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Analysis of Technical Efficiency of Sedentary Pastoralistsin Livestock-Crop Farming in Selected Local Government Areas of Adamawa State, Nigeria

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ABSTRACT
This study determined resource use efficiency in sedentary pastoralists in livestock-crop farming systems in Adamawa State of Nigeria.Two hundred agro-pastoralists were randomly selected from the study area. Data collected were analysed using stochastic frontier production function. The Maximum Likelihood Estimates (MLE) for the stochastic frontier production function for the agro-pastoratists revealed that the estimated coefficients of all the parameters except animal traction (X_4) and expenditure on crop residue (X_6) were positive and significant at 1% and 5%.Thereturns to scale was 1.64 indicating increasing return. Also, the variance ratio defined as Gamma (γ) was estimated as 0.61 and significant indicating presence of inefficiency. A range of technical efficiency was observed across the sampled farms, the best farmer had a technical efficiency of 0.97, while the worst farmer had a technical efficiency of 0.60, with a mean of 0.85indicating a wide efficiency differential.The following factors contributed to efficiency and were significant at 1% and 5% experience, education and cooperative membership. The results of the hypotheses test revealed the presence of technical inefficiency among the agro-pastoralist in the study area. The major constraints of the agro-pastoralists in their production activities include inadequate and high cost of inorganic fertilizers, high cost of paid labour. low fertility status of farm land, high cost of transportation and lack of adequate grazing land. It is recommended among others that the agro-pastoralists be educated in modern methods of agricultural production and also provide easyaccess to production inputs.

Key words: Agro-pastoralists, Sedentary, Adamawa,Efficiency

INTRODUCTION
Although trans-human pastoralism is still the dominant system of cattle production in Africa, this traditional system is breaking down in recent decades because of population pressure, cycles of low rainfall, drought and shortage of fertile land. Pastoralist production has been studied by different scholar from its trends to its utilization of resources (Kratli and Schareika, 2010; Ugwu, 2010, Ayantunde*et al*., 2011; Scholtz*et al*., 2011). Studies (Christianensen*et al.* 1995, Williams *etal*.,2000, Boserup 2005, McDemott*et al*. 2010, Charles *et al*., 2010) have also shown that population pressure is the prime mover for agricultural intensification and development of crop-livestock farming system. The population pressure and climatic changes in the Savannah have caused major changes in the pattern of livestock ownership and agricultural production. An increasing proportion of the stock in the Savannah is now owned by crop farmers, who invest their surplus revenue from crop sales in animal production when crop prices are higher. They also take advantage of low livestock prices during drought to acquire animals from poor farmers or pastoralists. Although the process has fostered crop-livestock integration into mixed farming, it has also created problems for pastoralists.

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Aigner *et al*. (1977) and Van den Broeck and Meeusen (1977) independently proposed the stochastic frontier production model. The model was further improved by Coelli and Battese (1995) and Ajibefun and Aderinolo (2003). The model assumes that the production technology of farmers to be specified by a Cobb-Douglas production function with a multiplicative disturbance term that allows for the simultaneous estimation of the random disturbance term (V_i) which is outside the control of the production unit and the inefficiency effect (U_i) which determines efficiency of the decision unit. The stochastic production frontier model has an edge over the average efficiency measures in that it allows for statistical noise rather than attributing all deviations to inefficiency (Xu and Jeffrey, 1998).

Studies by Pitts and Lee (1981) and Kalirajan (1981) adopted a two stage approach in studying efficiency using stochastic frontier production function. In the first stage it involves the specification and estimation of the stochastic frontier production function and the prediction of the technical inefficiency effects under the assumption that these inefficiency effects are identically distributed while the second stage involves the specification of a regression model for the predicted technical inefficiency effects which contradict the assumption of identically distributed inefficiency effects in the stochastic frontier. However, Coelli (1995) has identified a fundamental contradiction in the two-stage approach. In the first stage, the efficiency factors are assumed to be independently and identically distributed while, in the second stage, they are seemed to be a function of a number of firm-specific factors, which implies that they are not identically distributed.The inconsistency in the two stage approach was eliminated by Battese and Coelli (1995) by specifying stochastic frontier models in which the efficiency factors are made an explicit function of the firm-specific factors, whose parameters are estimated in a single-stage maximum likelihood procedure. This single-stage approach is less objectionable from a statistical point of view and is expected to lead to more efficienct estimator.

