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Efficiency of Resource Utilization in Dry Season Waterleaf *Talinum triangulare* Jacq. Wild Production by Women in Southern Nigeria

Nsikak-Abasi A. Etim[1*] and Glory E. Edet[1]

[1]*Department of Agricultural Economics and Extension, University of Uyo, P. M. B. 1017, Uyo Akwa Ibom State, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Author NAE designed the study, wrote the protocol and wrote the first draft of the manuscript. Author GEE managed the literature searches, analyses of the study performed the spectroscopy analysis. Author NAE managed the experimental process. Author GEE identified the species of plant. Both authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

The study estimated the efficiency of resource use by women in dry season waterleaf production. The study was conducted in Etinan Local Government Area of Akwa Ibom State during the short dry season between November 2011 and February 2012. Through the multistage sampling technique, primary data were obtained from women waterleaf producers using questionnaire. Resource-use efficiency was estimated by fitting stochastic production frontier functions to survey data obtained from women waterleaf producers. Using the Maximum Likelihood analysis, asymptotic parameter estimates were evaluated to describe explainers of resource use efficiency. Results indicate that the most important resources were family labor, organic fertilizer, irrigation water, planting materials (cuttings). Result indicates that waterleaf cultivation is highly laborious particularly during deflowering and irrigation water. Findings further show that waterleaf producers relied more on organic fertilizer for increased production and yield. Land size, family labor and organic fertilizer are significant (P<.01) whereas irrigation water and waterleaf cuttings are significant (P<.10) and (P<.05) respectively. Findings reveal that none of the producers

**Corresponding author: E-mail: etimbobo@gmail.com;*

reached the maximum production efficiency. The mean resource use efficiency of 68 percent showed an inefficiency gap of 0.32 implying that about 32 percent increase in waterleaf output could be achieved using the same resource combination. The benefits of economies of scale could be achieved by expanding the size cultivable waterleaf land either through consolidation of existing holdings or acquiring new farm plots.

Keywords: Efficiency; resource; waterleaf; Nigeria.

1. INTRODUCTION

Waterleaf *Talinum triangulare* Jacq. Wild is an erect, fleshy, annual herb cultivated in West Africa and used as a cooked vegetable [1,2]. It has swollen taproot and can be reproduced from seed or vegetatively from stem cuttings. Under proper cultural management, waterleaf can be harvested 35-45 days after planting [3]. Waterleaf is used in combination with other vegetables such as (*Gnetum africanum* welw.) locally known as “Afang”, Bush apple (*Heinsia crinata* (Afzel.) G. Taylor) locally known as “Atama” and Fluted pumpkin (*Telferia occidentalis Hook F.*) locally known as “Ikong ubong”, *Vernonia amygdalina* locally known as “Etidot”, *Lasienthera africana* locally known as “Editan” to prepare indigenous soups such as “Edikang ikong” (pumpkin soup), a combination of pumpkin and waterleaf; “Efere Afang” (Gnetum soup) a combination of Gnetum and waterleaf; “Efere Atama” (Heinsia soup) a combination of Heinsia and waterleaf; “Efere Etidot” (Bitter leaf soup) - a combination of bitter leaf and waterleaf and “Efere ikon” (melon soup) - a combination of melon and waterleaf. In 100 grams of fresh materials, waterleaf contains protein (2.4g), fats (0.4g), carbohydrates (40g), fibre (1.0g), calcium (121mg), phosphorus (67mg), iron (5mg), thiamine (0.08mg), riboflavin (0.18mg), niacin (0.30mg) and ascorbic acid (31mg) [4,5,2]. One hundred (100) grams of fresh waterleaf contains 25 calories [6]. Farming activities within and around cities in Akwa Ibom State primarily centre on the production of vegetables in which waterleaf cultivation feature prominently [7,8,9,2]. Despite the involvement of women in the cultivation of waterleaf, there has been a wide gap between the demand for waterleaf and its supply as evidenced in frequent rise in price of waterleaf particularly during dry season.

Waterleaf is widely cultivated and consumed in Southern Nigeria, particularly in Cross River and Akwa Ibom States [10,11,2] and is an additional source of income for subsistence producers [8,2]. Thus, if the price of this product which is consumed by even the poorest household is raised, the ready availability, accessibility and affordability of the product would be greatly hampered. Waterleaf cultivation is predominantly carried out by women [8] and all the production practices which require substantial amount of labor are done by women [8]; [2]. The cultivation of waterleaf requires the use of resources which must be transformed efficiently to optimize output. According to [12,2], production could be ffected adversely if resources are not used efficiently. Earlier and empirical study by [2] suggests that in order to optimize production farmers need to use available resources as efficiently as possible and being primary managers of land, farmers need to manage problems arising from deteriorating natural resources. Identifying the extent of resource utilization by women is imperative given the fact that the optimization of agricultural production is through efficient use of resources. This is important because productivity growth and resource-use efficiency issues are the core elements of sustainable crop production in small scale farming activities. Inefficient use of inputs can seriously jeopardize food availability, accessibility and affordability. This study is therefore aimed at measuring farm-level technical efficiency and the determinants of inefficiency effects in dry season waterleaf production by women.

