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Research paper

Cost Efficiency of Maize-Based Cropping Systems among Rain Fed Farmers in Adamawa State, Nigeria

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The study analyzed cost efficiency among maize-based farmers in Adamawa State, Nigeria. A multi-stage random sampling technique was adopted to select a sample size of 310 respondents in 16 villages from 8 sampled Local Government Areas of the State. Data were collected through structured questionnaires and analyzed using descriptive statistics, stochastic production frontier model. The results revealed that majority (68.08%) of the respondents were male with mean age of 47 years. The mean household size was 8 with varying levels of formal education. Maize intercropped with other crops was the dominant (76.13%) cropping system accounting for 64.89% of the total area cultivated. The maximum likelihood estimate of the stochastic cost function revealed that the explanatory variables; age, education, extension contact and crop diversification were significantly and positively related to cost efficiency in the study area. The cost efficiency index ranged from 0.43-0.94 with a mean of 0.80.

Keywords: Cost efficiency, Maize-based, Cropping systems

INTRODUCTION

Many developing countries face major challenges to achieve food security in a sustainable manner, considering the increasing population, limited availability of land and water resources (Tsoho and Salau, 2012). The importance of agriculture to economic growth and economic development of Nigeria cannot be over emphasized. This is because, prior to the discovery of oil, agriculture played a dominant role in the Nigeria economy. The sector was the highest earner of foreign exchange, greatest employer of labour as over 70% of the populations were engaged in agriculture. Agricultural sector is an important sector in the Nigerian economy in terms of its role in food security, poverty alleviation and economic growth. Food crop production is a major component of all production activities in that sector and comes under different cropping system. Most commonly farming system is mixed farming, mixed cropping or mono cropping due largely to consideration for risk minimization, stable income and adaptability to a particular season (Sani and Haruna, 2010).

Crop production in Nigeria is dominated by small-scale farmers who cultivate between 0.1-5.99 hectares and produce about 85-90% of the total food consumed in the country (Maurice *et al.,* 2013). These farmers are constrained by inadequate finance to expand production, hence rely on personal savings for their agricultural operations. They are also influenced by farm specific factors, which delineate their production frontiers resulting in low outputs. Studies have shown that socio-economic characteristics affect farmers' efficiency in production as it influences production decisions, availability and level of use of modern inputs and technology. When scarce resources are not efficiently utilized by resource poor farmers it could have a multiplier effect on their livelihood and incomes. These farmers would not be able to generate sufficient incomes to mitigate the rising cost of living, increasing population and the normal long dry spell in some parts of the country. This situation creates supply shortages in terms of food availability and accessibility and indirectly creates demand shortage by denying households access to sufficient income.

A number of agricultural development institutions and programmes were set up and special programmes launched by successive governments in the country with the aim of improving food supply situation. Most recently is the Agricultural Transformation Agenda; yet significant volume of food is still being imported annually; while agricultural productivity has not appreciated enough to match domestic demand. The share of food import to total import as a proxy for agricultural contribution to the nation's food supply shows an average annual share of 13%, 9.33% and 9.15% respectively for the periods 1999, 2000-2006 and 2007-2012 (CBN, 2012).

Maize (*Zea mays*) has been recognized widely as one of the most potential cereals produce. Due to high productivity and adaptability of maize, its cultivation has spread so rapidly around the globe (Anupama *et al*., 2005). Food and Agriculture Organization (FAO), (2009) reveals that maize production ranks third after sorghum and millet among the cereal crops produce in Nigeria. In addition to being food crop, maize has become a commercial crop on which many agro-based industries depend as raw materials.

In industrialized countries, maize is largely used as livestock feed and as raw materials for industrial products, while in developing countries; it is mainly used for human consumption. In sub Saharan Africa, maize is a staple food for an estimated 50% of the population. It is an important source of carbohydrate, protein, iron, vitamin B and minerals. Africans consume maize as a starchy base in a wide variety, thus playing an important role in filling the hunger gap after the dry season (International Institute of Tropical Agriculture, IITA, 2008). Maize is an important food in Africa and there is maize ingredient in several well-known national dishes. Examples are *tuwon masara* and *akamu* in northern Nigeria, *kiga* in Cameroon, *injera* in Ethopia and *Ugala* in Kenya. It is also used as animal feed and as raw material for brewing beer and for producing starch (IITA, 2008).

