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Analysis of Resource-Use Efficiency in Dry Season Vegetable Production in Jere, Borno State, Nigeria

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Abstract
This study examined the resource-use efficiency in vegetable production in Jere L.G.A. of Borno State, Nigeria. Data for the study were obtained from primary source with the aid of a structured questionnaire using the interview schedule. The data were for 2010 cropping season collected between October-December of 2010. Five villages notable for vegetables production were purposely chosen for the study and responses from 100 vegetable farmers from the four villages were used in the analyses. Production function analysis which incorporates the conventional neoclassical test of economic and technical efficiencies was used as the analytical technique. Findings revealed that seed ($p<0.01$), land ($p<0.01$), herbicide ($p<0.10$) and pesticide ($p<0.01$) significantly affected the vegetable output. And the farmers were inefficient in the use of all the resources. Farm inputs such as seed, land and pesticide were under-utilized while herbicide, fertilizer and labour were over-utilized. The study concludes that if additional units of seed, pesticide and land were available and accessible, it would lead to an increase in vegetable yield by 114.58, 322.64 and 568.72kg per hectare among the farmers respectively. The study suggests that there is need for making inputs such as improved seeds and herbicide affordable and accessible to the farmers so as to improve efficiency. Also policies that encourage the testing of soils fertility for fertilizer recommendations and creation of alternative employment opportunities to absorb the excess labour used in vegetable production in the area should be formulated.
Key words: Resource-use, efficiency, production function, jere, vegetable, production

1. Introduction

Among the hierarchy of man's basic needs, food is probably the most important and food self-sufficiency is a prerequisite for food security. However, in recent years Nigeria has failed to achieve self-sufficiency in food crop production. This might be due to the fact that Nigerian Agriculture is characterized by a multitude of small scale farmers scattered over wide expanse of land area, with small holding ranging from 0.05 to 3.0 hectares per farm land, rudimentary farm systems, low capitalization and low yield per hectare (Kassali *et al*., 2009: Kolawole and Ojo, 2007; Ojo, 2004).

Agricultural production requires resources that are limited in supply (Adegeye and Dittoh, 1982). The availability of these resources determines the quantity of output produced (Harwood, 1987). The cost-revenue relationship of the entire production process is influenced by how technically efficient the resources are utilized. Efficient use of farm resources is an important part of agricultural sustainability. One way peasant farmers can achieve sustainability in agricultural production is to raise the productivity of their farms, by improving efficiency in the use of the existing limited resource base and technology (Udoh, 2005). Efficient use of resources is a prerequisite for optimum farm production since inefficiency in resource use, can distort food availability and security (Etim, *et al*., 2005, Udoh and Akintola, 2001).

Agricultural productivity increases are one of the desired outcomes from sensible food security and agricultural policies. Increased productivity might lead to improved welfare of rural populations through several pathways. First, increased productivity leads to higher food availability at the household level. Second, increased food availability leads to lower prices of agricultural products and higher real wages, to the benefit of poor net buyers and wage laborers respectively. Third, a well-performing agricultural sector has important economic multiplier effects on the vibrancy of the off-farm rural economy.

Empirical analysis of technical efficiency of farms in Nigeria has been determined by several authors (Udoh and Akpan, 2007; Udoh 2006; Etim *et al*., 2005; Udoh, 2005; Ajibefun, 2003). These studies showed a mean efficiency value of about 69%, meaning that production can still be increased by 31% on the average using the available technology. The implication here is that there is scope for additional increases of output from existing hectares of farms (including vegetable farms), if resources are properly harnessed and efficiently allocated.

