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Resource Use Efficiency in Urban Farming: An Application of Stochastic Frontier Production Function

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ABSTRACT

Many city dwellers have turned to urban farming to fill the gap between urban food demand and supply. However, at the heart of urban farming, like other economic activities, is the issue of efficiency. In this paper, we employed the stochastic frontier production function to analyse the resource use efficiency of urban farmers in Uyo, Southeastern Nigeria. The result shows that 65% of urban farmers were 70% technology efficient; maximum efficiency is 0.91, while minimum efficiency in urban farm is 0.43

Key Words: Efficiency; Urban farming; Frontier; Production; Nigeria

INTRODUCTION

In Nigeria, agriculture was primarily a rural based activity. But, because of the increasing demand for food and jobs for many urban dwellers, it became necessary for urban households to embark on urban agriculture as a means of filling the food demand and supply gap and providing income for other household requirements. In addition, the practice of urban agriculture has continued to increase in recent years with the structural adjustment of the Nigerian economy. The rise in food prices, un-employment and inflation brought by the structural adjustment (World Bank, 1990) and the decline in the average real income of both rural and urban households have compelled many urban dwellers into farming in the urban areas. The urban farmer, like any other farmer, will typically produce to satisfy household food needs or make profit or both. If the interest were in producing for home consumption, the farmer would want to obtain the optimum from his/her effort If on the other hand, the farmer produces for the market, then the cost of production and the returns accruable to the farmer's effort become important measure of performance. Either of the two objectives of production requires efficient use of farm resources.

The question of efficiency in resource allocation in traditional agriculture is not trivial. It is widely held that efficiency is at the heart of agricultural production. This is because the scope of agricultural production can be expanded and sustained by farmers through efficient use of resources (Ali, 1996 & Udoh, 2000). For these reasons, efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of the farmers are resource-poor.

Studies relating to efficiency in Nigerian agriculture can be classified into two categories depending on weather a direct (primal) or indirect (dual) method is used. In the primal approach, the production function, in most cases Cobb-Douglas, is directly estimated by OLS technique. After obtaining the parameter estimates, marginal product (MP) of each endogenous input is calculated. The presence of allocative efficiency is then tested by equating the value of MP of inputs with their respective prices. Examples of works along this line are Akinwumi (1970), Ogunfowora *et al.* (1975), Umoh and Yusuf (1999). The dual approach involves estimating the profit function along with the input share (in profit) equation derived from Hoteling's lemma. Since the profit function accommodates allocative inefficiency, the hypothesis of (exact) profit maximization is tested by imposing parametric restrictions or the profit function. Some studies along this line are Udoh (1999) and Umoh (2003).

Recent literature search reveal that, in spite of the increase in agricultural activities in urban areas, empirical studies of Nigerian agriculture have concentrated on the traditional rural based farming. Urban farming system in Nigeria, particularly in South Eastern Nigeria where the study area is, can be classified in to two. These are market gardens (consisting of vegetables such as water leaf and fluted pumpkin planted as sole crop), and mixed crop farms consisting of multiple crops planted on the same plot. Empirical studies on efficiency in urban agriculture in Nigeria are scanty and far between. Few of such studies (e.g. Udoh, 2005) paid particular attention to market garden. The question, therefore is: Are Nigerian urban farmers efficient in the use of resources? This study is an attempt to answer this question with specific emphasis on the technical efficiency in mixed cropping urban farms.

Objectives of the study. The purpose of the study is to analyze empirically, the technical efficiency of resource use in urban farming. The specific objectives are to: **(i)** Examine the socioeconomic characteristics of urban farmers, (ii) Estimate the cost of and return to urban farming and (iii) Determine the technical efficiency of resource use in urban farming.

Theoretical framework. Three types of efficiency are identified in the literature. These are technical efficiency, allocative efficiency and overall or economic efficiency (Farrell, 1957; Olayide & Heady, 1982). Technical efficiency is the ability of a firm to produce a given level of output with minimum quantity of inputs under a given technology. Allocative efficiency is a measure of the degree of success in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of these inputs. Economic efficiency is a product of technical and allocative efficiency (Olayide & Heady, 1982). In one sense, the efficiency of a firm is its success in producing as large an amount of output as possible from given sets of inputs. Maximum efficiency of a firm is attained when it becomes impossible to reshuffle a given resource combination without decreasing the total output.