A number of empirical studies (Tadese and Krishnamorthy, 1997; Amaza and Olayemi, 2002;Umoh, 2006); Alene *et al*., 2008)have been conducted to estimated technical efficiency using stochastic frontier models. Also Kalijiran and Shand(1985); Parikh and Shah (1994) and Llewelyn andWilliams (1996) have investigated the determinants of technical efficiency among firms in an industry by regressing the predicted efficiencies, obtained from an estimated stochastic frontier on a vector of farmer-speciific factors such as age of the farmer, educational level of the farmer, access to extension, and so on, in a second stage regression. The identification factors; which influences the level of technical efficiency, is a valuable exercise because the factors are significant for policy formulation.This paper assesse the technical efficiency of the agro-pastoralists inAdamawa State and also identified the constraints faced by them in crop-livestock production.

METHODOLOGY

The study area

Adamawa State is located in the North-eastern part of Nigeria and lies between Latitudes 8^{o}N and 11^{o}N of the equator and Longitudes 11.5^{o}E and 13.5^{o}E of the Greenwich Meridian. The total land area of the State is approximately 38,741km^2, with about 22,604 km^2 being arable (Adebayo, 1999). The soils of the State are classified as ferruginous tropical, and generally have marked differentiation of horizons and abundance of free iron oxides usually deposited as red and yellow mottles of concretion. These soils include luvisols, legosols, combisols, verbisols, lithosols among others (Ray, 1999). The major vegetations found in the state are Southern Guinea Savannah, Northern Guinea Savannah and the Sudan Savannah. Within each formation is an interspersion of thickest tree savannah, open grass savannah and finging forests in the river-valley.The population of the State was 3.2 million in 2006 (NPC, 2006) and is projectedto 3.7 million from the censusfigures with a projected birth rate of 3.2%.Majority of the people are farmers, cultivating different variety of crops and rearing of animals. The major crops of economic importance in the state include maize, millet, sorghum, rice, yam, cowpea and groundnut. Animal such as cattle, sheep and goats are the predominant livestock production activities. The farming system in the area extends from mono-cropping to mixed farming. Ten cropping and two livestock combinations were identified in the study area (Lawal, 2012).

Sampling technique

Multi-stage sampling procedurewas employed in the selection of respondents for the study. The State consist of 21 Local Government Areas divided into four administrative zones under the Agricultural Development Programme (ADP) namely; Mubi (zone I),Gombi(zone II), Mayo-Belwa(zone III) and Guyuk(IV). The first stage was a random sampling of one (LGA) from each of the four ADP zones, making a total of four LGAs. In the second stage, five (5) villages were randomly selected from each of the LGAs, making a total of 20 villages. The third stage involved purposive sampling and proportionate selection of 200 agro-pastoralists from the sampled villages based on the number of pastoralist in the villages.

Analytical techniques

Data collected were analyzed using stochastic frontier production model. The model specified explicitly for the study is as follows:

$L_nY_i = \beta_0 + \beta_1 \log X_{1i} + \beta_2 \log X_2 i + \ldots\ldots\ldots \beta_9 \log X_{9i} + V_i - U_i$ .... (1)

Where;Ln = Logarithm to base e

Y = Value of output from crop and livestock (excluding value of retained livestock)(₦)

X_1 = Farm size(ha)

X_2 = Hired labour (mandays)

X_3 = Available household labour (mandays)

X_4 = Animal traction (days/bullock)

X_5 = Agro-chemicals (litres)

X_6 = Expenditure on crop residue (₦)

X_7 = Quantity of seed planted (kg)

X_8 = Quantity of inorganic fertilizer (kg)

X_9 = Other costs (₦)

B_0 - β_9 = Parameters estimated

V_i = Random error which are $N(0,\delta_v^2)$

U_i = Inefficiency effects which are non-negative with half normal distribution $/N(0,\delta_v^2)$.

