# RESOURCE USE EFFICIENCY AMONG DRY SEASON VEGETABLE GARDENERS IN ENUGU URBAN, ENUGU STATE: A STOCHASTIC FRONTIER PRODUCTION FUNCTION APPROACH

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## ABSTRACT
*Some urban dwellers embark on urban farming to bridge the gap between urban food demand and supply. The main aim of the study is to determine the technical efficiency of resource use among dry season vegetable gardeners in the study area. Stochastic frontier production function was used to analyse the resource use by the farmers. The results showed that about 91.6% of the farmers have technical indices of above 80%. The maximum efficiency is 98.46% while minimum efficiency, 68.01%. Farmers' accessibility to fertilizer, land, extension services among others were recommended.*

**Keywords:** Resource use efficiency, dry season, market gardener, and small holder farmers.

## INTRODUCTION
Urban agriculture in recent times seems to have gained prominence in developing economies as it contributes immensely to socioeconomic development of the household in terms of gainful employment, wealth creation, poverty reduction and food security (Operah, 2007). In the cities, it helps to improve cleanness of the cities, environmental restoration and greening (Coffee et al, 2005).

In Nigeria, the practice of urban agriculture is orchestrated and reinforced by aftermath of structural adjustment programme (SAP), which characterized by fluctuation of food prices, unemployment and inflation (World Bank, 1990). Umo (2005) classified urban agriculture into mixed cropping and market gardening. Market garden is a system that make use of intensive cropping system involving planting of vegetables with peculiar closeness to big cities and markets (Densten et al, 1998). Intensive cropping system occurs in the hydromorphic area along the bank of streams, rivers and flooded planes, affluent from drains from premises and streets drainage (Operah, 2007).

The production methods of market gardeners include raised seed bed, spacing of crops on the beds, watering regularly with watering cans, use of improved seeds of exotic vegetable varieties and application of either organic manure or inorganic fertilizer (NPK, single super phosphate [CAN]) (Denten, et al, 1998). Indeed, a lot of exotic and local vegetables are grown through urban farming to meet the demand needs of urban dwellers. Coffee, et al, (2005) showed that more than 80% of the perishable vegetables that are consumed by city residents are produced within the city..

In spite of the contributions of urban agriculture to food security and food safety of the country, particularly among the urban dwellers, the programme has been threatened by water and land scarcities and environmental pollution. The worst form of this pollution is the industrial wastes such as waterproof contamination of our water and soils (Operah, 2007). Furthermore, Coffee et al (2005) cited odour from livestock reared in urban areas as environmental health hazards which often results in closed down of such ventures by the appropriate government agencies.

The urban farmers like any other farmers produces to satisfy the house-hold needs or make profit or both, such production entail efficient use of farm resources (Umo, 2005). Farm efficiency and its resources are vital in developing countries. The parametric programming, non parametric programming, deterministic statistical and stochastic frontier approaches are used to measure efficiency (Schipper, 2000 and Okoye & Onyenweaku, 2008). Among the above mentioned approaches, the stochastic frontier and non-parametric programming known as Data Envelopment Analysis (DEA), are the most popularly used. The stochastic frontier approach is preferred for assessing efficiency in agriculture because of inherent stochasticity involved (Coelli, 1994). Inefficiency in resource use and utilization in farming can seriously hamper or jeopardize the production and availability of staple food (Edet & Nsikak, 2007). Nevertheless, resource use efficiency and productivity are influenced by a variety of factors which include the type of technology, level of capital utilization, the commitment of the labour force and the level of skill acquisition both material and technical (Okezie, and Okoye, 2006). Therefore, estimating the level of technical efficiency of dry season gardening becomes imperative. This will make it possible to determine whether the deviation in technical efficiency from the Frontier output is due to farm specific factors or external random factors.

The broad objective is to determine the socio-economic factors and resource use efficiency among dry season market gardening of small holder farmers in Enugu town of Enugu State.

**Material and Methods**

The study was conducted in Enugu town, Enugu State, Nigeria. Enugu is located within the following coordinates North $6^0$ 64'N, and $5^0$ 59'N, East $6^0$ 53'E and $5^0$ 56'E. Enugu has temperature range of 28 – $31^0$C, relative humidity of 72 – 85%, and annual rainfall of 12000mm - 23000mm.

The choice of Enugu was informed by its characteristic features of streams, rivers and sewage channels scattered all over the area. Enugu with coal deposits was the headquarters of former eastern region during colonial era, later east central state. Enugu later became the capital of former Anambra State and presently Enugu State capital.