Since the seminal work of Farrell in 1957, several empirical studies have been conducted on farm efficiency. These studies have employed several measures of efficiency. These measures have been classified broadly into three namely: deterministic parametric estimation, non-parametric mathematical programming and the stochastic parametric estimation. There are two non-parametric measures of efficiency. The first, based on the work of Chava and Aliber (1983) and Chava and Cox (1988) evaluates efficiency based on the neoclassical theories of consistency, restriction of production form, recoverability and extrapolation without maintaining any hypothesis of functional form. The second, first used by Farrell (1955) decomposed efficiency into technical and allocative. Fare *et al.* (1985) extended Farrell's method by relating the restrictive assumption of constant returns to scale and of strong disposability of inputs (Llewelyn & Williams, 1996; Udoh & Akintola, 2001).

Several approaches, which fall under the two broad groups of parametric and non-parametric methods, have been used in empirical studies of farm efficiency. These include the production functions, programming techniques and recently, the efficiency frontier. The frontier is concerned with the concept of maximality in which the function sets a limit to the range of possible observations (Forsund *et al.*, 1980). Thus, it is possible to observe points below the production frontier for firms producing less than the maximum possible output but no point can lie above the production frontier, given the technology available. The frontier represents an efficient technology and deviation from the frontier is regarded as inefficient.

The literature emphasizes two broad approaches to production frontier estimation and technical efficiency measurement: (a) The non-parametric programming approach, and (b) the statistical approach. The programming approach requires the construction of a free disposal convex hull in the input-output space from a given sample of observations of inputs and outputs (Farrell, 1957). The convex hull (generated from a subset of the given sample) serves as an estimate of the production frontier, depicting the maximum possible output. Production efficiency of an economic unit is thus measured as the ratio of the actual output to the maximum output possible on the convex hull corresponding to the given set of inputs.

The statistical approach of production frontier estimation can be sub-divided into two, namely, the neutral-shift frontiers and the non-neutral shift frontiers. The former approach measures the maximum possible output and then production efficiencies by specifying a composed error formulation to the conventional production function (Aigner *et al.*, 1977; Meeusen & van den Broeck, 1977). The non-neutral approach uses a varying coefficients production function formulation (Kalirajan & Obwona, 1994). The main feature of the stochastic production frontier is that the disturbance term is composed of two parts-a symmetric and a one-sided component. The symmetric (normal) component, v_i captures the random effects due to the measurement error, statistical noise and other non-symmetric influences outside the control of the firm. It is assumed to have a normal distribution. The one-sided (non-positive) component, μ_i with $\mu_i \geq 0$, captures technical inefficiency relative to the stochastic frontier. This is the randomness under the control of the firm. Its distribution is assumed to be half normal or exponential. The random errors, v_i are assumed to be independently and identically distributed as N (0, δv^2) random variables, independent of μ_is. The μ_is are also assumed to be independently and identically distributed as, for example, exponential (Meeusen & van den Broeck, 1977), half normal (Aigner *et al.*, 1977), truncated normal and gamma (Greene, 1990). The stochastic frontier function is typically specified as:

$$Yi=f\,(Xij;\,ß) + v_i - \mu_I \; (_i = 1, 2, n) \qquad (1)$$

Y_i = Output of the i^{th} firm;
X_{ij} = Vector of actual j^{th} inputs used by the i^{th} firm;
ß = Vector of production coefficients to be estimated;
$_{vi}$ = Random variability in the production that cannot be influenced by the firm and;
μ_i = Deviation from maximum potential output attributable to technical inefficiency.

The model is such that the possible production Yi, is bounded above by the stochastic quantity, f (Xi; ß) exp(Vi) (that is when $\mu_i = 0$) hence, the term stochastic frontier.

Given suitable distributional assumptions for the error terms, direct estimates of the parameters can be obtained by either the Maximum Likelihood Method (MLM) or the Corrected Ordinary Least Squares Method (COLS). However, the MLM estimator has been found to be asymptotically more efficient than the COLS (Coelli, 1995). Thus, the MLM has been preferred in empirical analysis.

