

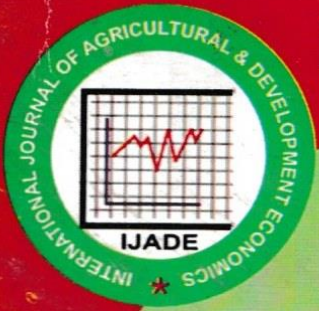
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TECHNICAL EFFICIENCY OF WATER-LEAF (*Talinum triangulare*) PRODUCTION AMONG SELECTED FARMERS IN NSUKARA AND AFAHA-OKU, AKWA IBOM STATE, NIGERIA

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ABSTRACT

The technical efficiency of water-leaf farms in Uyo was investigated using the stochastic frontier production function which incorporates a model for the technical inefficiency effects. Multi stage sampling procedure was employed to select 70 waterleaf farmers and data were obtained using well-structured questionnaire. Data from 70 water-leaf farmers were obtained using well-structured questionnaire. The parameters of stochastic production frontier were estimated simultaneously with those of the model of inefficiency effects. Using the maximum likelihood estimation technique, asymptotic parameter estimates were evaluated to describe efficiency determinants. Findings show that the most important resource inputs that increased output from the water-leaf farms were land, labour, organic fertilizer and capital resource. Results show that the average production area of waterleaf farmers was 62.48m² and the mean age was 42 years. Results reveal a mean efficiency index of 0.82 implying that output from water-leaf production could be increased by 18 percent using available technology. These findings suggest the need for further investment in agricultural research and development particularly in minor crop like waterleaf for increased productivity, nutrition security and poverty reduction in the State.

Keywords: Technical efficiency, Water-leaf, Production, Nigeria.

INTRODUCTION

Most people think of farming as an activity occurring almost exclusively on rural land (Kaufman and Bailkey, 2002 and Etim *et al*, 2005). While it is largely rural based, it is also known that some farming activities take place within and around most cities all over the globe. Such practice of cultivating short-cycle crops and raising livestock within and around cities is tagged city farming or urban farming (Etim *et al*, 2006). Throughout the globe, agriculture is increasingly a part of city landscapes (Bourque, 2000). City farming is one of the strong and positive activities urban residents are undertaking in an effort to take control of food security, social ills and environmental degradation in their communities (Mougeot, 1994; UNDP, 1996). Also, Etim and Ofem (2005) and Etim *et al* (2006), reported that city farming is an appropriate sustainable urban land management, food supply and security, and environmental friendly practice. Farming activities within and around the city primarily centre on the production of vegetables in home gardens in which water-leaf cultivation features prominently (Udoh, 1999; 2005 and Etim *et al*, 2006). Water-leaf (*Talinum triangulare*) (Jacq.) (Wild) is an erect, fleshy, annual herb with swollen taproot and can be produced from seed or vegetatively from stem cutting (Akobundu and Agyakwa, 1998). Under proper cultural management, water-leaf can be harvested 35 – 45 days after planting (Rice *et al*, 1986). It is cultivated in West Africa and used as a cooked vegetable. Udoh and Etim (2006a) reported that water-leaf is widely cultivated in Southern Nigeria, particularly in Cross River and Akwa Ibom States and is used in combination with other vegetables such as African jointfir (*Gnetum africanum*) (Welw; Bush apple (*Heinsia crinata* (Afzel) G. Taylor and Fluted Pumpkin (*Telferia occidentalis*) (Hook F.). In addition, production of waterleaf provides complementary income to farming households (Udoh, 2005).

However, empirical studies by Udoh and Akintola (2001b), Etim *et al* (2005), Etim and Udoh (2006), Udoh and Etim (2006b), Udoh and Etim (2007) suggest that farming has to use available inputs as efficiently as possible to optimise production and farmers being primary managers of land need to manage problems arising from deteriorating natural resources (Rosegrant *et al*, 2005). This study therefore measures technical efficiency of water-leaf production and specifically estimates its determinants.