In Nigeria, the demand for maize is increasing at a faster rate daily. This may be due to the fact that grain is been used for feeding poultry and also serve as the main food for many household (Oguniyi, 2011). The total land area planted to maize in Nigeria is above 2.5million hectares with an estimated yield of about 1.4 metric tons per hectare (Ogundari and Ojo, 2007).

Conceptual and Theoretical Framework

Efficiency can be defined in three related terms; technical, allocative and economic efficiencies. Technical efficiency is the measure of a firms' success in producing maximum output from a given set of inputs. This indicates all the undisputed gains that can be obtained by simply organizing management better. In other words, technical efficiency is associated with the ability of a firm to produce on the isoquant frontier. Cost efficiency (otherwise referred to as allocative efficiency) on the other hand refers to the ability of a firm to produce at a given level of output using cost minimizing input prices Ogundari and Ojo, 2007). The analysis usually assumes that the firm-farm seeks to optimize a cost minimization objective function subject to resource constraints. Similarly, cost inefficiency arises when resource inputs are used in proportions which do not lead to profit maximization. In this situation the value of the marginal revenue product (MRP) is not equal to that of the marginal cost of that input. Allocative (or price) efficiency refers to the ability of the firm to choose its inputs in a cost-minimizing manner. For allocative efficiency to hold, farmers must equalize their marginal returns with true factor market prices. Thus, technical inefficiency is related to deviations from the frontier isoquant, while allocative inefficiency reflects deviations from the minimum cost input ratios (Bravo-Ureta *et al.,* 1997). The corresponding cost frontier of Cobb-Douglas functional form which is the basis of estimating the allocative efficiencies of the farmers is specified as follows:

$$Ci = g\ (Pi, \beta) \exp\ (Vi + Ui) \quad 1$$

Where:

C_i represents the total cost of inputs of the i^{th} farms; g is a suitable function such as the cobb Douglas function; pi represent input prices employed by the i^{th} farm in food crop production and measured in naira; β is the parameter to be estimated, V_i is the systematic component which represents random disturbance cost due to factors outside the control of the farmers, *Ui* is the one sided disturbance term used to represent allocative inefficiency and is independent of *V*i. U_i provide information on the level of allocative efficiency of the ith farm. Hence allocative efficiency ranges between zero and one.

The cost efficiency (CE) of an individual farm is defined in terms of the ratio of observed cost (C^b) to the corresponding minimum cost (C^{mm}) giving the available technology.

$$\text{That is: } CE = Cb = g\ (Pi, Yi, \beta) + (Vi + Ui) = \exp(Ui) \quad 2$$

Eze *et al.* (2010) evaluated resource use efficiency in arable crop production among small holder farmers in Owerri agricultural zone of Imo State, Nigeria. The result revealed that resources were not efficiently allocated by the farmers. The farmers over-utilized the resources of labour, planting materials, fertilizer capital and under-utilized land. To attain optimality, the study recommended the need for farmers' education on some fundamental farm management skills. An empirical assessment of small holder cost efficiency and its determinants in maize production were carried out by Ogunniyi and Ajao, (2010) using stochastic cost frontier function. The study investigated whether the issue of gender was really important in estimating the cost efficiency of farmers and concluded that there was need for renewed efforts in addressing the problem of gender imbalance in smallholder agriculture in Nigeria. Finding from the study indicated that estimates of the stochastic frontier cost function revealed that the coefficient of seed was found to be significant and negative in female respondents, while it was insignificant in male. This further confirmed the fact that female farmers do not have continuous access to farm inputs (seed) and tend to use the seed from the previous harvest. The policy implication is that there should be a comprehensive review of agricultural policy that will correct the imbalance in the gender access to farm inputs. Zalkuwi *et al.* (2010) analyzed the determinants of cost efficiency in cowpea production in Adamawa State, Nigeria using stochastic frontier. The mean allocative efficiency was estimated at 0.66, indicating that farmers operate at 34% below the cost frontier. The inefficiency models revealed that socio-economic variables, namely; family size, farming experience, gender and extension contact have significantly reduces cost inefficiency among the farmers.

The paper examines the efficiency of farmers in terms of resource allocation.