In the context of the stochastic frontier production function, the technical efficiency of an individual firm is defined as the ratio of the observed output to the corresponding frontier output, conditional on the levels of inputs used by the firm. Thus, the technical efficiency of firm i is:

$$Tei = \exp(-\mu_i), \text{ that is} \qquad (2)$$
$$Tei = Yi/Yi^* \qquad (3)$$
$$= f\,(Xi;\,ß) \exp(v_i - \mu_i) / f\,(Xi;\,ß) \exp(v_i) \exp(-\mu_i).$$

Tei = Technical efficiency of farmer i; Yi = observed output and; Yi* = frontier output. The technical efficiency of a firm ranges from 0 to 1. Maximum efficiency in production has a value of 1.0. Lower values represent less than maximum efficiency in production.

Several empirical applications have followed the stochastic frontier specification. These studies are basically based on Cobb-Douglas function and transcendental logarithmic (translog) functions that could be specified either as production or cost function (Udoh & Akintola, 2001). The first application of the stochastic frontier model to farm level data was by Battese and Corra (1977) who estimated deterministic and stochastic Cobb-Douglas production frontiers for the grazing industry in Australia. The variance of the farm effects was found to be a highly significant proportion of the total variability of the logarithm of the value of sheep production in all states. Their study did not, however, directly address the technical efficiency of farms. Kalirajan (1981) estimated a stochastic frontier Cobb-Douglas production function using data from rice farmers in India and found the variance of farm effects to be highly significant component in explaining the variability of rice yields. Similarly, Bagi (1984) employed the stochastic frontier Cobb-Douglas production function model to investigate differences in technical efficiencies of small and large crop and mixed enterprise farms in West Tennessee. The study found that the variability of farm effects was highly significant. The mean technical efficiency of mixed enterprise farms was found to be smaller (0.76) than for crop farms (0.85).

The use of the stochastic frontier analysis in studies in agriculture in Nigeria is a recent development. Such studies include that of Udoh (2000), Okike (2000) and Amaza (2000). Udoh used the Maximum Likelihood Estimation of the stochastic production function to examine the land management and resource use efficiency in South-Eastern Nigeria. The study found a mean output-oriented technical efficiency of 0.77 for the farmers, 0.98 for the most efficient farmers and 0.01 for the least efficient farmers. Okike's study investigated crop-livestock interaction and economic efficiency of farmers in the savanna zones of Nigeria. The study found average economic efficiency of farmers was highest in the Low-Population-Low Market domain; Northern Guinea and Sudan Savannas ecological zones; and Crop-based Mixed Farmers farming system. Available literature indicates that urban agriculture in Nigeria is yet to benefit significantly from application of the stochastic frontier model. This may not be unconnected with the fact that urban farming is a relative new venture that has only recently started gaining attention as a complement to rural farming. Likewise empirical research effort in urban agriculture is also new. This paper employs the stochastic frontier model in estimating technical efficiency in urban farming.

RESEARCH METHODOLOGY

The study area. The study was conducted in Uyo Metropolis Akwa Ibom State, Nigeria. Uyo is located within the following coordinates: North-$5^0 04^1$ N, South-$5^0 00^1$ N, East-$7^0 59^1$ E and West-$7^0 53^1$ E. The choice of Uyo was informed by its characteristic as a metropolis in transition. Uyo was a village in Use Offot clan in southeastern Nigeria. It was a military post in 1903. During the period of colonial rule, 1914, it grew to become a commercial town as well as the district headquarters of the former Calabar Province in the then Eastern Region of Nigeria. Following the re-organization of the Provinces, Uyo became the headquarters of Uyo Division under the then Southeastern state. The change from Division to Local Government system under the Local Government Reform (Cross River State, 1977) also saw Uyo as the headquarters of Uyo Local Government Area. During this time, Uyo was inhabited by farmers, traders and a few civil servants who worked in public schools and a few government offices located in the city.

In 1987, the present Akwa Ibom State was created from the former Cross River state and Uyo was made the state capital. This also came with the change in the features of Uyo. Its status changed from that of a seat of a Local Government Area to a municipal/metropolis with people from various tribes, and races within and outside Nigeria. Among these are public/civil servants, business men/women, company workers and artisans and petty traders. One very noticeable change that has taken place in Uyo is the sharp rise in population. This in large part was caused by the influx of civil servants of Akwa Ibom extracting from Cross River State at their being displaced from the latter's public service. With the new status, Uyo has also become very attractive to un-employed youths who swarmed the city in search of jobs. Again, the status of Uyo as a state capital necessitated the opening of branches of Federal Ministries and parastatals in the area. This again brought in a number of workers to Uyo. Thus, the population of Uyo has been on the increase over the years. One expected implication of this is a rise in the demand for basic needs including food. In order to meet the increased demand for food, residents in the metropolis are now cultivating most available undeveloped plots and available spaces in the city in an effort to supplement food supply which largely come from the neighboring States and rural communities. School fields have been turned into market gardens while roadsides are littered with varieties of cultivated crops including cassava, plantain, corn, and vegetables.

