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## **Measurement of Farm-Level Efficiency of Water-Leaf (*Talinum triangulare*) Production Among City Farmers in Akwa Ibom State, Nigeria**

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### **Abstract**

*The technical efficiency of water-leaf farms in Akwa Ibom State was investigated using the stochastic frontier production function which incorporates a model for the technical inefficiency effects. Farm-level survey data from 70 urban water-leaf farmers were obtained using well structured questionnaire. The parameters 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. 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.*

**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). As also reported by Etim and Ofem (2005) and Etim *et al.*, (2006), 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 centres 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 by vegetative propagation 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 the farm level determinants of technical efficiency of water-leaf production among urban farmers.

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.

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), Hungson *et al.* (1983), 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 (2006) 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 – 3000 mm 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 latitude 5°17<sup>1</sup> and 5°27<sup>1</sup>N and longitude 7°27<sup>1</sup> and 7°58<sup>1</sup>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 2005/2006 farming season. Specifically, 70 water-leaf farmers were randomly selected from *Nsukara* and *Afaha Oku* urban and peri-urban zones. 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 hypothesised efficiency determinants into the inefficiency error components (Coelli and Battese, 1996). Assuming we specified a Cobb-Douglas functional form as:

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

Where Qty is the quantity harvested measured in kg; Land is the farm size measured in hectares; 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; value of planting materials 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

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

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<sub>i</sub> 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**

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 1. 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 generalised 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 Parickh *et al.* (1996), 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 2 shows 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.

**Table 1. ML estimates and inefficiency function**

Variable	Coefficients	Asymptotic T-value
<b>Production Function</b>		
Constant term ( $\beta_0$ )	2.1038	1.8249*
Land ( $\beta_1$ )	0.3972	2.2619**
Labour ( $\beta_2$ )	0.7721	1.6899*
Inorganic Fertilizer ( $\beta_3$ )	0.1382	0.3205
Organic Fertilizer ( $\beta_4$ )	0.4824	2.5230**
Planting materials ( $\beta_5$ )	1.5382	1.8779*
Capital ( $\beta_6$ )	0.1851	1.4749
<b>Inefficiency Function</b>		
Intercept ( $\alpha_0$ )	1.6211	1.9574**
Extension Contact ( $\alpha_1$ )	0.0832	0.7021
Farming Experience ( $\alpha_2$ )	-0.2841	-2.9842***
Education ( $\alpha_3$ )	0.5816	2.2450**
Age ( $\alpha_4$ )	0.7214	1.2080
<b>Diagnosis Statistics</b>		
Sigma-square ( $\delta s^2$ )	0.0815	3.7045***
Gamma ( $\lambda$ )	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 2. 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
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
<b>Total</b>	<b>70</b>	<b>100</b>

Mean efficiency =0.82, Minimum=0.01, Maximum=0.97

## Conclusion

The study measured the farm level 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 input and technology.

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