METHODOLOGY

Study area

Adamawa State is located at the North Eastern part of Nigeria and created in 1991 from the defunct Gongola State. It lies between latitude 7° and 11°N of the equator and between longitude 11° and 14°E of the Greenwich Meridian. It shares boundary with Taraba State in the South and West, Gombe State in the North West and Borno State in the North. Adamawa State has an international boundary with Cameroun Republic along its eastern border. The State covers a land area of about 38,741Km^2 and is divided into 21 Local Government Areas with population of 3,675,000 (NPC, 2006). The State has a tropical climate marked by dry and rainy seasons. The rainy season commences in April and ends in late October. The wettest months are August and September. Mean monthly temperature in the State ranges from 26.7°C in the south to 27.8°C in the north eastern part of the State. The mean annual rainfall ranges from 700 mm in the north eastern part of the State to 1600 mm in the southern part (Adebayo, 1999a). On the other hand the north eastern strip and the southern part have over 1,000 mm (Adebayo, 1999b).

Sampling technique

The target population for this study was farming households involved in maize-based production systems. Adamawa State is made up of 21 local government areas (LGAs) grouped into four Agricultural zones (zones I-IV) by the Adamawa State Agricultural Development Programme (ADADP). Maize is produced across all the ADP zones in the State. Based on the fore-going information, the study sample was spread across the four ADADP zones. Multi-stage random sampling technique was employed in the selection of the respondents in these zones. In the first stage, two local government areas were randomly selected from each zone, to give a total of eight sampled local government areas. In the second stage, two wards were randomly selected from each selected local government areas, giving a total of (16) wards. Third stage involved a random selection of 1 village from each ward giving a total of 16 villages. A total of 310 respondents which constitute 17.88% of the sampling frame were selected.

Data analysis

The empirical model used in determining allocative efficiency of food crop farmers is given by:

$$LnC_{ij} = \beta_0 + \beta_1 lnP_{1ij} + \beta_2 lnP_{2ij} + \beta_3 lnP_{3ij} + \beta_4 lnP_{4ij} + \beta_5 lnP_{5ij} + \beta_6 lnP_{6ij} + V_{ij} - \mu_{ij} \ldots\ldots (3)$$

Where:

Ln = Logarithm to base e
β_0- β_6= Estimates coefficients
C_i = Total production cost (N/ha)
P_1 = Cost of land (N)
P_2= Cost of family labour (N/ha)
P_3 = Cost of hired labour (N/ha)
P_4 = Cost of agrochemical (N/ha)
P_5 = Cost of inorganic fertilizer (N/ha)
P_6 = Cost of seed (N/ha).
The variance parameters are expressed in terms of
$\delta 1 + \delta 2 + \delta 3 \ldots\ldots n6$

Socio-economic characteristics of the respondents

Table 1 reveals that majority (87.10%) of them were male, implying that maize-based cropping system is dominated by male. This agrees with the findings of Kefas, (2012) who argued that females were mostly involved in farming as helpers or suppliers of labour in light farm operations like planting, weeding, harvesting, food processing and marketing which are not tedious activities compared to farm clearing, digging and threshing among other operations. This result is however at variance with the findings of Maurice, (2012) who found that food crop production in the state is dominated by the female. The distribution of the marital status of the respondents reveals that married people were the dominant (67.74%). The implication of this on agricultural

Table 1. Socio-economic characteristics of the respondents.

Variable	Frequency	Percentage
Sex		
Male	270	87.10
Female	40	12.90
Marital status		
Single	53	17.10
Married	210	67.74
Divorced	25	8.06
Widow	22	7.10
Age		
20-29	22	7.10
30-39	67	21.61
40-49	211	68.06
50-59	10	3.23
Farming experience		
≤10	60	19.35
11-20	210	67.74
21-30	18	5.81
≥31	22	7.1
Household size		
≤5	80	25.81
6-10	120	38.71
≥11	110	35.48
Educational level		
No formal education	70	22.58
Primary education	1629	54.52
Secondary education	47	15.16
Tertiary education	24	7.74
Occupation		
Farming	209	67.42
Civil service	78	25.16
Trading	23	7.42
Farm size		
≤2.0	197	63.55
2.1-3.9	78	25.16
4.0-5.9	32	10.32
≥6.0	3	0.97
Extension contact		
Non	176	56.77
Once yearly	61	19.68
Twice yearly	50	16.13
More than twice yearly	23	7.42

Source: Field survey, 2015.

