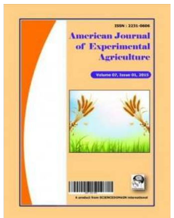

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Empirical Analysis of Allocative Efficiency among Fadama Food Crop Farmers in Adamawa State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study examined allocative efficiency and its determinants among fadama food crop farmers in Adamawa State, Nigeria using the stochastic cost frontier approach. A single-stage estimation procedure was used where socio-economic variables were incorporated directly into the estimation of the cost frontier model. Data were collected from 160 randomly selected fadama farmers in the state using stratified and purposive sampling techniques. The estimated coefficients of the stochastic cost function revealed that cost of land, cost of agro-chemicals and cost of seeds were statistically significant at 1% level, cost of hired labour and cost of water were significant at 5% level, while cost of inorganic fertilizers was significant at 10% level. The estimated coefficient of the socio-economic variables in the inefficiency cost model shows that farming experience, education and age increases allocative efficiency in fadama food crop production. On the allocative efficiency levels, the result revealed that the farmers were efficient in the allocation of resources in fadama crop production. However, there is a scope for allocative efficiency improvement in the short-run

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given the current state of technology of 21% and 58% for the average and least efficient farmer respectively. The study recommends the implementation of policies that would improve farmers' access to credit, timely distribution of productive inputs, subsidization of cost of agricultural inputs and the encouragement of research in fadama food crop farming.

Keywords: Allocative efficiency; food crop production; fadama; Adamawa State; Nigeria.

1. INTRODUCTION

Fadama refers to seasonally damp or flooded low-lying plains underlined by shallow aquifers along major rivers which can be cultivated under poor drainage, residual moisture condition, or under irrigation due to available ground water during the dry season. Though the surfaces of these flood plains become dry during the dry season, appreciable amounts of water can be trapped around the plains. Fadama lands are regarded as very rich agricultural areas due to erosional and depositional actions of rivers and streams. The soil parent materials are almost entirely colluvial and/or alluvial materials derived from surrounding uplands, which are made up of topsoil relatively rich in organic matter [1]. Fadama farming therefore implies cultivation of growing crop under irrigation or in the dry season because flood plains are inaccessible during the normal season [2].

The significance of fadama to individual farmers and national economy has continued to increase owing to their ecological peculiarities and exploitation for irrigation, fishing, animal grazing, domestic water supply and medicinal herbs. Additionally, agricultural production in Nigeria is dictated by climatic factors where crop failures due to drought and flooding have been a major problem especially in northern Nigeria. Full exploitattion of the fadama will not only permit multiple cropping and year-round cultivation of crops, but also an important component of agricultural strategy for coping with risks and uncertainty associated with farming.

Increase in output of food crops in the fadama is directly related to production efficiency, which arises from efficient input usage, given the current state of technology. 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 a certain level of output at least cost [3]. Increase in the efficiency of a farm will provide a range of hope that will lead to an improvement in the well-being of the farmers and consequently enhance food security and poverty reduction.

Nigeria is faced with the challenges of providing adequate food supply for its growing population. With a current estimated population of about 160 million people [4] and a projected population of about 192 million as reported by World Population Review [5]. FAO has consistently listed the country among countries that are technically unable to meet their food needs from rain-fed agriculture at low input level. According to Igwe [6], Nigeria has a potential comparative advantage in the production of a variety of fresh and processed high value crops especially vegetable during the dry season, and will ensure stability of output through a more stable production trend and maximization of monetary returns.

Chirwa [7] refers to allocative efficiency as the ability of a farm to apply inputs in optimal proportions given their respective prices at a given production technology. In their submission, Akinwumi and Djato [8] reported that allocative efficiency deals with the extent to which farmers make efficient decisions by applying inputs up to the level at which their marginal contribution to production value is equal to the factor cost. Similarly, Fans [9] expressed that under a state of competitiveness, a farm is said to be allocatively efficient if it is able to equate its marginal returns of the factor inputs used in the production process to the market price of the products produced.

There have been many research studies to assess the relative efficiency of farmers in recent years [10-12], only a few delved into allocative efficiency [13-15]. Allocatively efficient farms make better use of existing resources to maximize output on one hand and minimize production cost on the other, thus helping the attainment of self-sufficiency in food production. For a farm to achieve these objectives, it should be able to possess these features; namely, minimize cost of production, maximize the output that will guarantee increased income, and minimize risk during the production process. The attainment of these will lead to profit maximization. It is generally difficult especially in Nigeria to have farms that possess all these properties. This further underscored the need for efficiency analysis.