The technical inefficiency effects are independently distributed and U_i arises by truncation (at zero) of the normal distribution with mean μ_i and variance δ^2 where μ_i is defined as:

$\mu_i = \delta_0 + d\delta_1 Z_{1i} + \delta_2 Z_{2i} + - - - - - - - - \delta_9 Z_{9i}$ .... (2)

Where:

μ_i = The technical inefficiency of the i^{th} farmer

Z_1 = Number of years of formal education

Z_2 = Number of tropical livestock units owned

Z_3 = Number of years to continuous cropping of land

Z_4 = Family size (Number of persons)

Z_5 = Planting at least one legume crop (Dummy:d =1for planting and 0 otherwise)

Z_6 = Credit availability (Dummy:1 for obtaining credit and 0 otherwise)

Z_7 = Extension visit (Dummy:1 if visited more than once a year and 0 otherwise)

Z_8 = Cooperative membership (Dummy:1 if yes and 0 if otherwise)

Z_9 = Age of farmers (years).

The maximum likelihood estimates of β and δ were estimated simultaneously using the computer programme FRONTIER 4.1, in which the variance parameter are expressed in terms of $\delta^2_S = \delta^2 v + \delta^2$ and $\gamma = \delta / \delta^2$ (Coelli, 1994).

RESULTS AND DISCUSSION

The maximum likelihood estimates of the stochastic frontier production function are presented in Table 1. The estimated coefficients of all the parameters were positive except animal traction (X_4) and expenditure on crop residue (X_6), which were negative. This means that total output increases by the value of each coefficient as the quantity of each variable input increases by one percent except foranimal traction and expenditure oncrop residue variables. The returns to scale which is the sum of elasticities was 1.64, indicating increasing returns to scale. This shows that agro-pastoralists were operating in stage I of the production surface; a situation whereby an additional unit of input results in a larger increase in output than the preceding unit.In this case, optimum efficiency of production or resource use has not been attained, and resources are mis-allocated or under-utilized below the point of economic potimum. The sigma squared (0.03) was statistically different from zero at 1% level. This indicates a good fit and the correctness of the specified distributional assumptions of the composite error term. Also, the variance ratio defined by Gamma (γ) was estimated as 0.61, meaning that the existence of technical inefficiency among the agro-pastoralists accounted for about 61% of the variations in the output levels of the farmers. This confirms that in the specified model, there is the presence of one-sided error component. Thus, the diagnostic statistics confirmed the relevance of the stochastic production function to the data fitted.

From Table 1, the coefficient of farm size was statistically significant at 1% level and having a coefficient of 0.02, indicating that the crop output of the agro-pastoralists was inelastic to changes in the farm size. A 1% increase in hectares of land used in production would increase total output of crops by about 0.02%. This suggests that land is a significant factor associated with changes in crop output. The more land is put under cultivation, the more theoutput realizedceteris paribus.

Table 1:Maximum likelihood estimates of the stochastic frontier production function.

