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RESEARCH ARTICLE

OPTIMIZATION OF RESOURCE USE EFFICIENCY IN SMALLSCALE MAIZE PRODUCTION IN NIGER STATE, NIGERIA

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ABSTRACT

This study determines resource use efficiency in maize production in Niger state, Nigeria. Multi-stage sampling technique was used to elicit data from 200 maize farmers' through administration of pre-tested questionnaire in the study area. Data collection was for 2010 cropping season. Production function analyses which incorporate the conventional neoclassical test of economic and technical efficiencies were used as the analytical technique. Findings revealed that the farmers were inefficient in the use of all the resources. Generally, inputs such as farm size, improved seed, fertilizer and capital items were under-utilized. The results show that there is need to make inputs such as fertilizer and improved seeds affordable and accessible to the farmers so as to improve efficiency. Also policies that encourage the creation of alternative employment opportunities to absorb the excess labour used in maize production in the area should be formulated.

INTRODUCTION

Maize has been in the diet of Nigerians for centuries. It started as a subsistence crop but has gradually wider acceptability among farmers. Maize has now risen to a commercial crop on which many agro-based industries depend on as raw materials. After wheat and rice, maize is the most important cereal in the world, with its origin been traced to central America (Fakorede *et al.,* 1993). A key feature of the Nigerian Agriculture is the dominance of small-scale farms, which constitute an important component of the Nigerian economy. It is a known fact that over 12million farmers, scattered in different ecological zones, engage in the production of a wide variety of arable crop and this is done under traditional subsistence agriculture. Individually, while not exerting much influence, they collectively form an important foundation on which nation's economy rests (Olayemi, 1980; Okuneye, 1988) Resource allocation and productivity are important aspect of increased food production which is also associated with the management of the farmers who employ these resources in production. Furthermore, efficiency in the use of available resources is a major pivot for a profitable farm enterprise and sustainability. Therefore, inefficiency in the use of resources, wrong choice of enterprise combination and cropping system constitute the major constraint to increased food production in Nigeria (Okorji and Obechina, 1985). Despite the fact that the study area is known to have a suitable environmental condition that favours high yielding and quality maize grain than other cereal crops, and its preponderance in maize production in the state with small scale farmers dominating the production, there still exist wide variations in the output level among these farmers, further with most farmers still producing below the potential average yield levels. The question therefore is, why are they producing at low levels of output? And are they efficient and profitable at the levels they operate? Are there problems of management in the allocation of resources, institutional and socio-economic constraints? This study is aimed at answering these questions. Maize being one of the most important staple food crops in the state is of vital concern to agricultural decisions, food security and the overall development of the agricultural sector and the economy. The available studies on the productivity gains in maize production following government investment in agricultural sector suggest little improvement in productivity so the goal of self-sufficiency in food production remains a long term target. Available statistics show no systematic increase in maize yield as measured by

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output per hectare. The yield of the maize improved marginally, particularly between 1999 to 2004, then declined thereafter until 2006 when the oscillating pattern is more evident. Incidentally, the period of 2000 is associated with structural reforms that mainly targeted agricultural sector; this is the period in which maize witnessed a declining trend. This trend raised questions about the efficiency of maize production in the study area even in periods when it experiences favourable weather conditions (Meta-Agro Consult, 2009). Why has the productivity remained low. Most existing studies associated to maize in the state relate to research on maize varieties and technological advancement, the effect of structural reforms and analysis on the relationship between farm size and productivity in small-scale farming; and provide evidence of positive relationship. Inspite of the importance of maize crop in the study area over other cereal crops, empirical studies on efficiency are scanty with not much effort being put in place to improve its production efficiency. Few of such studies (Adamu, 2008) paid particular attention to technical efficiency. The question therefore is, why are they producing at low levels of output? And are they efficient and profitable at the levels they operate? Are there problems of management in the allocation of resources, institutional and socio-economic constraints? This study is aimed at answering these questions. Maize being one of the most important staple food crops in the state is of vital concern to agricultural decisions, food security and the overall development of the agricultural sector and the economy.

