum return from the resources committed to the enterprise.

This study therefore examines the levels of efficiency of selected rice farmers for the two major rice ecologies in the country (upland and lowland rainfed ecologies) and explain those factors that determine their levels of efficiency.

Analytical framework

Assuming a farm frontier production function of the form (Coelli, 1995):

$$Y = g(X_a; \beta) \ldots\ldots(1)$$

where Y = output quantity, Xa = input quantities vector and β = vector of production function parameters. For a given level of production (Y) the technical efficient input vector Xt, is derived by solving Eq. (1) and the input ratios X1/ Xi = ki (i > 1), Assuming a Cobb-Douglas . the frontier production function is self-dual the corresponding cost frontier function is :

$$C = h(P, Y; \gamma) \ldots\ldots(2)$$

Where C = minimum cost associated with the production of Y, P = input price vector and γ = vector of parameters. Using Shephard's Lemma we derive a system of minimum cost input demand equations written as:

$$\frac{\partial C}{\partial P_i} = X_i(P, Y; \Psi) \ldots\ldots(3)$$

Substituting a firm's input prices and output quantity into the demand system in Eq. (3) yields the economically efficient input vector Xe. By combining the technically efficient, economically efficient and actual input vectors (Xt, Xe and Xa,) respectively with the input price vector P we obtain technical efficiency (TE), economic efficiency (EE) and allocative efficiency (AE), following Farrell, (1957) indexes given as follows:

$$TE = (X't\,P)/(X'a\,P) \ldots\ldots(4)$$
$$EE = (X'e\,P)/(X'a\,P) \ldots\ldots(5)$$
$$AE = (X'e\,P)/(X't\,P) \ldots\ldots(6)$$

In all cases, efficient production is represented by an index value of 1.0, and a lower index value is an indication of less efficient production (i.e., a greater degree of inefficiency). Using Jondrows et al., (1982) approach which separates the devotions from the frontier into random and an efficiency component. The new frontier function is of the form:

$$Y = f(X_a; \beta) + \varepsilon \ldots\ldots(7)$$

where ε= v – u, is the composed error term. v and u are said to be independent of each other; v is the two-sided, normally distributed random error (vi ~ N(0, σv2), and u is one-sided efficiency component with a half-normal distribution (ui ~ N(0, σu2 |). If v is then subtracted from both sides of Eq. (7), we obtain:

$$Y^* = f(X_a; \beta) - u = Z - v \ldots\ldots(8)$$

where Y* is the firm's observed output adjusted for the statistical noise captured by v.

Methodology

Data and empirical procedure

Data for the study were generated from a farm survey of 240 rice farmers selected by multi stage sampling procedure in the 2003 production season from Niger state which is one of the major rice (*about 16 %*) producing state in Nigeria endowed with two predominant rice production ecologies:- *rainfed upland and lowland* (Erestein *et al* 2003, Nigeria On line 2004). 120 farmers each were randomly selected for each of the rice production ecologies. Input, output and other relevant socio-economic data were then collected from the farmers through personal interview conducted with the aid of structured interview schedules.

The Model

Notwithstanding its limitations, the Cobb-Douglas functional form which, has been widely used in both developed and developing countries for farm efficiency analysis (Battese, 1992 and Bravo-Ureta and Evenson, 1994) was chosen to estimate stochastic production frontiers for the two rice systems using Frontier 4.1. The methodology which requires the production function to be self-dual also assumed the functional form to be an adequate characterization of technology in rice production for the purpose at hand. The specific model estimated is of the form:

$$\ln Y_j = \beta_0 + \beta_{1j}\ln Fz_j + \beta_{2j}\ln Lb_j + \beta_{3j}\ln Trct_j + \beta_{4j}\ln Agch_j + \beta_{5j}\ln Sd_j + \beta_{6j}\ln Fert_j + \varepsilon \ldots\ldots(9)$$