2. METHODOLOGY

The study was conducted in the Etinan Local Government Area of Akwa Ibom State, Southern Nigeria. A farm-level survey was conducted during the 2011 and 2012 dry seasons to provide primary data. Multistage sampling technique was employed in selecting the representative waterleaf producers that were used for this study. The first stage was the random selection of 2 villages namely Ikot Eba and Ekpene Ukpa. The second stage sampling involved the random selection of 60 waterleaf producers per village to make a total of 120. Information on product quantity, unit prices, resource-use and socio-economic characteristics of the producers were obtained. Multiple regression analysis based on a stochastic production frontier model was employed. The model incorporates efficiency determinants into the inefficiency error components as hypothesized by [14] to estimate the efficiency of resource use among producers. This model describes the best and most efficient outcome possible based on the various parameters studied.

By definition, a stochastic frontier production function is:

$$Y_i = F(X_i;\beta)\ \exp(V_i - U_i)\ I = 1,2 \ldots, N \quad (1)$$

Y_i is the output of ith waterleaf farm; X_i is the corresponding (MX2) vector of inputs; β is a vector of unknown parameter to be estimated; F(.) denotes an appropriate function form; V_i is a symmetric error component that accounts for random effects and exogenous shock; while $U_i \leq 0$ is a one-sided error component that measures technical inefficiency.

To develop a model that is flexible, which can include the data, a power production function, known as a Cobb-Douglas production function was specified.

This is expressed as:

$$\text{Ln } Q = \beta_0 + \beta_1 \text{Ln}(X_1) + \beta_2 \text{Ln}X_2 + \beta_3 \text{Ln}X_3 + \beta_4 \text{Ln}X_4 + \beta_5 \text{Ln}X_5 + \beta_6 \text{Ln}X_6 + \beta_7 \text{Ln}X_7 + V_i - U_i \quad (2)$$

Where:

Q = The total quantity of waterleaf produced in kilogram;
X_1 = Plot size in square meters;
X_2 = Irrigation water in liters;
X_3 = Family labor in mandays;
X_4 = Planting materials (waterleaf cuttings) in kilogram;
X_5 = Chemical fertilizer in kilogram
X_6 = Organic fertilizer in kilogram
X_7 = Capital invested in Naira expressed as the value of all farm implements used; while

$$V_i \sim N(O, \sigma v^2) \text{ and}$$
$$e^{-ui}\ \rho_0 + \rho_1(X_8) + \rho_2(X_9) + \rho_3(X_{10}) + \rho_4(X_{11}) + \rho_5(X_{12}) + \rho_6(X_{13})\ Z_i \quad (3)$$

Where:

X_8 = Farming experience in years;
X_9 = Household size in number;

X_{10} = Age of the waterleaf producer;
X_{11} = Years of formal education
X_{12} = Access to extension contact (dummy)
X_{13} = Access to credit;
Z_i = Error term assumed to be randomly and normally distributed

The values of the unknown coefficients in equation (2) and (3) are simultaneously estimated by maximizing the likelihood function [15,16,2].

3. RESULTS AND DISCUSSION

3.1 Descriptive Analysis

Results for the output and some explanatory variables were summarized in Table 1. The mean plot area was 94.82 square meters implying that waterleaf cultivation was on subsistence level with small plot sizes. Recent and empirical findings by [17] suggest that the labor-intensive nature of the production practices or inability of the producers to acquire larger plots could be responsible for the small farm holdings by waterleaf producers. The production practices which include land clearing, construction of beds, fertilizer application, planting, irrigation, weeding, deflowering and harvesting require substantial labor. Result on household size confirms that most of the labor in waterleaf cultivation were provided by family members. This is confirmed by the average family labor of 156.22 mandays supplied by household members and dependents. The wide gap between chemical (15.81kg) and organic fertilizer (150.62kg) is an indication that the producers depended more on organic fertilizer (mostly poultry droppings). According to [18,2], this may be attributable to the relatively cheaper cost of a bag of organic fertilizer which is N400.00 per 50kg bag compared to a bag of chemical fertilizer sold at N6,900 per 50kg bag. The statistics on age and educational level of the producers are suggestive that they were within an active and productive age.