Variables	Coefficient	Parameter	t-ratio
Production factors			
Constant	$ß_0$	0.5781	4.4441***
Farm size (X_1)	$ß_1$	0.0158	3.7006***
Hired Labour (X_2)	$ß_2$	1.4507	2.5356**
Family Labour (X_3)	$ß_3$	0.0027	0.2575
Animal Tractor (X_4)	$ß_4$	-0.0279	-1.6818
Agro-Chemicals (X_5)	$ß_5$	0.0290	2.6826**
Crop Residue (X_6)	$ß_6$	-0.0013	-0.2248
Seed (X_7)	$ß_7$	0.0306	2.4115**
Fertilizer (X_8)	$ß_8$	0.1328	4.6539***
Other Costs (X_9)	$ß_9$	0.0120	3.0380***
Inefficiency Effects			
Constant	δ_0	0.2439	0.7186
Education (Z_1)	δ_1	-0.02026	-2.6408**
LTU (Z_2)	δ_2	-0.0050	-0.0720
Experience (Z_3)	δ_3	-0.2038	-3.3657***
Family size (Z_4)	δ_4	-0.1298	-0.7594
Legume (Z_5)	δ_5	-0.0392	-2.0855**
Credit (Z_6)	δ_6	0.0449	-1.06138
Extension Visit (Z_7)	δ_7	-0.0235	-0.7698
Cooperative membership (Z_8)	δ_8	-0.0373	-2.1875**
Age (Z_9)	δ_9	-0.1231	-0.8850
Diagnostic Statistics			
Likelihood ratio		106.132***	3.5884***
Sigma –square (υ^2)		0.0259	3.6969***
Gamma (γ)		0.6063	

Source: Computer output from frontier 4.1. ***Significant of 1% level, **Significant of 5% level *Significant of 10% level./

Hired labour also contributed significantly to crop output as indicated by the statistical significance of the coefficient at 5% level. A 1% increase in man-days of hired labour for the agro- pastoralist would increase output of crops by 1.45%. The use of hired labour on the farm is expected to increase the scale of production of the farmers, which consequently increases output. The coefficient of elasticity was 1.45 (elastic) indicating that hired labour used on the farmswas under-utilized, hence additional man-days of hired labour could increase output more than the preceding unit (Olayide and Heady, 1982).

Agro-chemicals which include both herbicides and pesticides hads an coefficient of 0.029 and was statistically significant at 5% level. This means that a 1% increase in the quantity of agrochemicals used by the agro- pastoralist would increase output of food crops by about 0.03%. The use of agrochemicals increases efficiency in production and also reduces drudgery and fatigue associated with crop production. Pesticides increase yield of crops by destroying pests that affect normal cropgrowth and development.Inorganic fertilizer hads ancoefficient of 0.13 and was statistically significant at 1% level. Fertilizer is a soil augmenting input which increases the fertility of existing soils. From the result a 1% increase in the use of inorganic fertilizer would increase output of crop by 0.13%. Cereals require a lot of nitrogen for maximum yield, and this is expected to be supplied by the inorganic fertilizers.

Other costs which include; cost of transportation, cost of empty sacks, among others has acoefficient of 0.01 and was highly significant (1% level). Since productivity increases with increase in area under cultivation,an increase in area under cultivation would increase production costs; increase in output would definitely bring about increase in other costs associated with production activities.

The inefficiency parameters were specified as those relating to farmers' specific socio-economic characteristics and were examined by using the estimated δ coefficients. A negative δ coefficient indicates that the parameter estimate has a positive effect on efficiency and vice versa. Thus, all the inefficiency parameters have the expected signs. The coefficient of education variable was estimated to be negative and statistically significant at 5%. This implies that as agro-pastoralists aquire formal education their technical efficiency increases. This might be due to their enhanced ability to acquire technical knowledge, which moves them closer to the frontier output. It is very plausible that the farmers with educational attainment respond easily to the use of improved technology such as the application of pesticides, fertilizers and so on, thus producing closer to the frontier. This agrees with the findings of Amaza *et. al*. (2006), Tanko and Jirgi (2008), who also found a positive relationship between education and technical efficiency.

The coefficient of legume mixture in crop production is also significant at 5% and negatively related to technical inefficiency. This indicates that as more legumes are used in crop mix, the technical efficiency of agro-pastoralists increases. Legumes increase nitrogen content of the soil through nitrogen-fixing bacteria and other bacteria that are in their root nodules. Thus, when they are used, the fertility level of the soil increases resulting in increased yield of crop.