Data collection procedures. The stratified random sampling method was used in collecting data for the study. Uyo Metropolis was stratified into three farming systems. This was based on crop types. Several crops were cultivated in a variety of combinations in the urban farms in the study area. These were fluted pumpkin (*telfaria occidentalis*), water leaf (*talinum triangulare*), cassava *(manihot esculentalis*), corn (*zea mays*) and okra (*hibiscus esculentus*). The farming population was stratified into three dominant farmining system. These were vegetable growers (market-driven farming system), arable crops growers (consumption-driven farming system) and vegetable/arable crops growers (market/consumption-driven farming system). Farming system is a collection of distinct units, such as crop, livestock, processing and marketing activities, which interact because of the joint use of inputs they receive from the environment, which deliver their output to the environment and which have the common objective of satisfying the farmers' aims. Its predominant functional unit therefore, identifies any cropping system. Thus, in our classification, a vegetable-based farming system is a system in which vegetable is the predominant activity among several other crops, etc. This stratification was informed by the homogeneous characteristics of each farming system in terms of the input requirements, output produced and marketing niche, among others.

The next stage in the sampling exercise was the selection of farmers within each farming system. Thirty farmers were selected from each stratum. Thus, ninety (90) farmers were selected altogether. The major instrument used for data collection was structured questionnaire. The questions were structured as to elicit answers on the objectives of the study. Data were collected on number and size of plots, types of crops cultivated, inputs used including their quantities and unit prices, quantities of output produced and their unit prices. The questionnaires were administered on the farmers in the field-in the mornings and evenings when most of them chose to work on their farms. They were interviewed and their responses filled into the questionnaire. This method also allowed for field observation, which made for authentication of some of the farmers responses. Quantities of outputs of these crops were obtained in their local measures and converted to kilogramme. The crop outputs in kilogrammes were further converted to grains equivalent using Grain Equivalent Table. This was to have a uniform unit of expressing the crops output.

Methods of data analysis. Three methods of were used to analyze the data collected. These were: (i) Descriptive statistics consisting of simple percentages and proportions. These were used to examine the socio-economic characteristics of the urban farmers. (ii) Gross Margin Analysis: This was used to estimate the cost and return in urban farming. It is given as:

$$GM = TR - TVC,$$

Where GM = gross margin; TR = total revenue, and TVC = total variable cost (The cost incurred in the used of variable inputs).

The Stochastic Frontier Production Function: This was used to estimate the resource use efficiency in urban farming. It is given by:

$$\ln Y_i = \ln ßo + \sum ß_j \ln X_{ij} + vi - \mu_i; \qquad (4)$$

Where Y_i = Farm output (in grain equivalent) from farm i; Xi = Vector of farm inputs used. X_1 = labour (in man days); X_2 = Farm size (in hectares); X_3 = Fertilization (Dummy; 1 = use fertilizer, 0 = not use fertilizer) and X_4 = Planting materials (in kg); v = random variability in the production that cannot be influenced by the farmer; μ = deviation from maximum potential output attributable to technical inefficiency. ßo = intercept; ß = vector of production function parameters to be estimated; i = 1, 2, 3, n farms; j = 1, 2, 3, m inputs. The inefficiency model is:

$$\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + + \delta_4 Z_4 \qquad (5)$$

Where, μ_i = technical inefficiency effect of the i^{th} farm; Z_1 = educational level of farmer in years of formal education completed; Z_2 = household size; Z_3 = sex of farmer (dummy; 1= male, 0 female); Z_4 = age of farmer in years; δ = parameters to be estimated.