Table 1. Summary statistics of output and explanatory variables

Description	Unit	Mean	Range
Output	Kilogram (kg)	4891.09	1280 - 6020
Plot	Square meter (m^2)	94.82	30.87 – 210.02
Water	Liters	9380	336.24 – 11200
Family labor	Mandays	156.22	52 – 280.08
Planting materials	Kilogram (kg)	201.83	88.80 – 724.33
Chemical fertilizer	Kilogram (kg)	15.81	10.54 – 50
Organic fertilizer	Kilogram (kg)	150.62	30.67 – 250.66
Capital	[z]Naira (₦)	1,250	450 – 1,892.68
Farming experience	Years	9	4 – 16
Household size	Number	7	5 – 12
Age	Years	48	16 – 66
Education	Years	8	3 – 13

[z] Naira (₦) is Nigeria currency. To convert to US$ divide by 170

3.2 Results of Maximum Likelihood and Inefficiency Estimates

The model specified is estimated by the maximum likelihood method using FRONTIER 4.1 as shown in Table 2. The value of sigma square indicates goodness of fit and the correctness of the specified distribution assumption of the composite error term. The variance ratio is high as 66.75% suggesting that the systematic influences that are not explained by the production function are relatively dominant random error sources. Result means that the existence of inefficiency of resource use among the waterleaf producers accounts for about 67% of the variation in the output level of the waterleaf 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. Result confirms the relevance of the specified production function and maximum likelihood estimation.

The production function estimate is an indication of the relevance of resources in waterleaf production. Except chemical fertilizer and capital, the elasticities of other resources have the expected signs and magnitude and are statistically significant at different levels. Family labor, organic fertilizer, irrigation water and farmland seem to be the most important resources based on the magnitude of their coefficients. The large elasticity for family labor is an indication that waterleaf production is quite laborious particularly during planting, irrigation, weeding, deflowering and harvesting. Finding is synonymous with earlier empirical studies of [2,19]. During the short dry season, the irrigation of crops with water is essential to provide sufficient moisture for uptake by plants. This is revealed by the coefficient of irrigation water which is positive significant ($P<.10$). Finding is in conformity with earlier result by [20]. The elasticity of organic fertilizer is synonymous with empirical results of [8] that the majority of waterleaf producers increase their yield through the application of organic fertilizer.

The coefficient of formal education is significant ($P<.05$) implying waterleaf producers with higher education appear to be less efficient in resource use. This may be attributable to the fact that a handful of persons with higher educational attainment would be engaged in the production of waterleaf as part-time farmers, as most of the farmer did not attend tertiary institutions. The variable experience is statistically significant ($P<.10$) meaning that increased experience in cultivation may also enhance critical evaluation of the relevance of better production decisions including efficient utilization of productive resources. The statistical significance of the coefficient indicates that specialization is developed over time leading to improved production method and higher efficiency. Finding is in conformity with [21,22,23,24] who obtained similar result. The variable credit has elasticity of 0.1963 and significant ($P<.05$) indicating that accessibility and availability of credit loosens the production constraints and makes for timely purchase of resources thereby increasing productivity through efficiency. Results agree with empirical findings by [25,23,24] but contrary to [26] who reported a negative impact of credit on technical efficiency. Access to extension services has elasticity of 0.1281 and is significant ($P<.10$). Farmers' access to the variable enhances their access to information and improved farming techniques. Result suggests that extension services delivery in Nigeria is lagging in effectiveness and efficiency, especially after the withdrawal of funding of the Agricultural Development Project by the World Bank and therefore needs a more proactive and effective policy decision to improve the extension service delivery in Nigeria.

Table 2. Maximum likelihood estimates and inefficiency function

Variable	Coefficient	Asymptotic T-value
Production Function		
Constant term β_0	0.1082	2.6106
Plot β_1	0.4111	2.5901
Irrigation water β_2	0.4128	1.9271
Family labor β_3	0.6456	3.3352
Planting materials β_4	0.3271	2.1018
Chemical fertilizer β_5	0.1874	1.0357
Organic fertilizer β_6	0.4932	2.8892
Capital β_7	0.2176	1.3491
Explainers of Inefficiency		
Intercept ρ_0	0.3001	0.2618
Farming experience ρ_1	-0.3755	-1.8113
Household size ρ_2	0.2120	0.8956
Age ρ_3	0.3312	1.1467
Formal education ρ_4	0.4229	2.0935
Extension contact ρ_5	0.1281	1.6254
Credit ρ_6	-0.1963	-2.0112
Diagnosis statistics		
Sigma-square δs^2	0.5342[a]	2.8117
Gamma λ	0.6675	4.9310

[z]All explanatory variables are in natural logarithms. A negative sign of the parameters in the inefficiency function means that the associated variables have a positive effect on technical efficiency and a positive sign indicates the reverse.