Although rain fed agriculture is the most common practice in Nigeria as more than three quarters of the country's agricultural area is rain fed and subsistence in nature. However, rain fed agriculture can no longer cope with the increasing food demand throughout the year as a result of growing population coupled with climate

change. This made rain fed agriculture unreliable as well as unpredictable and therefore has to be supplemented by irrigation for effective agricultural production to be realized.
Vegetables are widely cultivated in most part of sub-Sahara Africa, as a cheap and reliable source of protein, vitamins, zinc and iron as well as providing an extra income to the farmers. Dry season production of vegetables in Jere LGA (Local Government Area) is common along the river bank that cut across cities and towns. Dry season production of vegetables in the study area has been a source of employment and income to the farmers for decades. Vegetables constitute between 30% and 50% of iron and vitamin A in resource poor diet (Sabo and Dia, 2009). Hence' it is widely consumed by every household in Nigeria irrespective of socio-economic status of the individual. Despite the importance vegetables play in human diets, research information on the resource use efficiency of dry season vegetable production is limited as compared with cereals and legumes. Hence, this study becomes crucial in examining the resource use efficiency in dry season vegetable production.

2. Theoretical Framework

The modeling and estimation of production efficiency of a farm relative to other farms or to the best practice in an industry has become an important area of economic study. Productivity is generally measured in terms of the efficiency with which factor inputs, such as land, labour, fertilizer, herbicides, tools, seeds and equipment etc are converted to output within the production process (Umoh and Yusuf, 1999). Ehui and Spencer (1990), identified two measures of productivity namely, partial productivity and total factor productivity (TFP). Partial productivity is measured as the ratio of output to a single output. The ratio of output to all inputs combined is the total factor productivity.
Generally, two approaches are used in measuring TFP. These are the growth accounting or index number approach and the econometric or parametric method. The econometric method is based on an econometric estimation of the production function or the underlying cost or profit function. The growth accounting approach involves the development of indices of output and input and the computation of non-parametric factor productivity measures. In this study, the production function was used to measure the productivity (or resource-use efficiency of the vegetable farmers).
From the production function, we derived the conventional neoclassical test of economic efficiency. The rule of this test is that the slope of the production function (MPP) should be equal to the inverse ratio of input price to output price at the profit maximization point following Goni *et al.* (2007). This is given as:

$$MPP_{xi} = \frac{P_{xi}}{P_y} \quad \ldots\ldots (1)$$

Where:
Px_i = the price per unit of resource input used
P_y = the output (vegetable) price
MPP_{xi} = the marginal physical product of resource input used

$$MPP \times P_y = MVP \quad \ldots\ldots (2)$$

$$\frac{MVP}{MFC} = k \quad \ldots\ldots (3)$$

Where:
MVP = marginal value product
MFC = marginal factor cost
K = numerical constant
In an attempt to substitute the efficiency hypothesis, focus was centered on the estimated value of k and its closeness to unity. Efficiency is attained if:

$$MVP = MFC \quad \ldots\ldots (4)$$

3. Methodology

The data for the study were obtained from primary source with the aid of a structured questionnaire using the interview schedule. The study uses multi-stage sampling technique to select the sample respondents. In the first stage five, (5) wards were purposively selected out of the twelve (12) wards in the area based on the intensity of vegetable production. These wards include Gongolon, Alau, Zabbarmari, Dusuman and Lawanti wards. In the second stage, 20% of the vegetable farmers in each of the five (5) wards were randomly selected making a sample size of 100 respondents.

Method of Data Analysis

The analytical technique employed was production function analysis. This was used to obtain the parameters for the measurement of resource use efficiency of the vegetable farmers. Four functional forms were tried and the lead equation was selected based on economic, econometric and statistical criteria including the signs and magnitude of the coefficient, the magnitude of R^2, F-statistics (Umoh and Yusuf, 1999; Gujarati, 1999). The functional forms experimented with were: linear, Double Log, Semi-log and Exponential. The implicit function can be presented as:

$Qv = f(X_S, X_L, X_F, X_{fL,} X_{hL})$………………………………………………….… (5)

(Olayide and Heady, 1982; Olukosi and Ogungbile, 2005)

Where

Q_r = Output of vegetable (kg/hectare)
X_S = quantity of vegetable seed planted (kg/hectare)
X_L = farm size (hectares)
X_F = fertilizer used (kg/hectare)
X_{fL} = family labour (hours/ man days)
X_{hL} = hired labour (hours/ man days)

Table 1: Types of vegetables grown in Jere Local Government Area of Borno State

Types of vegetable	Number of respondents
Tomatoes	68
Pepper	62
Amaranthus	58
Sorrel	40
Cucumber	38
Onion	30
Okra	20
Lettuce	18
Garden egg	12
Total	346

Source: Field survey, 2010. NB: Multiple cropping existed.