The ß and δ coefficients are un-known parameters to be estimated along with the variance parameters δ^2 and γ. The δ^2, and γ, coefficients are the diagnostic statistics that indicate the relevance of the use of the stochastic production frontier function and the correctness of the assumptions made on the distribution form of the error term. The δ^2 indicates the goodness of fit and the correctness of the distributional form assumed for the composite error term. The γ, indicates that the systematic influences that are un-explained by the production function are the dominant sources of random errors. The statistical significance of the shows the presence of a one-sided error component, vi, in the model specified. This means that a traditional response function estimated by the ordinary least square cannot adequately represent the data; and the use of a stochastic frontier function estimated by the maximum likelihood estimation procedures is therefore appropriate. The parameters of the models were obtained by the maximum likelihood estimation method using the computer programme, FRONTIER version 4.1 (Coelli, 1994).

RESULTS AND DISCUSSION

Socio-economic characteristics of urban farmers. Efforts were made to understand the socio-economic characteristics of urban farmers in the study area. This was done with the hope of identifying those characteristics that may explain the farming activities of the area. The characteristics considered were age, sex, educational attainment, migrant status and income level. The result is presented in Table I. On age classification, more than half of the farmers (68.9%) were found to be within the age bracket of 31 to 50 years. The least number of respondents were found in the 20 years and less than 20 years age bracket. Only11.1% of the respondents is older than 50 years. Contrary to findings of past studies which reported the farming population to be ageing (Idowu, 1988), the present study shows a young farming population. This may be attributed to the location of the study site being an urban area. Unlike the rural areas that may be populated mostly by the aged men and women left behind as a product of rural-urban drift. The urban centers are inhabited mostly by young migrants alongside the aborigines. It is well documented that those who migrate from rural to urban areas always go in search of white collar jobs. In a case where the white collar job often sought by rural-urban migrants are not readily available, or the white collar jobs do not provide enough income, some city dwellers may take to farming either on full time or part time basis. This may, to some extent, be responsible for the urban

Table I. Socio-economic Characteristics of Urban Farmers

Characteristics	Number of Farmers	%
	Age	
≤ 20	6	6.7
21-30	12	13.3
31-40	28	31.1
41-50	34	37.8
>50	10	11.1
	90	**100**
	Sex	
Male	24	26.7
Female	66	73.3
	90	**100**
	Educational Level:	
No formal education	5	5.6
Primary school	12	13.3
Secondary school	36	40.0
Post secondary school	27	40.1
	96	**100**
	Migrant status	
Migrant	58	64.4
Native	32	35.6
	90	**100**
	Income level	
Low income (≤₦23000)	39	43.3
Middle income (₦23000)	4	4.4
High income (>₦23000)	47	52.2
Mean income ₦23000	**90**	**100**

Source: Field Data.2002

farming population being young. The implication of this is that, if other farm inputs are available in the right quantity and time, urban agriculture though not an alternative to rural farming or replacing it, can add substantially to output of rural agriculture. This conclusion is premised on the assumption that the young urban farming population would be productive.

From gender perspective, the females were found to make up the bulk of urban farming population in Uyo metropolis. About 73% of the sampled farmers are women. In this respect, urban farming in the study area is not significantly different from rural farming. Several studies have indicated that women constitute up to 60% of African agricultural workforce. Sigot (1995) reports: "evidence shows that women in Africa are responsible for an estimated 70% of total food production throughout the continent. The farming women undertake is mostly for subsistence, i.e. providing urgent needs of families". As home-makers, more women than men may be involved in urban farming in order to supplement the food needs of their households from market purchases.

The educational level of farmers is known to affect their farming activities. Agricultural extension experts point out that farmers with higher educational qualification are wont to adopt agricultural technological innovations more than those without or with lower educational qualification. Evidence from this study reveals that 40% of the respondents have secondary school education while about 30% are farmers with post secondary qualifications. Thus, not less than 70% of the respondents have had one form of formal education or another. The urban farming population in is an educated one. These findings tend to contradict the often reported illiterate status of farmers from many previous studies. This may not be un-related to a possible largely migrant farming population in the urban. It is recognized that it is the able bodied and educated men and women who migrate from rural to urban centers. The fact that not less than 64% of the respondents are migrants collaborate this migrant-high educational level hypothesis.