where *Y* is total annual output of rice (kg) for each production system; *Fz* is the size of farm cultivated to rice; *Lb* is man-day of labour used, *Trct.* is total hours of traction engaged (***Note:-the tractor variable was removed from the lowland rice farmers' model since this input was hardly used by this group of farmers***); *Agch* the quantity of agrochemical used (litres); *Fert* is the quantity of fertilizer used (kg), and *Sd* is the quantity of seeds used for the production of rice measured in kilograms; *βi* parameters to be estimated (i = 0, 1,2,3,4,5,6); j indicates the type of rice system (1 = upland and 2 = lowland); and *ε* is the composed error term defined earlier. Similarly the dual cost frontier for both rice systems (upland and Lowland) is given by;

$$\ln C_j = \alpha_0 + \alpha_{1j}\ln PFz_j + \alpha_{2j}\ln PLb_j + \alpha_{3j}\ln PTrct_j + \alpha_{4j}\ln PAgch_j + \alpha_{5j}\ln PSd_j + \alpha_{6j}\ln PFert_j + \alpha_{7j}\ln Y_j^* \text{--------}(10)$$

Where C is per farm costs of production for each production system, P*Fz* is the price of fertilizer; P*Lb* is daily wage rate of labour; P*Trct* is the price of tractor service per hour; P*Agch* per litre price of agrochemical; P*Sd* is the price of seeds used as input; P*Fert* is the price of fertilizer applied per hectare of land; Y* is the annual total farm output of rice for each system in kilograms adjusted for any statistical noise as specified in Eqn. (8) above. The explanatory variables included in the models are similar to those used in previous studies of developing Nigeria agriculture (Imolehin and Wada 2000; and Awotide 2004).

Empirical result

Table 1 shows the maximum likelihood parameter estimates of the stochastic production frontier (eqn. 9) for upland and lowland producers along with some descriptive statistics for the sample as well as OLS estimates of average production functions for comparison. In general, the frontier estimates amount to neutral upward shift of the average function. The function coefficient for upland rice is very close to one (0.97) while the value for lowland rice is 1.05. Based on restricted least squares regression, the hypothesis of constant return to size cannot be rejected for either upland or lowland rice. These results are consistent with the fact that all farms in the sample are relatively small**.** The largest number of hectares devoted to upland rice production is five while the corresponding figure for lowland is greater than five. The mean economic (EE), technical (TE) and allocative (AE) efficiency index computed for 120 upland rice farmers shown in Table 2 are 51.9, 83.1 and 66.6 respectively.

The corresponding indexes for the 120 lowland rice farmers are 55.4, 77.6 and 79.0. Frequency distribution of economic, technical and allocative efficiency estimates for the two groups of farmers are given in Fig. 1, 2 and 3. It is clear that a greater proportion (over 50%) of upland rice farmers is closely clustered near a range of between 0.21 to 0.70, and 0.31 to 0.70 of EE and AE indices respectively. Similarly, over 50 percent of the lowland rice farmers cluster near a range of between 0.51 to 0.80, and 0.7 and above for EE, and AE indices respectively. However, over 70 percent of the farmers in both groups clustered within the range of 0.71 and above for the TE index. Given that the same crop is produced under different farming system, it is necessary to compare the efficiency levels for the two systems. Using the t-test as means of evaluation the null hypothesis that the mean efficiency (EE, TE and AE) for both systems is equal, is accepted for EE and rejected for TE and AE respectively (P< 0.05). We therefore conclude that technical efficiency is significantly higher in upland rice production compared to the lowland rice production system, while on the other hand AE is significantly higher in the lowland rice production compared to the upland rice production system. Furthermore, correlation analysis for each efficiency measure between the two production systems suggests a weak association. The coefficients are -0.08 for both EE and AE and 0.15 for TE. Several authors (see Bravo- Ureta and Pinheiro, 1997) have investigated the relationship between efficiency and various socio-economic variables using two alternative approaches. One approach is to compute correlation coefficients to conduct other simple