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The term efficiency of a firm can be defined as its ability to provide the largest possible quantity of output from a given set of inputs. The modern theory of efficiency dates back to the pioneering work of Farrell (1957) who proposed that the efficiency of a firm consist of technical and allocative components, and the combination of these two components provide a measure of total economic efficiency. Technical efficiency measures how well the individual farm transforms inputs into a set of outputs based on a given set of technology and economic factors (Aigner *et al* 1977; Kumbhakar and Lovell, 2000). Technical efficiency can be measured either as input conserving oriented or output-expanding orientation which according to Jondrow *et al* (1982) and Ali (1996), is the ratio of observed to maximum feasible output, conditional on technical and observed input usage. (Jondrow *et al*, 1982, Ali, 1996). This study aims at using output expanding orientation to measure technical efficiency effects. The term frontier involves the concept of maximality in which the function sets a limit to the range of possible observations (Forsound *et al*, 1980). It is therefore possible to observe points below the production frontier for firms producing below maximum possible output, but there cannot be any point above the production frontier given the available technology. Deviations from the frontier are attributed to inefficiency. The need to measure inefficiency effects is the major motivation for the study of frontiers. Frontier studies are classified according to the method of estimation. Kalaizandonakes *et al* (1992) grouped these methods into two broad categories - parametric and non-parametric methods. For the parametric methods, it can be deterministic, programming and stochastic depending on how the frontier model is specified. Many researchers, including Schmidt (1976) have argued that efficiency measures from deterministic models are affected by statistical noise. This however, led to the alternative methodology involving the use of the stochastic production frontier models Aigner *et al* (1977), and Meeusen and Vander Broek (1977) independently proposed the idea of stochastic measurement. The major feature of the stochastic production frontier is that the disturbance term is a composite error consisting of two components, one symmetric, the other one-sided. The symmetric component, V_i , captures the random effects due to measurement error, statistical noise and other influences outside the control of the firm and it is assumed to be normally distributed. The one-sided component U_i , captures randomness under the control of the firm. It gives the derivation from the frontier attributed to inefficiency. It is assumed to be half-normally distributed or exponential. The major weakness of the stochastic frontier model is its failure to provide an explicit distribution assumption for the inefficiency term (Sharma *et al*, 1999).

By definition, stochastic frontier production function is

$$Y_i = F(X_i; B) \exp(V_i - U_i) \quad i = 1, 2 \dots N \dots \dots \dots (1)$$

Where Y_i is the output of the it firm, X_i is the corresponding (MX2) vector of inputs, B is a vector of unknown parameter to be estimated. (F .) denotes an appropriate functional

form, V_i is the symmetric error component that accounts for random effects and exogenous shock; while $U_i < 0$ is a one sided error component that measures technical inefficiency. In recent times, econometric modelling of stochastic frontier methodology associated with efficiency estimation has been important aspect of economics research. Both time varying and cross-sectional data based mostly on Cobb-Douglas and transcendental production function or cost function has been used by Bagi and Hunag (1993); Bagi (1984), Apeziteguia and Garate (1997), Yao and Liu (1998), Udoh and Akintola, (2001a), (2001b), Udoh (2005), Etim *et al* (2005), Etim and Udoh (2006), Udoh and Etim (2006a) to estimate individual firm efficiency. This study however estimates technical efficiency of water-leaf production by assuming a stochastic nature of production based on Cobb-Douglas Production Function.

METHODOLOGY

The Study Area, Sampling and Data Collection Procedure

The study was conducted in Uyo Local Government Area, the capital city of Akwa Ibom State, Nigeria. Uyo is situated 55 Kilometres inland from the coastal plain of South-East Nigeria. The area lies within the humid tropical rainforest zone with two distinct seasons – the rainy and short dry season. The annual precipitation ranges from 2000 – 3000mm per annum. According to Etim and Ofem (2005), this rainfall regime received in most parts of the State encourages farming throughout the year. The area is located between Latitudes $5^{\circ}17'$ and $5^{\circ}27'N$ and Longitudes $7^{\circ}27'$ and $7^{\circ}58'E$ and covers an area of approximately 35 Square Kilometres. The occupation of the inhabitants reflects the economic activity of the residents. The settlement pattern in Uyo is nucleated and being an administrative headquarters, majority of civil and public servants and political office holders reside there. Etim *et al* (2006) noted that these people engage in part-time farming activities and other commercial ventures within and around their homes as a way of augmenting and supplementing family income and food supplies. Data used for this study are mainly primary and were obtained from the water-leaf farmers using questionnaire during 2009/2010 farming season. Multi stage sampling procedure was employed. The first stage involved the random selection of two peri-urban areas in Uyo Local Government Area viz: Nsukara and Afaha Oku. The second stage involved the selection of 35 farmers from each of the two peri urban areas to make a total of 70 farmers. Baseline information on socio-economic characteristics, input use and output levels were collected and analysed.