This study sets out to analyse the farmers' allocative efficiency and its determinants using the stochastic frontier approach. A single-stage estimation procedure is used to estimate the determinants of the efficiency. By implication, the socio-economic variables were incorporated directly into the estimation of the cost frontier model because such variables may have direct influence on allocative efficiency.

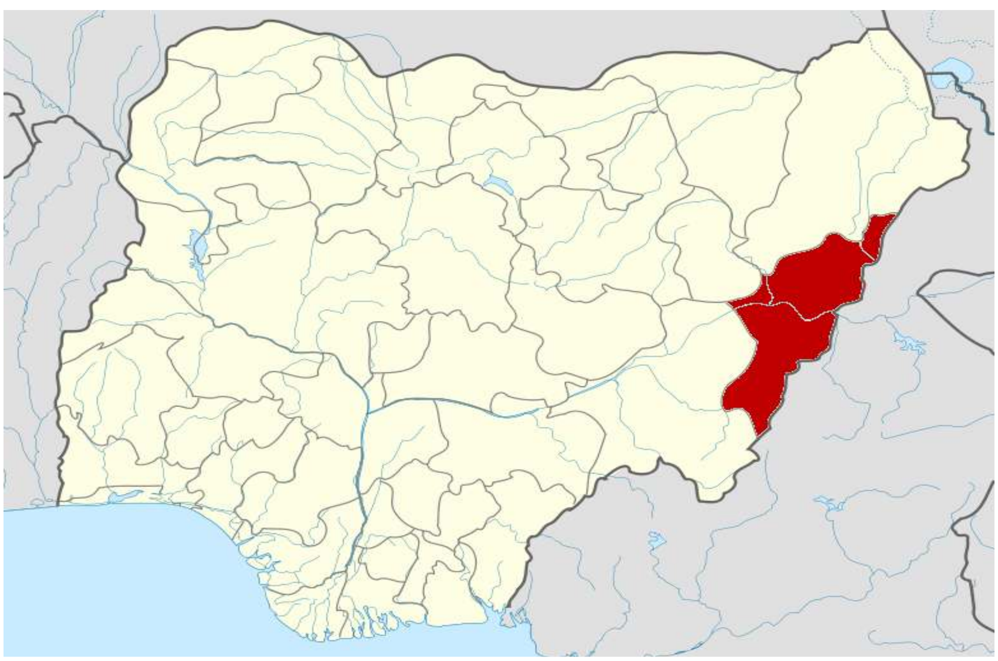
2. METHODOLOGY

2.1 Study Area

Adamawa State is located in the North Eastern part of Nigeria and lies between latitude 7° and 11°N of the equator and longitude 11° and 14°E of the Greenwich meridian (Fig. 1). It shares common boundary with Taraba State in the south and west, Gombe State in the northwest and Borno State in the North. The state has an international boundary with the Cameroun republic along its eastern border. It covers a land area of about 38,741 km^2 with a population of 3,168,101 people [4]. Out of this estimated land area, about 226,040 ha is under cultivation while about 400 ha is under irrigation [16].

The climate of the state is characterized by distinct dry to rainy season which is typical of tropical climate. The dry season starts in November and ends in April, while the rainy season is between April and October. August and September are usually the wettest months with rainfall ranging from 700 mm to 1600 mm. The maximum temperature in the state can reach 46°C particularly in April, while minimum temperature can be as low as 18°C between December and January. Relative humidity is as low as 25% in March to as high as 80% in August [17].

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 [18]. The major vegetation formations 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 fringing forests in the river-valley.



Coordinates 9°20′N 12°30′E

Fig. 1. Location of Adamawa State in Nigeria

The fadama land lies along the basins of major rivers, streams, lakes and dams in the state. These are; Benue, Gongola, Yedzaram, Gerio, Mayo-Inne, Beti, Mayo-Belwa, Kilange, Kiri, Song, Wandu, Digil, Chochi, Faro and Mayo-Hesso. Their hydrological record shows that the water in them could be used for irrigation without drying up. The farmers living along the banks of these water basins and related bodies have been practicing small-scale irrigated agriculture on limited potential fadama lands. Major food crops of economic importance cultivated include vegetables, maize, cocoyam, sweet potatoes and sorghum and rice.