Table1: Average production functions and stochastic production frontiers for upland and lowland rice based on sample of farmers in Niger State Nigeria

Variable	Upland (N=120)			Lowland (N=120)		
	Mean (SD)	Average function	Stochastic frontier	Mean (SD)	Average Function	Stochastic frontier
Intercept	-	1.844*	1.845*	-	1.946*	2.149*
		(0.330)	(0.403)		(0.336)	(0.289)
Farm size	3.27	0.327*	0.317*	4.61	0.411*	0.391*
	(2.41)	(0.091)	(0.104)	(3.84)	(0.153)	(0.136)
Labour	35.36	0.212*	0.252*	52.21	0.223*	0.231*
	(15.67)	(0.075)	(0.058)	(105.41)	(0.078)	(0.063)
Tractor	143.20	0.033*	0.036*	-	-	-
	(28.56)	(0.012)	(0.012)			
Agrochemical	61.75	0.121**	0.111*	118.84	0.012	0.011
	(103.09)	(0.051)	(0.043)	(164.42)	(0.016)	(0.011)
Seed Quantity	32.92	0.134**	0.141*	19.07	0.167**	0.165*
	(48.74)	(0.054)	(0.053)	(12.36)	(0.068)	(0.058)
Fertilizer	43.26	0.113	0.115	135.03	0.303*	0.249**
	(57.24)	(0.082)	(0.083)	(126.61)	(0.113	(0.104)
Quasi fun. coefficient		0.940	0.972		1.116	1.047
Variance parameters						
σ^2	-	0.032	0.031*	-	0.075	0.137*
			(0.004)			(0.029)
γ	-	0.050	0.047	-	0.64	0.77*
			(0.098)			(0.111)
Loglikelihood	-	39.21	41.63	-	-115.44	-188.11
LR test of one sided error	-	-	4.837	-	-	5.466

*Significant at the 0.01 level, ** at the 0.05 level, ***at 0.1 level

non-parametric analysis. The second way, usually referred to as a two-step procedure, is to first measure farm level efficiency and then to estimate a regression model where efficiency is expressed as a function of socioeconomic attributes. Kalirajan (1991) observed that socio-economic attributes have roundabout effects on production and, and hence, should be incorporated into the analysis indirectly, while Ray (1988) argued that the two-step procedure is justifiable if one assumes that production function is multiplicatively separable in what he calls discretionary (included in production function) and nondiscretionary (used to explain variations in efficiency) inputs. Despite the controversy it is still useful to examine the possible relationship between efficiency and socioeconomic characteristic. For this purpose, the analysis of variance (ANOVA) was used in this study to investigate the association between EE, TE and AE, for the following seven socioeconomic characteristics; (1) Age, given by the age of the household head; (2) Education, the number of years of schooling completed by the household head; (3) Experience, the number of years of farming rice by the household head (4) Household size, the total number of people in the household both old and young (5) Farm size, the total number of hectares in the farm unit under each system, (6) Sex, equal to 1 for the female rice farmers and zero for the male farmers (7) Seed variety, equal to one for improved rice variety and zero for the traditional variety. ANOVA results presented in Table 2 show there is the lack of consistent pattern of

Table 2: Distribution of the Efficiency Scores and Socio economic characteristics of rice farmers.