Enugu is inhabited by people from various tribes and races within and outside Nigeria. They include public/civil servants, business men and women, company workers, farmers, artisans and petty traders. Enugu has high population rate of 1.4 million people (NPC, 2006) and consists of civil servants in the neighbouring states around Enugu state still operate from the metropolitan. More so, Enugu has become very attractive to unemployed youths who seek for job because of many federal and state ministries, parastatals, and private businesses.

The data for this study were primarily sourced and obtained from vegetable farmers using questionnaire, during the 2009 cropping season. Secondary data were also sourced through published and unpublished related literatures.

A total of 120 vegetable farmers were randomly sampled from areas in Enugu urban where vegetable cultivation is intensive. Baseline information on farmer's socioeconomic characteristics and input and output were collected and analyzed.
Theoretical Framework of Stochastic Production Function

Efficiency can be defined as ability to produce the largest possible quantity of output from a given set of input. Efficiency is of technical, allocative and economic (overall efficiency) types (Farrel, 1975). Technical efficiency is the ability to produce a given level of output with minimum quantity of input.

Farrell (1975), first introduced technical efficiency measures. But the more satisfactory measure of technical efficiency through stochastic frontier model was independently formulated by Aigner et al (1977) and Meeusen and Vander Broeck (1988), which improved the estimation of technical efficiency by incorporating both statistical noise representing un-controlled exogenous factors and technical efficiency. The major features of the stochastic production function are that the disturbance term is a composite error consisting of two components – symmetric component and one sided component. The symmetric component captures the random effects due to measurement errors, statistical noise and other influences, and is assumed to be normally distributed. The one sided component $U_1$ captures randomness under the control of the firm. It attributes deviation from the frontier to inefficiency and is half normally distributed or exponentially distributed.

The stochastic frontier production function =

$$Y_1 = f(X_1 B) \exp (V_1 - U_1)\ 1 = 1.2 \text{ -----------------------------------} (1)$$

Where: Y = output of the $1^{th}$ firm

$X_1$ = corresponding ($Mx_2$) vectors of unknown parameter to be estimated

F (.) denote an appropriate function (e.g. Cobb Douglas, translog, etc)

$\beta$ = beta

Ui is the symmetric error component that accounts for random effect and exogenous shock

Where: Ui = 0 is one sided error component that measure technical inefficiency.

Empirical Model

Stochastic production frontier was used which builds hypothesized efficiency determination into the inefficiency error component (Coell and Battese, 1996). The Cobb Douglas production functions as thus:

$$Ln (Qty) = \beta_0 + \beta_1 Ln (land) + \beta n Ln (lab) + \beta 3 Ln (fert) + \beta 4 Ln (plantma)$$
$$+ \beta 5 Ln (capital) + V_1 - U_1 \text{ ---------------------------------------------------} (2)$$

Where: Qty is the quantity of vegetable in kg or bundle

Lan = land per hectare

Lab = labour employed in farm operation in manday

Fert = is the quantity of fertilizer used in kilogram

Plantma = is the planting materials in kg

Capital = is depreciated on capital input in Naira

$V_1$ = error term not under the control of the farmer

$U_1$ = error term under the control of the farmer

$\beta o$ = intercepts

$\beta_1 - \beta_5$ = coefficient estimated

$$U_1 = d_0 + d_1 (Ext) + d_2 (Exp) + d_3 (Age) + d_4 (Edu) + e_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where: Ext = access to extension contact (dummy)

Exp = is the farming experience in years

Age = is the age of the farmers in years

Edu = is the level of education attainment of the farmer in years

$e_i$ = error term

**Results and Discussion**

The following socioeconomic variables were studied viz: age, gender, migrant status, educational level attained, farming experience, household size and membership of cooperatives. On age, 45% of the respondents were within the age bracket of 31 – 40 years while the least were farmers in the age bracket greater than 50 years. This work contradicted the statement that farming is left for the ageing.

(Idowu, 1988) supported Umo, (2005) that urban farming are for young farming population because of rural – urban drift.

On gender, the female population (70%) topped the total respondent studied while the remaining 30%)) were male. This implies that women constitute a greater percentage of those engaged in vegetable production in the Enugu urban area. Vegetable production is less laborious than other farming especially root crops and does not require lot of physical strength (Udo and Akintola, 2005).

On migrant status, 68% of the total respondents were migrants and aborigines, whom are products of rural – urban drift in quest for greener pastures. The income accruing from these white collar jobs may be meager or non availability of such job, resulting in many city dwellers engaging in urban farming either as part-time or full time basis (Umo, 2005). Most of the respondents are educated (67.4%). This result is not only in line with migrant high education hypothesis but agreed with the works of Umo, (2005) and Udo and Etim (2008). Educated farmers are expected according to Okoye and Onyenweku (2008) to be more receptive to improve farming technique.