2.2 Sampling Procedure and Sample Size

Stratified, purposive and simple random sampling techniques were used in the selection of respondents. In the first stage, the 21 Local Government Areas (LGAs) in the State were stratified into four zones by the Adamawa Agricultural Development Programme for administrative convenience where 50% were purposively selected and used for the study owing to their relative concentration of flood plains and water bodies. A total of 160 fadama food crop farmers in the State were randomly sampled in proportion to the number of farmers in each LGA.

2.3 Analytical Techniques

The stochastic frontier cost function was used to determine the allocative efficiency of the farmers. Mathematically, the model is specified as;

$$\ln C = \alpha_0 + \beta_1 \ln P_1 + \beta_2 \ln P_2 + \beta_3 \ln P_3 + \beta_4 \ln P_4 + \beta_5 \ln P_5 + \beta_6 \ln P_6 + \beta_7 \ln P_7 + \beta_8 \ln P_8 + V_i + U_i$$

Where;

- C = Total cost of production (₦)
- P_1 = Cost of hiring land (₦)
- P_2 = Cost of agrochemicals (₦)
- P_3 = Cost of fertilizers (₦)
- P_4 = Cost of family labour (₦)
- P_5 = Cost of hired labour (₦)
- P_6 = Cost of ploughing (₦)
- P_7 = Cost of water (₦)
- P_8 = Cost of seeds (₦)
- ln = Logarithm to base 10

The allocative inefficiency model μ_{ij} is defined by:

$$\mu_{ij} = \delta o + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5$$

- μ_{ij} = Cost inefficiency of the i^{th} farmer
- Z_1 = Farming experience (in years)
- Z_2 = Formal education (years spent in formal schooling)
- Z_3 = Extension contacts (number of meetings)
- Z_4 = Household size
- Z_5 = Age of farmers in years
- δ_o = constant term
- δ_1 to δ_5 = Parameters to be estimated

3. RESULTS AND DISCUSSION

The estimated stochastic cost function used in determining allocative efficiency is presented in Table 1. All the estimated coefficients in the model have the expected *apriori* signs. The coefficients of cost of land, cost of agro-chemicals, cost of seeds were statistically significant at 1% level, while cost of hired labour and cost of water were significant at 5%. The coefficient of cost of inorganic fertlizers was significant at 10% level. This implies that these factors are important determinants of total cost associated with fadama food crop production among the selected respondents. Thus, a 1% increase in the costs of land, agrochemicals, hired labour, water and seeds will increase total production cost by 0.013%, 0.025%, 0.014%, 0.092% and 0.393% respectively.

The return to scale (sum of elasticities) is 0.563, indicating decreasing returns to scale. This implies that the farmers are operating in stage II (rational stage) of the production surface in terms of cost allocation. This is an indication that fadama food crop farmers are efficient in the allocation of resource inputs.

The variance ratio, estimated by gamma, γ (0.87) is very close to one and statistically significant at 1% level, suggesting that systematic influences that are unexplained by the cost frontier are the dominant sources of random errors. In other words, the existence of allocative inefficiency among the famers accounted for 87% of the variation in the total cost of fadama crop production. Consequently, the sigma squared (δ^2) is 0.44 and also significant at 1% level. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term.

The estimated coefficient of the socio-economic variables in the inefficiency cost model shows that all the coefficients have the expected sign. A negative sign in an estimated parameter indicates that increase in the variable decreases allocative inefficiency and vice-versa. Three of the five variables included in the model were found to affect cost inefficiency in food crop production. These are farming experience, education and age.

The coefficient of education is negative and significant at 5% level, implying that increase in education decreases allocative inefficiency. Education has been identified as catalysts in technology adoption in Nigeria. People with some level of formal education tend to be more active in learning and decision making, and this moves them closer to the frontier output.

The coefficient of household size is negative and significant at 1% level, implying that increase in household size would decrease cost inefficiency. Larger household size guarantees readily supply of family labour and reduces cost of paid labour in agricultural production. A similar result was obtained by [19] who obtained a positive relationship between farming experience, household size and age with allocative efficiency.