These small scale maize producers continue to produce the bulk of the nation's needs. This fact cannot be overlooked. Some evidence show that research work on efficient resource use in small scale farming so far, covered only few crops and small geographical areas, thus, resulting in inadequate information (Gani and Omonoma, 2009). Examination of utilization of farm resources of small scale maize farmers is intended to generate empirical information that will give insight into farmers' resources allocation and use in the study area. Studies like this would provide useful information about resource use efficiency in the study area. Effort designed to improve efficiency would be more cost effective than introducing a new technology as a means of increasing output (Udoh, 2005). This study will be useful to policy makers and also serve as basis for further research**.** In-depth research was carried out to assist the farmers in solving their problems and make recommendations that will be useful to policy makers in enhancing efficient allocation of resources in small scale farming, because without rapid development in small scale production at grassroots level generally, the hope of achieving long term stable economic growth and significant reduction in absolute poverty level will be minimal. Furthermore, it will provide information on Niger state agriculture in particular and Nigerian agriculture in general.

Production Function in Efficiency Studies

The modeling and estimation of production efficiency of a farm relative to other farms or 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 (Goni *et al*., 2007).

Umoh and Yusuf (1999), 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 input. 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. In this study, the production function is used to measure the productivity or resources use efficiency of the maize farmers. From the production function, the conventional neoclassical test of economic efficiency was derived. The rule of this test is that the shape of the production function (MPP) should be equal to the inverse ratio of input price to output price at the profit maximization point. This is given as:

$MPP_{Xi} = Pxi/Py$

Where:

Pxi=the price per unit of resource input used
Py= the output price
MPP = the marginal physical product of resource input used
MPP x Py = MVP
MVP/MFC = r

Where:

MVP = marginal value product
MFC = marginal factor cost
r = numerical constant

In an attempt to substitute the efficiency hypothesis, focus is centered on the estimated value of r and its closeness to unity (1). Efficiency is attained if MVP = MFC.

LITERATURE REVIEW

Literature indicates that the output of maize is dependent on production variable such as land, labour, seed, fertilizer, capital and management. Ogar *et al.* (2002) employed production function approach to study allocative efficiency of labour for swamp rice production in Obudu Local Government Area of Cross River State and found that farmers were inefficient in the allocation of labour for land clearing but were efficient in allocating labour for weeding. Goni *et al.* (2007) adopted production function approach to determine the resource use efficiency in rice production in Lake Chad Area, and found that the farmers were technically inefficient in the use of their farm resources. Yusuf *et al*. (2007) in determining the efficiency of resources used in '*Egusi'* melon production in Okehi local Government Area of Kogi State and found that the resources of land, seed and labour were under-utilized. It was also employed by Muhammad and Ahmed (2007) in mushroom production, and found that plot size, substrate and labour were all under-utilized. Oniah *et al.* (2008) also adopted production function approach to determine the efficiency of resource use in small scale swamp rice production in Obubura Local Government Area of Cross River State and found that the farmers were allocatively inefficient in their resource use and more so these resources were under-utilized. Haruna *et al.* (2009) in studying resource use efficiency in Cotton production in selected Local Government Area of Zamfara State and found that the farm resources were not efficiently utilized. Furthermore, the method was employed by Baiyegunhi *et al.* (2010) used production function approach to determine resource use efficiency in sole sorghum production in three villages of Kaduna State and found that the farm resources were inefficiently utilized for sole sorghum production by small and large scale farmers. Stephen *et al.* (2010) employed production function approach to determine resource use efficiency in cowpea production in the North-East Zone of Adamawa State and found that the farm resources of seed and pesticides were under-utilized, while family and hired labour were over-utilized. Yusuf *et al.* (2010) adopted this method in economic evaluation of improved maize variety (SRV) production in Sabon-Gari Local Government Area of Kaduna State and found that the resources of farm size, labour and seed were under-utilized. Tsado *et al.* (2010) also used this method in assessing the economics of millet production in Wushishi Local Government Area of Niger State and found that resources of land, labour and fertilizer were under-utilized while agrochemical was over-utilized. Jidda *et al.* (2010) also used this method to study the resource use efficiency in millet production in Borno State, and found that farmers were inefficient in the use of all resources considered.