Determining Economic Efficiency of Resources Use

The following ratio was used to estimate relative efficiency of resource use (r).

$r = \frac{MVP}{MFC}$ ………………………………………….…………………………..……… (6)

Where:

MFC = Cost of one unit of a particular resource
MVP = value added to vegetable output due to the use of an additional unit of input calculated by multiplying the MPP by the price of output i.e.

$MPP_{xi} \times P_q$……………………………………………………………..... (7)

$MPP_{xi} = dy = b\ Y/x_i$……………………………………………………………….… (8)

(direct elasticity from the double log form)

Decision rule

If r = 1 Resource is efficiently utilized
r = >1 Resource is under-utilized
r = <1 Resource is over-utilized

Economic optimum takes places where MVP-MFC if r ≠1, it suggests that resources are not efficiently utilized. Adjustments could therefore be made in the quantity of inputs used and costs in the production process to restore r = 1.

Determining Technical Efficiency of Resource use

The elasticity of production which is the percentage change in output as a ratio of a percentage change in input was used to calculate the rate of return to scale which is a measure of a firm's success in producing maximum output from a set of input (Farrel, 1957)

$$EP = \frac{MPP}{APP} \quad \text{……………………………………………………………………………} (9)$$

Where:

EP = elasticity of production
MPP = marginal physical product
APP = average physical product
If $\sum$ EP = 1; constant return to scale
EP$\sum$ < 1, decreasing return to scale
EP$\sum$ > 1; increasing return to scale

Table 2: Summary statistic of variables for the analysis

Variables	units	mean	SE	minimum	maximum
Output	kilograms	14278.10	565.87	1090.00	31250.00
Seed	kilograms	8.65	0.37	2.00	18.00
Land	hectare	3.43	0.15	1.00	9.00
Herbicide	litter	2.19	0.11	1.00	8.00
Pesticide	liter	3.29	0.10	1.00	6.00
Fertilizer	kilograms	232.5	11.84	50.00	500.00
Labor	man-day	92.08	2.89	40.00	202.00

Source: Field survey, 2010.

4. Results and Discussion

The influence of production inputs on vegetable output was determined with the aid of production function analysis. On the basis of *a priori* expectations, the statistical significance of the coefficient of determination, the exponential functional form was chosen. Table 3 presents the results of the analysis.

Table 3: Production Function Results for Vegetable Production in Jere L.G.A. of Borno State, Nigeria

	Double Log			Semi-log			Exponential		
Variable	**Coefficient**	**SE**	**T-value**	**Coefficient**	**SE**	**T-value**	**Coefficient**	**SE**	**T-value**
Constant	7.36	0.78	9.42***	8.55	0.16	53.00***	-8002.80	7387.17	-1.08ns
Seed	0.27	0.10	2.76***	0.04	0.01	3.27***	3125.97	930.86	3.36***
Land	0.47	0.14	3.29***	0.12	0.04	2.98***	6217.43	1346.77	4.62***
Herbicide	-0.33	0.13	-2.48**	-0.12	0.05	-2.50**	-2520.60	1237.56	-2.04*
Pesticide	0.26	0.16	1.62ns	0.08	0.05	1.53ns	4554.01	1491.05	3.05***
Fertilizer	0.14	0.11	1.24ns	0.00	0.00	0.76ns	781.55	1071.58	0.73ns
Labour	0.05	0.17	0.28ns	0.00	0.00	0.30ns	269.81	1573.69	0.17ns
R^2	0.46			0.45			0.61		