production is that, labour supply will be more where the household heads are married. Comparable results were obtained by Nwachuku, (2007) and Dary and Kunnibe, (2012) who found that 90 percent of food production in this country comes from rural households who are mostly married. The age distribution shows that majority (96.77%) of the respondents were within the age range of 20-49 years, with a mean age of 47 years. This indicates that the respondents were in their active and productive age bracket, and they will be willing to adopt and practice new technology effectively (Kefas, 2012). This study is in consonance with the finding of Nwalieji and Ajayi, (2009) who reported a higher proportion of younger people in adoption of improved production practices. Younger farmers have the tendency to operate more efficiently than the older farmers (Onu and Edon, 2009). The distribution of the respondents by farming experience reveals that 19.35% of the respondents had farming experience of less than 10 years, while majority (67.74%) of them had farming experience of between 11 and 20 years. The mean farming experience was about 23 years, indicating that the respondents are experienced in maize production. By implication, the more experience the farmers are, the more innovative they will be in terms of practicing new technology. This agrees with studies conducted by Ayaode, (2010) who reported that increase

Table 2. Distribution of respondents by prevalent cropping systems.

Cropping systems	Respondents		Ha allocation		Average farm size (ha)
	No.	%	No.	%	
Sole maize	74	23.87	267.5	35.11	3.61
Maize/sorghum	11	5.54	31.0	4.07	2.82
Maize/cowpea	168	54.19	384.5	50.47	2.29
Maize/cowpea/sorghum	28	9.03	63.4	8.32	2.26
Maize/groundnut	10	3.22	9.0	1.18	0.9
Maize/cowpea/groundnut	10	3.22	2.0	0.26	0.2
Maize/rice	9	2.90	4.5	0.59	0.5
Total	310	100	761.9	100	12.58

Source: field survey, 2015.

in farming experience increases the probability of a farmer to adapt to climate change and vice versa. 65% percent of the respondents had household size of up to 1-10 persons; with mean household size of 8 persons. The number of persons in a household is very important in determining the labour availability for farm work. It will also affect household income and expenditure. Thus, household size in the state is fairly large. The educational level of the respondents reveals that majority (77.42%) had one form of education or the other with primary education accounting for 54.52% while tertiary education had the least with 7.74%. This implies that the respondents are literate. About 64% cultivate 2 hectares of farm land, which implies that respondents are small scale farmers. This is in line with the work of Afolabi, (2010) who reported that food production in Nigeria is usually undertaken by small and medium scale farmers. The distribution of respondents based on extension contact reveals a greater number (57%) of them did not have any contact with extension agents in the last 12 months. By implication, farmers were denied opportunity of utilizing new technology that could improve their skills and technical know-how.

Cropping systems of the respondents

The objective of any cropping system is efficient allocation of all resources (Panda, 2007). The distribution of cropping system of maize–based farmers' as presented in (Table 2) has revealed seven (7) cropping systems. Sole cropping accounted for 23.87 percent, having 35.11 percent of the total hectare allocation, while mixed cropping accounted for 76.13 percent, having 64.89 percent of the total hectare allocation. Mixed cropping which is the common cropping system among the respondents is due largely to consideration for risk minimization, stable income and adaptability to a particular season (Sani and Haruna, 2010). Maurice *et al*. (2015) in their research on rice-based cropping system in Adamawa state reported that mixed cropping accounted for 53.3 percent, while sole cropping accounted for 46.7 percent.

Allocative efficiency

The estimated stochastic cost function used in determining allocative efficiency is presented in (Table 3). All parameter estimates have the expected sign; cost of hired labour, cost of transportation, cost of agrochemicals and cost of seeds, were all statistically significant, meaning that these factors are determinant of total cost associated with food crop production in the study area. The cost elasticity's with respect to all input variables used in the production analysis are positive , implying that an increase in the cost of hired labour, cost of transportation, cost of agrochemicals and cost of seeds increases total production cost. That is 1% increase in the cost of hired labour will increase total cost of production by 0.177%, 1% increase in the cost of transportation will increase total production cost by 0.186% and the same applied to the cost of agrochemicals and cost of seeds. The estimated gamma parameter of 0.860 is highly significant at 1% level, indicating that 86% of the variation in the total cost of production among the sampled farmers is due to differences in their cost efficiencies. Sigma square on the other hand is 0.368 and is statistically significant at 1% level, indicating correctness of fit of the model as assumed for the composite error term. A similar result was also reported by Zalkuwi *et al*. (2010), that both the results of the gamma and the sigma square were statistically significant at 1% level and correctness of fit.