[a]The value of sigma square is statistically significant at α= 0.01

3.3 Resource-use Efficiency Distribution

An important feature of the stochastic production frontier is its ability to estimate individual, farm-specific technical, allocative and economic efficiencies.

Efficiency indices varied across the waterleaf farms Fig. 1. The distribution spreads from left to right at different intervals, hence validation of the assumption of normal distribution of inefficiency effects ($-U_i$) in equation (2). The mean resource-use efficiency is 0.68 leaving an inefficiency gap of 0.32, implying that about 32% increased production could be achieved using the same resource combination. This indicates product wastage as a result of inefficiency in resource use by the producers. From the distribution, the most efficient producer in terms of resource use has an efficiency index of 0.95 and the least efficient an index of 0.03. None of the producers reached the frontier threshold indicating that producers encountered problems they were unable to completely overcome, and which could include technical production constraints and socioeconomic and/or environmental factors [27,28]. In subsistence farming resources are mostly allocated to various uses on the basis of their shadow values, which is the amount by which the contribution could be raised if one additional unit of the resource is used, thereby preventing the producers from reaching the maximum production efficiency [21,29,20,8]. Waterleaf production could be increased by 32% using available technology. To derive the benefit of economies of scale, expanding cultivable plots devoted to waterleaf cultivation by producers either through land consolidation or acquiring new farmlands.

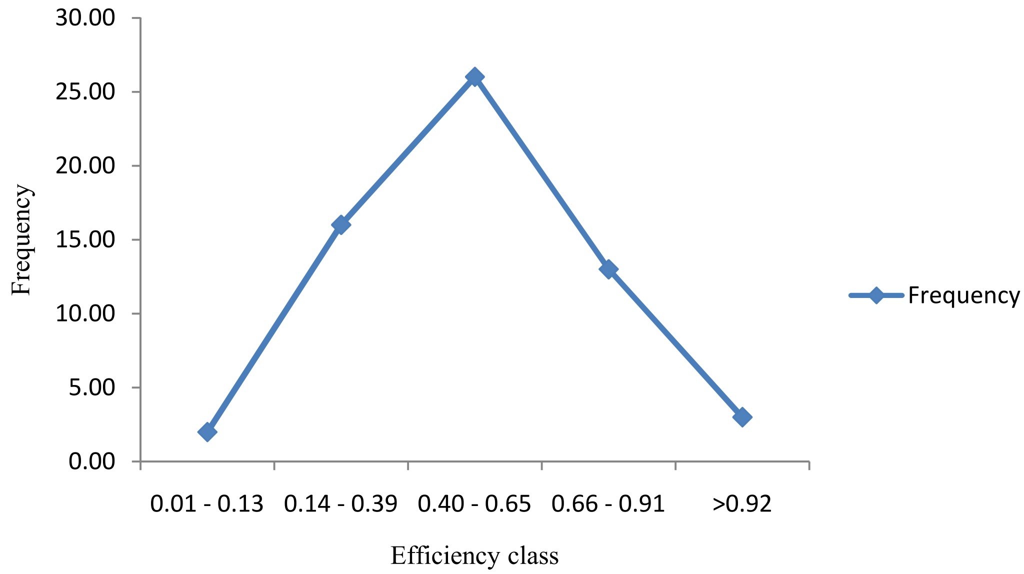

Fig. 1. Farm specific technical efficiency across waterleaf farms

4. CONCLUSION

The study estimated resource use efficiency in dry season waterleaf production by women in Southern Nigeria. Results reveal that the most important resources in waterleaf production which increased output were land, organic fertilizer, irrigation water, planting materials and family labor. Findings also reveal that most of the labor employed in waterleaf cultivation were provided by family members as the average household size was 7. The cultivation of waterleaf required substantial mandays of labor particularly during deflowering and irrigation. The distribution of farm-specific technical efficiency reveals that the farmers were operating below the frontier threshold. To derive the benefit of economies of scale, policy options that will encourage farmers to increase their farm holdings and utilize more organic fertilizer should be formulated. This will not only result in increased production but ensure higher net returns. Also, the provision of adequate technical assistance, extension and supportive services by government and relevant agencies should be provided to women waterleaf farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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