The Empirical Model

The study utilized stochastic production frontier, which builds hypothesized efficiency determinants into the inefficiency error components (Coelli and Battese, 1996). Assuming we specified a Cobb-Douglas functional form as:

$$\ln(Qty) = \beta_0 + \beta_1 \ln(Land) + \beta_2 \ln(Labour) + \beta_3 \ln(Inorganic Fertilizer) + \beta_4 \ln(Organic Fertilizer) + \beta_5 \ln(Planting materials) + \beta_6 \ln(Capital) + V_i - U_i \quad (1)$$

Where Qty is the quantity harvested measured in kg; Land is the farm size measured in square meters; Labour is the labour employed in farm operations measured in mandays; inorganic fertilizer is fertilizer applied on the soil measured in kg; organic fertilizer is farm yard manure applied on the soil measured in kg; planting materials is waterleaf

cuttings measured in naira; Capital is the depreciation value of the implement used measured in naira.

With $V_i \sim N(0, \sigma_v^2)$; and

$$e^{-ui} = \alpha_0 + \alpha_1 (\text{Ext}) + \alpha_2 (\text{Exp}) + \alpha_3 (\text{Edu}) + \alpha_4 (\text{Age}) + Z_i \dots\dots\dots (2)$$

Where, Ext is access to extension contact (dummy), Exp is farming experience in years, Age is the age of the farmer (years); Edu is the level of educational attainment of the farmer in years, Z_i is an error term assumed to be randomly and normally distributed. The value of the unknown coefficients in equations (1) and (2) are jointly estimated by maximizing the likelihood function (Yao and Liu, 1998; Udoh and Akintola 2001b).

RESULTS AND DISCUSSION

Results for the variables were summarized (Table 1). The average production area was 62.48m², indicating that waterleaf is cultivated on small holdings. This small farm size could either be due to the labour-intensive nature of the cultural practices involved or because the farmers cannot acquire, or cultivate large hectareage. Production practices include land clearing, construction of beds, planting, fertilizer application, deflowering and harvesting. All these practices require substantial amounts of labour 115.42 mandays. The large difference between synthetic and organic fertilizer is less than that for the same quantity of synthetic fertilizer, which is not readily available in the local market (Udoh *et al*, 2003; Udoh and Etim, 2006a). The statistics on age and educational level are indications that the producers are within an active and productive age group, and have acquired some levels of formal education. The model specified was estimated by the maximum likelihood (ML) method using a FRONTIER 4.1 software developed by Coelli (1995). The ML estimates and inefficiency determinants of the specified frontier are presented in Table 2. The sigma square (0.0815) is statistically significant and different from zero at $\alpha = 0.01$. This indicates a good fit and the correctness of the specified distribution assumption of the composite error term. The variance ratio defined as $\lambda = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ is estimated to be 64.20 percent. The result suggests systematic influences that are unexplained by the production function as the dominant source of random errors. In other words, the presence of technical inefficiency among urban water-leaf farmers explains about 64.20 percent variation in the output level of the water-leaf cultivated. The presence of one-sided error component in the specified model is thus confirmed implying that the ordinary least square estimation would be inadequate representation of the data. The generalized likelihood ratio test ($\lambda^2 = 7.6816$) is significant. This means the presence of one-sided error component. The results of the judgement statistics thus confirm the relevance of stochastic parametric production function and maximum likelihood estimation. The importance of resource inputs is revealed in the production function estimates. Except for capital and inorganic fertilizer, the coefficients of other factors have the expected signs and magnitudes. Labour appears to be the most important factor of production with an elasticity of 0.7721. The result explains the labour intensive nature of water-leaf cultivation. Organic fertilizer is the second most important factor with an elasticity of 0.4824 followed by land. The non-significance of capital resource coefficient explains the labour intensive nature of water-leaf production in the study area. The estimated coefficients of the inefficiency function explain the technical efficiency levels among individual water-leaf farms. Except for extension contact and age, the coefficients of other inefficiency variables were significant. This implies that years of

schooling and farming experience of water-leaf farmers positively affect the farm level technical efficiency effect. This is so because higher educational attainment enhances farmers' acquisition and utilization of agricultural innovations and the development of a particular area of knowledge or specialization is by experience, which eventually leads to improvement in agricultural production technique and higher technical efficiency. Results are consistent with findings by Parikh *et al* (1995); Udoh (2005); Etim *et al* (2005); Udoh and Etim, (2006).