Variable	Upland farmers				Lowland farmers			
	N	TE	EE	AE	N	TE	EE	AE
Age (Years)								
≤29	10	93.3	39.2	42.0	7	93.0	27.5	29.6
30-39	36	88.0	40.3	44.0	26	82.9	27.5	33.3
40-49	41	95.7	36.9	38.5	68	86.8	34.3	39.1
50-59	16	97.1	49.3	52.8	17	85.3	19.9	22.8
≥ 60	17	96.3	79.2	80.5	2	71.6	15.2	22.2
F-Value		6.1*	1.1	1.2		1.5	1.3	1.3
Education								
None	6	88.5	41.8	47.3	3	67.0	23.5	36.4
Primary	90	94.3	42.2	45.3	50	84.5	29.3	34.5
Junior Sec.	-	-	-	-	6	88.0	23.0	26.3
Senior Sec	24	94.9	38.9	39.4	61	88.6	31.7	35.7
F-Value		11.8 *	0.2	0.5		2.5***	0.3	0.2
Experience (Years)								
≤ 9	10	95.4	44.6	47.3	16	76.0	23.7	31.9
10-19	19	94.2	33.2	34.9	81	86.8	30.5	35.0
20-29	41	89.5	38.6	41.7	21	89.5	35.2	37.9
30-39	31	95.6	47.3	49.8	2	88.8	9.9	11.4
40-49	10	96.4	43.2	48.3	-	-	-	-
50-59	7	96.4	34.5	35.3	-	-	-	-
≥60	2	98.4	89.9	91.5	-	-	-	-
F-Value		2.0 ***	2.1 ***	1.9 ***		3.7 *	0.9	0.6
Household Size								
<10	97	92.6	39.5	42.0	58	83.0	23.9	29.1
10-20	19	97.5	51.1	54.3	62	88.5	35.8	40.0
>20	4	93.3	39.8	45.5	-	-	-	-
F-Value		3.4*	1.7	1.7		4.9**	6.8*	4.2 **
Farm size (HA)								
<1	-	-	-	-	18	74.5	15.7	21.7
1-5	99	92.4	40.6	43.4	38	81.4	15.4	31.9
>5	21	98.5	45.7	47.9	64	91.7	36.9	40.1
F-Value		13.1 *	0.7	0.5		18.1 *	5.6 *	3.2**
SEX								
0	41	86.7	36.6	41.7	15	77.7	14.7	20.1
1	79	96.9	44.0	45.5	105	87.0	32.3	36.8
F-Value		36.7*	2.18	0.5		6.3*	5.8*	4.4**
Seed Varity								
0	72	91.5	35.4	38.9	72	86.5	31.4	35.9
1	48	96.4	50.6	52.1	48	84.9	52.0	58.9
F-Value		48.8*	10.6*	7.0*		6.4*	8.5*	4.3**
Mean efficiency (%)		51.90	83.08	66.64		55.44	77.56	78.97