The coefficient of age variable is negative as expected and statistically significant at 1% level, implying that as age increases, cost inefficiency decreases. Older farmers tend to have more experience in farming and higher managerial skills than younger farmers; and these are impetus for higher cost efficiencies.

3.1 Allocative Efficiency Distribution of Respondents

The Allocative Efficiency (AE) indices, which measure the rate at which resources are allocated in optimal proportions, are presented in Table 2. The allocative efficiency ratings of all the respondents was less than 1.00 indicating that fadama food crop farmers in the area were producing below the maximum cost efficiency frontier. The average AE is estimated at 0.78 indicating that farmers were 78% allocatively efficient in food crop production. The best farmer has an AE of 0.99, while the least efficient farmer has an AE of 0.41. This indicates that in the short-run given the current state of technology, for an average farmer to attain the level of the most efficient farmer, there must be an efficiency gain of 21%; while there is a scope for efficiency gain of 58% for the least efficient farmer to attain the level of the most efficient farmer. Based on the findings, it is evident that fadama farmers in the area are efficient in the allocation of scarce resources at their disposal, especially those resources that were found to significantly affect total production cost in food crop production. The implication of this is that the farmers averagely produce output at a minimum cost.

Table 1. Maximum likelihood estimates of parameters of stochastic cost function

Variables	Parameters	Coefficient	t-ratio
Constant	β_0	2.560	12.571***
Cost of land	β_1	0.013	3.637***
Cost of agrochemicals	β_2	0.025	2.650***
Cost of fertilizers	β_3	0.026	1.917*
Cost of family labour	β_4	0.007	1.531 NS
Cost of hired labour	β_5	0.014	2.362**
Cost of ploughing	β_6	- 0.007	- 0.931 NS
Cost of water	β_7	0.092	2.202**
Cost of seeds	β_8	0.393	5.44***
Inefficiency model			
Farming experience	δ_1	- 0.011	- 0.065 NS
Education	δ_2	-0.380	-2.243**
Extension Contact	δ_3	0.028	0.871 NS
Household size	δ_4	-0.302	-3.974***
Age	δ_5	-0.267	-3.168***
Diagnostic statistics			
Sigma square	δ^2	0.440	7.572***
Gamma	γ	0.868	4.766***

Source: Field Survey, 2014

****Significant at 1% level **Significant at 5% level *Significant at 10% level; NS = Not Significant*

Table 2. Allocative efficiency indices of the sampled farmers

Efficiency level	Frequency	Percentage
0.40 - 0.49	4	2.50
0.50 - 0.59	10	6.25
0.60 - 0.69	27	16.88
0.70 - 0.79	51	31.88
0.80 - 0.89	29	18.13
0.90 - 0.99	39	24.38
Total	160	100
Mean 0.78		
Maximum 0.99		
Minimum 0.41		

Source: Field Survey, 2014

The distribution of the efficiency levels indicate that only about 3% of the respondents had allocative efficiency level of less than 0.50 (50%), while about 23% had efficiency level of 0.50 - 0.69 (50 - 69%). About 32% of the farmers had efficiency level of 0.70- 0.89 (70 - 89%), while those with efficiencies of 0.80 – 0.89 and 0.90 – 0.99 were 18% and 24% respectively. This result reveals that the potential gain in allocative efficiency among the farmers is large. Similar result was obtained by [20,12].

4. CONCLUSION

The study examined allocative efficiency and its determinants among fadama food crop farmers in Adamawa State, Nigeria using the stochastic frontier approach. A single-stage estimation procedure was used to estimate the determinants of allocative efficiency where socio-economic variables were incorporated directly into the estimation of the cost frontier model. The result revealed that the farmers were allocatively efficient in the allocation of resources in fadama crop production. However, there is a scope for efficiency improvement of 21% and 58% for the average and least efficient farmer respectively in the short-run given the current state of technology.

5. RECOMMENDATIONS

1. Policies should be put in place by the government to improve farmers' access to credit and timely distribution of productive inputs.
2. The cost of agricultural inputs should be further subsidized to ensure their affordability efficient utilization. This will encourage the large proportion of the unemployed youths in the country to be gainfully employed in the agricultural sector.
3. Formal education and adult literacy education should be encouraged and strengthened especially among full-time farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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