The estimated coefficient of the explanatory variables in the inefficiency cost model shows that all the coefficients have the expected sign. Four of the six variables included in the model were found to affect cost inefficiency in food crop production. These are age, education, extension contact and crop diversification. The coefficient of age is estimated to be negative and statistically significant at 1% level, indicating that as age increases cost inefficiency decreases. Older farmers tend have more experience in farming and high managerial skills than younger farmers. The coefficient of education is estimated to be negative and statistically significant at 5% level, indicating that farmers who are educated tends to be efficient than those who are not educated.

Table 3. Maximum likelihood estimates of the parameters of the stochastic frontier cost function.

Variable	Parameter	Coefficient	t-ratio
Cost factors			
Constant	β_0	5.490	37.787***
Cost of hired labour	β_1	0.177	2.936***
Cost of transportation	β_2	0.186	2.471**
Cost of inorganic fertilizer	β_3	0.015	0.740
Cost of agrochemicals	β_4	0.143	2.789***
Cost of ploughing	β_5	0.028	0.692
Cost of seeds	β_6	0.163	1.982**
Inefficiency effects			
Constant			
Age	δ_1	-0.137	-3.030***
Farming experience	δ_2	-0.075	-0.795
Education	δ_3	-0.437	-2.439**
Household size	δ_4	-0.026	-0.098
Extension contact	δ_5	-0.136	-2.079**
Crop diversification	δ_6	-0.415	-2.242**
Diagnostic statistics			
Sigma square	(δ^2)	0.368	5.263***
Gamma	(γ)	0.860	15.120***

Source: Field survey, 2015

Table 4. Allocative efficiency of sampled farmers.

Efficiency index	Frequency	Percentage
0.40-0.49	6	1.94
0.50-0.59	3	0.97
0.60-0.69	5	1.61
0.70-0.79	4	1.29
0.80-0.89	253	83.55
0.90-0.99	33	10.64
Total	310	100.0

Source: Field survey, 2015

Mean	0.80
Minimum	0.43
Maximum	0.94

Farmers who are educated tend to acquire new technology more easily than those that are not. The coefficient of extension contact is estimated to be negative and statistically significant at 5% level, implying that increase in extension services to farmers tend to decrease inefficiency in food crop production. Advisory services given to farmers tend to assist them in making sound production and marketing decisions which help in enhancing cost efficiency.

The coefficient of crop diversification in the model is negative and statistically significant at 5% level implying that crop diversification increases cost efficiency in food crop production. On the other hand, as crop diversification decreases and fewer crops are grown, cost inefficiency increases. The practice of mix cropping enable various crops to use some resources jointly such as labour which otherwise would be allocated to only one crop if produced solely.

The allocative efficiency indices which measure the rate at which resources are allocated is presented in (Table 4). The allocative efficiency of the sampled farmers ranged from 0.43 to 0.94.The mean allocative efficiency is estimated to be 0.80, meaning that an average farmer in the study area has the scope for increasing allocative efficiency by 20% in the short run under the existing technology. This will enable the average farmer equate the marginal value product (MVP) of the inputs to the marginal cost of the inputs thereby increasing food output and improving income. Only about 2% of the respondents have allocative efficiency of less than 0.5 (50%), while about 3.4% have allocative efficiency of 0.5-0.79 (50-79%). Majority of the respondents about 84% have allocative efficiency level of 0.8-0.89 (80-89%), while only about 11% have allocative efficiency level of 0.9-0.99 (90-99%). The result shows that farmers in the study area allocatively efficient in producing a given level of output. However, in the short run there is the scope for increasing allocative by 20% given the state of technology.

Conclusion

The analysis reveals that mixed cropping dominated the cropping patterns accounting 76.13% and about 64.89% of the total hectarage allocation to food crop production. The maximum likelihood estimate of the stochastic frontier cost function revealed that cost of hired labour, cost of transportation, cost of agrochemical and cost of seed contributed significantly and positively to total cost of production. The allocative efficiency index ranged from 0.43-0.94, with a mean of 0.80.

Recommendations

(i) The study recommends the need to encourage farmers to acquire education which serve as a vehicle for increase productivity.
(ii) Also, farmers' should practice intercropping as that gives more output than sole cropping.
(iii) Farmers' are encouraged to go into intercrop production with a view to maximize total output and increase profitability.
(iv) Effective extension programmes that will educate farmers on efficient allocation of production resources are points upon which the various smallholder development programmes initiated by the government should be built.

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