*Significant at P≤ 0.01, ** Significant at P≤ 0.05, ***Significant at P≤ 0.1,

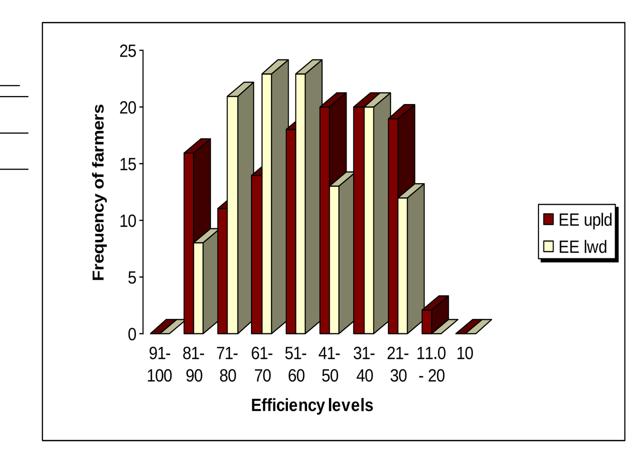

Fig.1: Economic efficiency of upland and lowland rice farmers

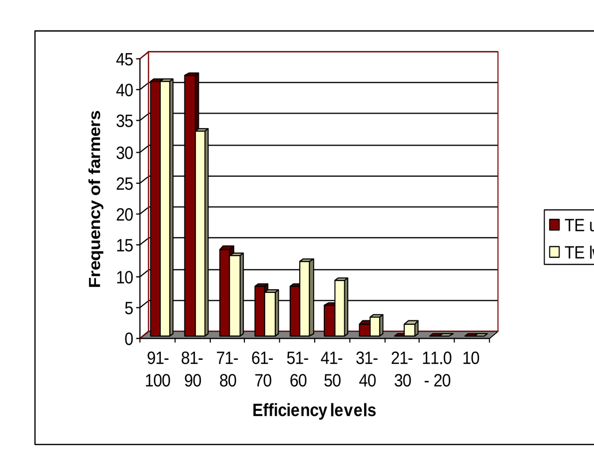

Fig. 2: Technical efficiency of upland and lowland rice farmers

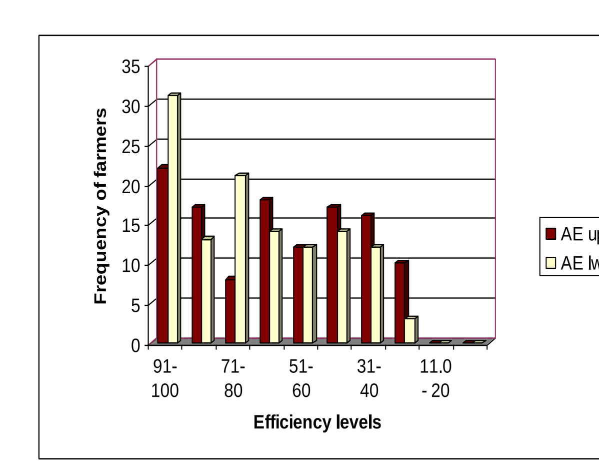

Fig.3: Allocative efficiency of upland and lowland rice farmers

association between efficiency and some socioeconomic characteristics as age and education in both production systems; experience in the case lowland system; and household size, farm size and sex in the case of the upland system. Some of these results are consistent with findings reported by authors who have studied the productivity of traditional farmers. For instance, Bravo-Ureta and Evenson (1994), and Ajibefun (2003) reported the presences of a weak association between efficiency and education attribute for eastern Paraguay and southwest Nigeria respectively. Azhar, (1991) lend support to this notion by asserting that elementary education (4 - 6 years of schooling) does not have much effect on agricultural productivity in traditional farm settings. In this study, about 75% of the farmers had primary education, 20% had secondary education and 5% had no education. The clearest pattern that emerges is that, all the socio-economic characteristics were positively related to efficiency. However, four of these characteristics- experience, household size, farm size and sex, had four out of the six cases statistically significant at various levels with marked influence on all efficiency measures under lowland production system except for experience. The significant influence of farm size relates to capturing variation in efficiency that arises from differences in scale and this effect has been widely reported by authors (Bravo-Ureta and Rieger 1991, Amara et al., 1998). Finally, variety of seed (especially the improved variety) exhibits the greatest number of significant relationships with efficiency in all of the six cases. The emergence of a clear-cut pattern thus shows the effect that improved seeds have on individual farm efficiency.

Conclusion

Results form this study suggest that, farmers in the study area could increase output and household income through better use of available resources given the state of technology in terms of improved varieties of rice seeds. Gains in output stemming from improvements in productivity are important to Niger State farmers considering that opportunities to increase farm production by bringing additional virgin lands into cultivation have significantly diminished over the years with the rise in population and consumption of rice in every household in Nigeria. The frontier function under-scores the significance of traction in improving technical efficiency of lowland rice farmers since the variable is hardly used in the area by the lowland rice farmers. Relationship between efficiency and various socioeconomic variables did not reveal a clear strategy (except for seed variety) that could be recommended to improve performance despite their statistical significance. This possibly might be due to the existence of a stage of development threshold below which this type of relationship is not observed. If this is the case, then our results imply that Niger state rice farmers are yet to reach such threshold. Consequently, our analysis suggests that policy to improve education and adoption of new rice technology, for example, would be needed in order to go beyond this threshold. Once this is accomplished, additional productivity gains would be obtained by further investments in human capital and related factors.