MATERIALS AND METHODS

Study Area

This study was based on the farm level data on small scale maize farmers in Niger State, Nigeria. Niger State is in the North-central part of Nigeria and lies in between longitude 3^0 30^1 and 7^0 20^1 east of the Greenwich Meridian and latitude 8^0 20^1 and 11^0 30^1 north of the equator .The land area is about 80,000 square Kilometre with varying physical features like hills, lowland and rivers. The state enjoys luxuriant vegetation with vast Northern guinea savannah found in the north while the fringe (southern guinea savannah) in the southern part of the state. The people are predominantly peasant farmers cultivating mainly food crops such as yam, cassava, maize and rice for family consumption, and markets.

Sampling technique and Data Collection

The data for the study was drawn from primary source with the aid of well structured questionnaire. The questionnaires were administered to 200 maize famers selected through multistage sampling procedure. The first stage involved the purposive selection of one Agricultural zone out of the three Agricultural zones in the state, namely, Kuta for its prominence in maize production. In the second stage, two local government areas, namely Bosso and Chanchaga were purposively selected due to preponderance of small scale maize producers. The third stage involved random selection of five villages from each LGAs. Finally 20 respondents were drawn from each of the villages, thus, given a total sample size of 200 respondents'.

Method of Data Analysis

The analytical procedure employed was production function analysis. This was used to obtain the parameters for the measurement of resource use efficiency of the maize farmers. Four functional forms were tried and the lead equation was selected based on economic, econometric and statistical criteria including signs and magnitudes of the coefficients, the magnitude of R2, T-statistics, F-statistics (Goni *et al*., 2007). The function experimented with were linear, semi log, double log and exponential.

Model specification: The implicit function can be presented by the following equation:

Y= f(X1,X2,X3,X4,X4,X5,X6,X7) ………………….. (1)

Where:

Y = Output of Maize (kg)
X_1 = Farm Size (in hectares)
X_2 = Quantity of seed (kg)
X_3 = Family labour used (in manday)
X_4 = Hired labour used (in manday)
X_5 = Fertilizer used (kg)
X_6 = Herbicides (litres)
X_7 = Depreciation on capital inputs (in naira)

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 = MPP/APP

Where:

EP = elasticity of production
MPP = marginal physical product
APP = average physical product

If

EP =1: constant return to scale
EP < 1: decreasing return to scale
EP > 1: increasing return to scale

Determining the Economic Efficiency of Resource use

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

r = MVP/MFC

Where:

MFC = unit cost of a particular resource
MVP = value added to maize output due to the use of an additional unit of input, calculated by multiplying the MPP by the price of output. i.e. MPPxi x Py

Decision rule

If r = 1, resource is efficiently utilized,

if r > 1, resource is underutilized, while,
if r < 1, resource is over utilized.

Economic optimum takes place where MVP = MFC. If r is not equal to 1, it suggests that resources are not efficiently utilized. Adjustments could be therefore, be made in the quantity of inputs used and costs in the production process to restore r = 1 and the model is given as follows:

Divergence % = (1-1/ri) x100 or [(ri-1)/ri] x100

RESULTS AND DISCUSSION

Estimated Maize Production Function

Table 1 shows the multiple regression estimates of the four functional forms that were fitted into the production function models. The lead equation was chosen based on the value of the coefficient of multiple determination (R^2), the signs and significance of the regression parameters, t-statistics and F-ratio. The double-log production function provided the best line of fit and was selected considering the *apriori expectations* as explained above. The regression results indicate that about 90 percent (R^2) of the variation in the output of maize is jointly explained by the explanatory variables included in the model. The remaining 10 percent not explained by the explanatory variables which could be attributed to the error or random disturbance in the model. The F-ratio of 56.615 was significant at 1 percent level, implying that the explanatory variables included in the model have strong explanatory power. The F-ratio is a measure of joint significance of all the explanatory variables.