It was hitherto assumed that they poor account for the majority of urban farmers, and that the engage in this activity essentially on a subsistence basis. Recent empirical evidence suggests that this is not necessarily the case. According to Tacoli (1997), some studies have shown that high and middle-income households constitute a significant and growing proportion of urban farmers, who often engage in this activity for commercial purposes. The results from our study, to some extent, support this position. About 52% of the respondents of urban farmers are of the high-income bracket [arrived at, based on the mean income of twenty three thousand naira (₦23000) in the study area] while 43.3% belong to the low-income group. This shows that the urban farming population straddles both the high as well as low-income households. This implies that urban farming in the study area may be driven by other factors more than subsistence needs.

Cost and returns to urban farming. As revealed in the previous section, urban farming may not be for the purpose of only satisfying the household food need or subsistence. The farmers may be interested in selling their outputs to raise income. Thus, the farmers like any other entrepreneur would be interested in the profitability of the farm enterprise. For this reason, efforts were made to determine the cost associated with urban farming and also revenue that accrues to the farmers' efforts. Only the variable cost of production was considered while the profitability was measured as the gross margin. (Table II).

Of all labor-related activity, planting constitutes bout 22% of the total variable cost. This is followed by land preparation, which makes up about 17% of the cost. Fertilizer application scores the lowest percentage point of all labor-related activities. This may imply that fertilizer is not commonly applied by farmers or not applied in reasonably large quantity. Generally, labor-related activities put together take the lion share of the short-run cost of production. The cost of planting materials is 29.38% of the production cost. On the average, it costs ₦69, 003.30 to cultivate one hectare of farm in Uyo metropolis. An average of ₦136, 666.67 accrues to a farmer as revenue and ₦67, 663.37 is left as the gross margin. This level of profit translates to about ₦5000 per month as income to the farmers. This amount is lower than the national minimum wage of ₦6500 in Nigeria as well as the national poverty line $350 per annum (₦45500 at exchange rate of ₦130 to $1 during the period of study).

It is, thus, clear that even in the urban areas, farming is not profitable enough to sustain an average farmer.

Technical efficiency and associated inefficiency factors. The results of the estimates of the parameters of the stochastic frontier and the inefficiency model are presented in Table III. The variance parameters for δ^2 and γ are 0.2456 and 0.6167. They are significant at the 1 percent level. The sigma squared δ^2 indicates the goodness of fit and correctness of the distributional form assumed for the composite error term while the gamma γ indicates that the systematic influences that are un-explained by the production. Function and the dominant sources of random errors. This means that the inefficiency effects make significant contribution to the technical inefficiencies of urban farmers. Thus, the hypothesis that the coefficient of β = 0 is rejected. The result shows that inefficiency effects were present and significant.

Labour (β_1). The coefficient of labor was significant and had a positive sign. This shows the importance of labour in urban 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 the study area, farming is still at the subsistence level generally. This involves the use of traditional farming implements such as hoe and machete. Human power plays crucial role in virtually all farming activities. This situation has variously been attributed to small and scattered land holding, poverty of the farmers and lack of affordable equipment (Umoh & Yusuf, 2000). It appears that labour will continue to play important role in urban agriculture, affecting its efficiency, until those factors constraining mechanization are addressed.

Farm size (β_2). The coefficient of farm size was found to be positive and significant at 1% level. This result is in line with the findings from Okike's (2000) study of farmers in the savanna zone of Nigeria reported farm size to be significant and positive for the low-population-high-market domain. The result could mean that it is possible to expand farming activity in the study area. It may be possible that competition between infrastructure development and crops for land is not yet keen enough to jeopardize the expansion of crop production. Statistically, the magnitude of the coefficient of farm size shows that output is inelastic to land or farm size. If the farm size is increased by 10%, output level will improve by less than proportionate (by a margin of 3.781%). This means that there is still some scope for increasing output per plot by expanding farmland.

Fertilization (β_3). The production elasticity of output with respect to quantity of fertilizer is 0.4183. By increasing the quantity of fertilizer by 10%, output level will improve by a margin of 4.183%. The estimated coefficient is highly statistically significant at 1% level. The finding is at variant with the report by Winrock (1992), which shows non-significant contribution of livestock manure and crops residues in semi-arid sub-Saharan. Though not ascertained, it may be possible that none separation of fertilizer into their different forms (e.g. crop residue, livestock manure, inorganic fertilizer, etc) account for the differences in the findings of this study and that reported by Winrock.