38.8%t of the respondents interviewed had farming experience ranging between 8– 11 years, while the least had less than 3 years (11.7%). Nwaru, (1993) opined that farmers count more on their experiences than educational attainment to increase their productivity. Majority of the respondents had household size of 7 – 9 (45%). The implication of large household size is higher access to family labour, consequently reduction in the cost of production of vegetable in the study area.

8.3% of the respondents studied were identified with one cooperative society or the other while 91.6% were not. Cooperative society usually assists the member farmers in procuring inputs and credits without much difficulty and among other benefits.

Table 4 showed that most of the farmers interviewed reported that land scarcity was the limited factor to urban agriculture. Umo, (2003) confirms these findings, when he opined that the vegetable production during this period (dry season) is restricted only along source of water which is already a limited source in the region. Besides, market gardening is also viewed as only grown by people who have access to source of water. Other major constraints to market garden production as reported by the farmers were pests and diseases, soil fertility problem, theft and unavailability of extension agent.

The technical efficiency model specified was estimated by the maximum likelihood (ML) method using frontier 4.1 software developed by Coelli, (1995). The maximum likelihood estimates and inefficiency determination of the specified frontier were presented in the table 3. On estimation of technical efficiency, the stigma squared ($L^2$ 0.0797) the gamma ($\gamma = 0.0876$) are high and sigma square ($U^2$) has goodness of fit and agree with assumption of composite error term distribution. The gamma ($\gamma$) shows that 0.0876 of the variability in the output of vegetable farmers that are unexplained by the function is due to technical inefficiency (Okoye & Onyenweaku, 2008). Two variables labour ($B_1$) and fertilizer ($B_3$) were significant among the variables considered and hereby discussed as follows: Labour ($B_1$) – It was rightly signed positive and significant at 1%. This is in attestation to the fact that farming among small holder farmers in developing countries is manual and rarely mechanized, in effect constitute greatly to total cost of production. The non mechanization of these farms could be attributed to among others excessive land fragmentation, lack of affordable equipment and poverty (Udo, 2008).

Fertilizer ($B_3$) – The variable was significant at 1% probability level and positively signed as prior expected. This relationship may connote that 10% increase in fertilizer use may result to 8.436% improvement in the vegetable output in the study area. This result concurred with the work of Umo, (2008) on urban farming in Uyo, Akwa Ibom, of which the importance of fertilizer in boosting crop yield was stressed. The production elasticity of output with respect to quantity of fertilizer was 0.8436.

Among the socioeconomic variables considered as inefficiency determinants, only the coefficients of level of education and household size were significant and positive.
Educational Level attained ($Z_1$) – The variable had positive sign and significant at 5% probability level. The elasticity of production of education level attained was 4.862. This finding infer on the importance of the variable as a motivating factor to farmers in acquiring and utilization of innovation, more effectively. This leads to improvement in production methods and higher technical efficiency level (Edet and Nsikak, 2005). This result is synonymous with findings of Udo, 2005) and Udo and Etim (2006).
Household Size ($Z_2$) – The coefficient of household size was positive and significant at 1% probability level. This could mean that it is possible to increase vegetable production in the study area at low cost especially among aged poorer household members that are still living with their parents. This is more pronounced in situation where hired labour is expensive. More so, children of this economic class can be used as hired labours.

The frequency distribution of technical efficiency in dry season market gardening is presented in table IV. Individual technical efficiency indices range between 68.01% and 98.46% with mean technical efficiency of 92.96%. About 91.66% of the dry season market garden farmers have technical indices of above 80%. The high level technical efficiency obtained in this study was consistent with the low variance of the farm effect.

## Conclusion and Recommendation

The major conclusions deduced from this study include:

(i) Most of the urban farmers studied are literate women.

(ii) Land and water availability are the major constraints to urban agriculture.

(iii) Labour availability and fertilizer are the major determinants of technical efficiency of resource use among the respondents. While inefficiency determinant variables are educational level attained and house household size.

(iv) From the result shows that there is still room for improvement in the level of technical efficiency of the farmers in the study area, is the mean efficiency score = 92.96%.

The following recommendations were made:

i. Need to formulate policy aimed at improving farmers access to improved production inputs of land, fertilizer, credits and extension services to increase farmers technical efficiency and to encourage old and new entrants farmers especially youths in dry season vegetable production.

ii. As women play significant role in the crop production, therefore free education for the girl-child is advocated.

iii. Labour saving devices should be researched on, developed and disseminated to the farmers in order to reduce or curtail high cost of hired labour and consequently reducing the total cost of production.

iv. Need for research and collaborations to promote the safe use of waste water in irrigating vegetables.

v. Need to create public awareness on safe handling of the produce.

vi. Finally, the need for family planning among the respondents, so as to get a manageable household size.