Source: Field survey, 2010.NB: ***P<0.01, **P<0.05,*P<0.10

Table 3 showed that the value of the R^2 reveals that approximately 61% of the variations in vegetable output in the area were explained by the independent variables. Moreover, seed ($p \leq 0.01$), land ($p \leq 0.01$), herbicide ($p \leq 0.10$) and pesticide ($p \leq 0.01$) significantly affected the vegetable output. Since the coefficients of the double

log function are direct elasticities (Olayide and Heady, 1982), the following can be inferred: a unit increase in the level of seed, land, herbicide and pesticide will led to 0.27, 0.47, 0.33, 0.26, and 0.05 unit increase in vegetable output respectively.
The value of the function coefficient which was 0.86 shows increasing returns to scale (Olayide and Heady, 1982). This suggests that vegetable farmers in the area can increase their vegetable output by employing more of these resources. Similarly, measure of technical efficiency of resource use such as Average Physical Product (APP), Marginal Physical Product (MPP) and Marginal Value Product (MVP) and Marginal Factor Cost (MFC) were also derived (Table 4).

Table 4: Values of Estimates of Efficiency Parameters

Resource	APP	MPP	MVP	MFC	MVP/MFC	Efficiency gap	Divergence %
Seed	481.24	114.58	4232.59	88.06	48.05	4144.53	97.92
Land	1213.62	568.72	21008.52	2000	10.50	19008.52	90.48
Herbicide	1900.78	-617.75	-22819.69	800	-28.53	-23619.69	103.51
Pesticide	1265.26	322.64	11918.32	1200	9.93	10718.32	89.93
Fertilizer	0.08	0.01	0.41	110	0.004	-109.59	-267.29
Labour	45.21	2.08	76.84	400	0.19	-323.16	-4.21

Source: Computed from Field survey, 2009.

The values of the MPP show that the farmers were efficient in the use of seed, more efficient in the use of pesticide and most efficient in the use of land. This suggests that if additional units of seed, pesticide and land were available and accessible, it would lead to an increase in vegetable yield by 114.58, 322.64 and 568.72kg among the farmers respectively. This implies that the farmers were technically efficient in the use of seed, more technically efficient in the use of pesticide and most technically efficient in the use of land.
Of all the resources used, herbicide, fertilizer and labour had the least MPP (-617.75, 0.01 and 2.08 kg in that order). This shows inefficiency in the use of herbicide, fertilizer and labour given the level of technology and prices of both inputs. A resource is said to be optimally allocated if there is no significant difference between the MVP and MFC i.e. if the ratio of MVP to MFC =1 (unit).
Table 2 further revealed that the ratios of the MVP to the MFC were greater than unity (1) for seed, pesticide and land. This implies that seed, land and pesticide were under-utilized while herbicide, fertilizer and labour were over-utilized (less than one). This means that vegetable output was likely to increase and hence revenue if more of such inputs (seed, land and pesticide) had been used. The adjustment in the MVPs for optimal resource use (% divergence) in Table 4 indicates that for optimum allocation of resources more than 97% increase in seed was required, while approximately 91% and 90% increase in land and pesticide respectively were needed. Conversely, herbicide, fertilizer and labour were over-utilized and required approximately 103.51%, 267.29% and 4.21% reduction respectively for optimal use in vegetable production.

5. Conclusion and recommendations

Findings from this study revealed that vegetable farmers in the area were technically inefficient in the use of farm resources. The inefficiency of the farmers may be directly or indirectly linked to high cost of rent on land and / or unavailability of land, high cost of improved seeds, high rate of unemployment and poor extension services. The implication of the study is that technical efficiency in vegetable production in the area could be increased through better use of seed, land, pesticide, herbicide, fertilizer and labour. The improvement in the efficiency among the farmers is the responsibility of the individual farmers, government and research institutions. There should be improvement in extension services delivery. The provision of improved rural infrastructures and enabling policies (such as making available all agricultural inputs required at the right time and affordable prices) among others, are also required in order to enhance efficiency. In addition, there should be policies that encourage the creation of alternative employment opportunities to absorb the excess labour used in vegetable production. Fertilizer was over-utilized probably because vegetable production was done along river bank, and most of the river sides are rich in minerals which improve the soil fertility around and do not require much fertilizer. It is the responsibility of the research institutions to conduct soil test in the study areas to determine the actual level of fertilizer requirements so as to avoid wastage.

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