Cooperative membership also contributes significantly to technical efficiency of the agro-pastoralists at 5% level. This indicates that as agro-pastoralists organize themselves into cooperative associations, the benefits that will accrue from it in terms of loan accessibility and input supply would increase their technical efficiency.

Technical efficiency levels

The distribution of the agro-pastoralists technical efficiency indices derived from the analysis of the stochastic production function is presented in Table 2. The technical efficiency of the respondents was less than 1.0, indicating that all the agro-pastoralists in the study area were producing below the maximum efficiency frontier. A range of technical efficiency was observed across the sampled farms, although the spread was not large. The best farm had a technical efficiency of 0.97 while the worst farm had a technical efficiency of 0.60. The mean technical efficiency was 0.85implying that on the average, the respondents were able to obtain a little over 85% of optimal output from a given mix of production inputs and production technology. This indicates that there is a scope for increasing technical efficiency by 15% in the short-run under the existing technology. Only 4% of the respondents had a technical efficiency of 60 – 69%, while majority (52.5%) had a technical efficiency of 80 – 89%.

Table 2:Technical efficiency indices of agro-pastoralists in crop production

Efficiency Level	Frequency	Percentage
0.60 - 0.69	8	4.0
0.70 - 0.79	41	20.5
0.80 –0.89	105	52.5
0.90 - 0.99	46	23.0
Total	200	100.0
Mean	0.85	
Minimum	0.60	
Maximum	0.97	

Source: Computer output from Frontier 4.1

Productionconstraintsof the Agro-pastoralists

Agricultural production in Africa is bedeviled by a lot of challenges and the agro-pastoralists in Nigeria are not spared. The agro-pastoralists of Adamawa State are faced with the following as problems that affect their optimal production (Table 3). About 50% of the respondents indicated inadequate and high cost of fertilizer and is ranked in order of severity. The reason for this could be the non-availability of the input on time in most of the goverment subsidy sources. This is followed by high cost of paid labour (ranked second), while low fertility of the soil was ranked third.The least problem for the agro-pastoralist as captured in the study was found to be the high cost of supplimentary feeds which ranked 13th.This is because in most cases, only the feeds from their cultivated fields are fed to the animals. Other problems include attack by pests and diseases (ranked 12th) and lack of improved seeds (ranked 11th) . Given that they are now venturing into crop production from their traditional livestock production it is not suprising that their most serious challenges are those associated with crop production.

Table 3: Distribution of respondents based on constraints associated with livestock- crop farmingsystem.

Constraints	Frequency	%*	Ranking+
Inadequate and high cost of fertilizer	98	49.00	1
High cost of paid labour	96	48.00	2
Low fertility status of farm land	93	46.50	3
High cost of transportation	81	40.50	4
Lack of adequate grazing land	69	34.50	5
Clashes with pastoralists	55	27.50	6
Lack or inadequate water during the dry season	39	19.50	7
High cost of agrochemicals (herbicide & pesticide)	37	18.50	8
Drought/floading	26	13.00	9
Insecurity for life and property	20	10.00	10
Lack of improved seeds	15	7.50	11
Attack by pests and diseases	5	2.50	12
High cost of supplimentary feeds	3	1.50	13

Source: Field survey, 2011. *Multiple responses existed hence >100%, + Ranks are in descending order of severity.

CONCLUSION AND RECOMMENDATIONS

Agro-pastoralism in Adamawa State is a well established enterprise. There is a scope however for increasing output in the short run through efficient utilization of existing inputs given the current state of technology. The study has shown that the agro-pastoralists were operating at the first stage of production surface indicating inefficient utilization of resources. Therefore, the agro-pastoralists production efficiency could be improved. This would enhance the profitability of the enterprises, especially if the major input of production are provided at the appropriate time and at the right price. Also conflict resolving mechanism should be in place. Provision of western education should become a priority for greater results.

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