**Table 1: Distribution of Socioeconomic Characteristics of Urban Farmers**

| Character | Frequency | Percentage (%) |
|---|---|---|
| **Age** | | |
| < 20 | 10 | 8.3 |
| 21 – 30 | 22 | 18.3 |
| 31 – 40 | 54 | 45 |
| 41 – 50 | 18 | 15 |
| > 50 | 16 | 13.3 |
| **Total** | 120 | 100 |
| **Gender** | | |
| Male | 10 | 30 |
| Female | 22 | 70 |
| **Total** | 120 | 100 |
| **Migrant Status** | | |
| Migrant | 82 | 68.3 |
| Native | 38 | 31.7 |
| **Total** | 120 | 100 |

| | | |
|---|---|---|
| **Level of Education** | | |
| No formal education | 14 | 11.7 |
| Primary school | 25 | 20.8 |
| Secondary school | 46 | 38.3 |
| Post secondary school | 35 | 29.1 |
| **Total** | 120 | 100 |
| **Farming Experience** | | |
| 1- 3 | 14 | 11.7 |
| 4 – 7 | 22 | 18.3 |
| 8 – 11 | 46 | 38.3 |
| 12 & above | 18 | 15 |
| **Total** | 120 | 100 |
| **Household Size** | | |
| 1 – 3 | 10 | 8.1 |
| 4 – 6 | 35 | 29.1 |
| 7 – 9 | 54 | 45 |
| > 10 | 21 | 17.5 |
| **Total** | 120 | 100 |
| **Membership of Cooperative** | | |
| Yes | 10 | 8.3 |
| No | 110 | 91.7 |
| **Total** | 120 | 100 |

**Source: Field Survey, 2009**

**Table 2: Constraints to Market Garden Vegetable Production**

| Constraints | Percentages (%) |
|---|---|
| Land scarcity | 65 |
| Weeds | 24 |
| Pests and diseases | 58 |
| Scarcity of labour | 34 |
| Theft | 52 |
| Lack of extension agent | 53 |
| Inadequate planting materials | 13 |
| Lack of knowledge on harvest storage | 23 |
| Soil fertility | 56 |
| Lack of improved varieties | 14 |

**Source:** Field Survey Data, 2009
*Multiple responses

## Table 4: Distribution of technical efficiency in dry season urban market gardening

| Technical Efficiency | Frequency | Relative Frequency (%) |
|---|---|---|
| < 60 | 0 | - |
| 61 – 70 | 2 | 1.67 |
| 71 – 80 | 8 | 6.67 |
| 81 – 90 | 10 | 8.33 |
| 90 – 100 | 100 | 83.33 |
| **Total** | **120** | **100** |

Mean technical efficiency = 92.96
Minimum technical efficiency = 68.01
Maximum technical efficiency = 98.46

**Source:** Field Survey, 2009

**Table 3: Maximum Likelihood Estimate of the Stochastic Frontier Function and Technical Inefficiency**

| Variable | Parameter of Stochastic | Coefficient Frontier | Standard error | t-statistics |
|---|---|---|---|---|
| Constant term | $B_0$ | 3.712 | 2.614 | 1.420 |
| Labour | $B_1$ | 0.117 | 0.156 | 0.748$^{xxx}$ |
| Farm size | $B_2$ | 0.564 | 0.261 | - 2.160 |
| Fertilizer | $B_3$ | 0.8436 | 0.277 | 3.045$^{xxx}$ |
| Planting method | $B_4$ | - 2.172 | 0.371 | - 5.851 |
| **Inefficiency Effect** | | | | |
| Level of education ($Z_1$) | | 4.862 | 1.334 | 3.644$^{xx}$ |
| Household ($Z_2$) | | 2.092 | 2.065 | 1.449$^{xxx}$ |
| Farmer's age ($Z_3$) | | 3.142 | 2.889 | 1.096 |
| Farm size ($Z_4$) | | 3.843 | 1.141 | 3.367 |
| **Variance Parameter/Diagnostic** | | | | |
| Sigma squared ($Q^2$) | | 0.0794 | 2.4880 | |
| Gamma (γ) | | 0.0876 | 1.0077 | |
| Log likelihood | | 1.76778 | | |
| Log Ratio Test | | 5.7837 | | |
| No. of Observation | | 120 | | |

xxx, xx, x are significant at 1%, 5% and 10% levels respectively

**Source:** Computed from Maximum Likelihood Estimate Result Field Survey Data, 2009

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