Resource-Use Efficiency Distribution

A very important characteristic of the stochastic production frontier is its ability to estimate individual, farm specific technical, allocative and economic efficiencies. Table 2 shows farm specific resource use efficiency indices. Results on Table 3 show considerable variation of technical efficiency index across the water-leaf farms. The fact that the technical efficiencies of all the sample water-leaf farms are less than one means that none of the waterleaf farms reached the frontier threshold. This implies that the water-leaf farms have the potential to increase efficiency. Farm output could however be increased despite the mean technical efficiency index of 0.82.

CONCLUSION AND RECOMMENDATIONS

The study measured the technical efficiency and its determinants using stochastic parametric estimation techniques. The parameters of the ML estimates and inefficiency determinants obtained using Cobb-Douglas Production Function estimated by maximum likelihood estimation technique were asymptotically efficient, unbiased and consistent. The important resource inputs that increased output from the water-leaf farms are land, labour, organic fertilizer and capital. The distribution of farm-specific technical efficiency shows that the water-leaf farmers were operating below the frontier threshold. Thus, within the context of efficient agricultural production, water-leaf output can still be increased by 18 percent using available imputer and technology. Result emphasizes the need for appropriate policy formulation and implementation to enable water-leaf farmers reduce their technical inefficiency in production as this may have multiplier effects ranging from water-leaf productivity growth, food security, food self-sufficiency, increased family income to economic growth and poverty reduction.

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TABLE 1: Summary statistics for a sample of waterleaf farms variables

Variables	Unit	Mean Value	Range
Output	Kilogram	3051.24	16 - 4210
Land	Square meters	62.48	20.43 – 185.64
Labour	Mandays	115.42	22.12 -181.30
Inorganic Fertilizer	Kilogram	10.81	4.24 – 45.39
Organic Fertilizer	Kilogram	120.77	21.27 – 193.85
Cuttings	Naira	2,100	1,400 – 6,182
Capital	Naira	204.17	43.17 – 438.44
Experience	Years	4	1 – 8
Education	Years	6.4	1 – 13
Age	Years	42	16 – 53

TABLE 2: ML estimates and inefficiency function

VARIABLE	COEFFICIENTS	ASYMPTOTIC T-VALUE
Production Function		
Constant term (β_0)	2.1038	1.8249*
Land (β_1)	0.3972	2.2619**
Labour (β_2)	0.7721	1.6899*
Inorganic Fertilizer (β_3)	0.1382	0.3205
Organic Fertilizer (β_4)	0.4824	2.5230**
Planting materials (β_5)	1.5382	1.8779*
Capital (β_6)	0.1851	1.4749
Inefficiency Function		
Intercept (α_0)	1.6211	1.9574**
Extension Contact (α_1)	0.0832	0.7021
Farming Experience (α_2)	-0.2841	-2.9842***
Education (α_3)	0.5816	2.2450**
Age (α_4)	0.7214	1.2080
Diagnosis Statistics		
Sigma-square (δs^2)	0.0815	3.7045***
Gamma (λ)	0.6420	2.0381***
Ln (Likelihood)	21.0482	
LR test	7.6816	
Quasi function	1.4201	
Numbers of observations	70	

Source: Computer print out of Frontier 4.1

Note: All explanatory variables are in natural logarithms. A negative sign of the parameters in the inefficiency function implies that the associated variables have a positive effect on technical efficiency and a positive sign indicates the reverse is true.

Asterisk indicate significance ***1%, **5%, *10%.

TABLE 3: Farm specific technical efficiency

Efficiency Class	Frequency	Percentage
0.01 - 0.10	4	5.71
0.11 - 0.20	2	2.86
0.21 - 0.30	3	4.29
0.31 - 0.40	5	7.14
0.41 - 0.50	7	10.00
0.51 - 0.60	5	7.14
0.61 - 0.70	6	8.57
0.71 - 0.80	9	12.86
0.81 - 0.90	12	17.14
0.91 - 1.00	17	24.29
TOTAL	70	100.00

Mean efficiency = 0.82
 Minimum = 0.01
 Maximum = 0.97