Table II. Cost and returns in Urban Farming in Uyo Metropolis

Cost item	Average Cost (₦)	Percentage
Land preparation	12000.00	17.39
Planting	15000.00	21.74
Fertilizer Application	6800.00	9.86
Weeding	7200.00	10.43
Harvesting	7733.30	11.21
Seeds/cuttings	20270.00	29.38
Total variable cost (TVC)	69003.30	100
Total revenue (TR)	136666.67	
Gross margin (TR-TVC)	67663.37	

Source: Field data 2002

Table III. Maximum Likelihood Estimates of the Stochastic Frontier Function and Technical Inefficiency

Variable	Parameter	Coefficients	Standard error	t-statistics
	Stochastic frontier			
Constant term	β0	8.4415***	0. 9944	8.4890
Labour	β1	0.8885**	0.4840	1.8357
Farm size	β2	0.3981***	0. 6797	0.5856
Fertilizer	β3	0.4183***	0.1537	2.7212
Planting material	β4	0.0567***	0.2086	2.7204
Educational level of farmer	(Z_2)	-0.0763	0.7146	-1.0677
Household size	(Z_2)	-0.0925	0.9618	-0.9619
Farmer's age	(Z_3)	-0.1163	0.1824	-0.6377
Farmer's sex	(Z_4)	0.0596	0.1004	0.5938
	Variance Parameters			
Sigma squared (δ^2)		0.2456		
Gamma (γ)		0.6167	0.1125	
Mu (μ)		0.1304	0.4051	
Log likelihood function		- 0.0045199	0.1127	
LR test		0.4859		

** = significant at 5% level, *** = significant at 1% level.

Table IV. Farm-specific Resource Efficiency Indices among Farms

Class interval of efficiency indices	Frequency	Percentage
0.40-0.49	5	5.6
0.50-0.59	11	12.2
0.60-0.69	15	16.7
0.70-0.79	37	41.1
0.80-0.89	21	23.3
0.90-1.00	1	1.1
Total	90	100

Source: Field Data, 2002; Mean efficiency = 0.72; Mode = 0.71; Minimum value = 0.43; Maximum value = 0.91

Planting materials (β_4). The coefficient of planting materials was positive and significantly different from zero. This implies that planting materials are important in crop production in urban farms in the study area.

Inefficiency Effects (Z_1-Z_4). The contribution of farmers' personal characteristics-level of education, age and sex, and household size to farm inefficiency was also studied. The coefficients of all the variables are negative, except sex. In addition, none of the variables is significant. This implies that these characteristics do not contribute to farm inefficiency. Since these variables were not significant, they do not deserve further discussion.

Individual farm technical efficiency scores. Along with the parameters already presented and discussed, the technical efficiency score of each respondent was also estimated. This is presented in Table IV. More than 65% of the respondents were found to be more than 70% technically efficient. About 5% of the respondents were found to be less than 50%. The most efficient farmer operated at 91% efficiency while the least efficient farmer was found to operate at 43% efficiency level. Urban farmers performed at an average technical efficiency of 72% while the most frequently occurring efficiency score was 71%. From the results obtained, although farmers were generally relatively efficient, they still have room to increase the efficiency in their farming activities as about 30% efficiency gap from the optimum (100%) remains yet to be attained by all farmers.

CONCLUSION AND RECOMMENDATIONS

In this paper, we employed the stochastic frontier production function to estimate technical efficiency in urban farming. We also characterized urban farmers into social and economic classes and estimated the cost and returns to urban farming. The results show that fertilizer and planting materials (seeds, seedlings & cuttings) are significant determinants of farm outputs. Analysis of inefficiency effects reveal that farmers' personal characteristics do not contribute to farm inefficiency. Individual farm technical efficiency scores shows that 65% of urban farmers are more than 70% technically efficient.

Overall, urban farmers performed at an average technical efficiency of 72%, only one farmer was between 90 and 100 efficient. In addition, an urban farmer realizes an average gross margin of N 67.663.37 from cultivating one hectare of land. Generally, women were found to dominate urban farming in the study area.

The findings of the study have implications for increased food production in the study area. Attainment of 70% efficiency means that farmers still have room to increase their efficiency to the optimum (100%). This will require addressing those factors, which are constraints to efficiency. Such include the availability of planting materials, and other inputs. Bridging the gap between the demand and supply of the important inputs in urban farming will increase efficiency and, ultimately, agricultural production in the urban environment.

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