Table 1. Multiple Regression Estimates of Maize Production Function

Variable	Linear	Exponential	Double log (+)	Semi –log
Constants	-15756.43	4.470	4.184	60413.878
	$(-1.537)^{ns}$	(42.51) ***	(2.66) **	$(0.29)^{ns}$
Farm size	18074.67	0.942	0.487	13148.246
	(2.58) **	(13.13) ***	(2.64) **	$(0.55)^{ns}$
Improved Seed	18798. 28	0.274	0.491	20745.201
	(3.86)***	(5.49) ***	(4.30) ***	$(1.39)^{ns}$
Family labour	-4.441	-9.01E-005	-0.173	-10836.050
	$(-1.51)^{ns}$	(-2.99) ***	(-2.57) **	$(-1.24)^{ns}$
Hired labour	-1.458	2.04E-005	-0.053	12027.468
	$(-0.25)^{ns}$	$(0.35)^{ns}$	$(-0.83)^{ns}$	$(-1.43)^{ns}$
Fertilizer	-118.863	0.000	0.228	-7805.726
	(-2.13) **	$(0.23)^{ns}$	(1.18) *	$(-0.31)^{ns}$
Herbicides	5.005	0.000	-0.049	6806.446
	$(0.81)^{ns}$	$(1.79)^{ns}$	$(-0.77)^{ns}$	$(0.82)^{ns}$
Capital	0.828	0.000	0.626	20295.282
	$(0.23)^{ns}$	(3.061) ***	(2.85) ***	$(0.71)^{ns}$
R^2 Value	0.341	0.889	0.900	0.377
R^2 Adjusted	0.314	0.884	0.884	0.278
No. of Sgn	3	4	5	0
F –ratio	12.433***	191.25***	56.615***	3.809***

Source: Field survey 2010 *** ** * = significant at 1 percent, 5 percent and 10 percent level of probability respectively.
NS: Not significant; ( ): t – ratio computed; and +: lead equation

It could be seen from Table 14 that the intercept was positive, implying that about 4.184kg could be obtained at zero commitment of variable inputs included in the model. The regression coefficient with respect to most of the explanatory variables were positive except for family labour (X_3), hired labour (X_4) and herbicides (X_6) which were negatively signed. One unit increase in any of the positively signed inputs would increase maize output by proportion corresponding to the regression co-efficient of the variable in question, all other inputs held constant. It should be noted however, that hired labour and herbicides were not statistically significant and need no further explanation. In various studies conducted by Oluwatayo, *et al.* (2008), Yusuf, *et al.* (2010), farm size, seed, fertilizer, capital input were found to have positive coefficients. But the negative sign of family and hired labour is contrary to the finding of Oluwatayo, *et al.* (2008), who reported positive relationship of family and hired labour. More so, unit increase in any of the negatively signed inputs would decrease maize output by a proportion corresponding to the regression coefficient of the variable in question, *ceteribus paribus*.

Elasticity of Productive Resource and Return to Scale

Since the co-efficient of the double log function is the elasticity, the following can be inferred from Table 1 and presented in Table 2. Capital was found to be the most important determinant of maize output in the area. The sum of elasticities of 1.557 was obtained. This value being greater then unity, means that the farmers are operating at the region of increasing- returns to scale. Increasing returns portrays a case whereby an additional unit of input results in a larger increase in product than the preceeding unit. This suggests that maize famers in the area can increase their output by increasing the use of some of these key resources. Yunus *et al.* (2010).Shu'aib *et al.* (2010) and Jidda *et al.* (2010) obtained similar results. This requires re-allocation of existing resources optimally to maximize returns.

Table 2. Estimated Elasticities of Production Resource and Returns to scale

Variables	Elasticities of Production
Farm size	0.487
Improved Seed	0.491
Family labour	-0.173
Hired labour	-0.053
Fertilizer	0.228
Herbicides	-0 .049
Capital	0.626
Return to scale	1.56

Source: Field survey, 2010

Estimates of Technical Efficiency for Resource-use

Measures of technical efficiency of resources such as Average physical product (APP), Marginal physical product (MPP) and Marginal value product (MVP) and Marginal factor cost (MFC) were derived and the results presented in Table 3. The values of the MPP showed that the famers were more efficient in the use of land than other resources. This suggests that if additional one hectare is available, it would lead to an increase in maize production / yield by 691.78 kg among the farmers. This implies that the farmers are more technically efficient in the use of land. Of all the resources used, family labour had the least (-0.865kg). This shows inefficiency in the use of available family labour, hence the need to reduce it.

Table 3. Estimates of Technical Efficiency for Resource-use

Resource	Mean	APP	MPP
Farm size(ha)	1.88	1420.49	691.78
Improved seed(kg)	33.89	78.49	38.68
Family labour(md)	534.08	5	-0.865
Fertilizer(kg)	112.99	23.25	5.3
Capital(₦)	1059.66	2.52	1.58

Source: Computed from lead equation (+)
APP: Average Physical Product.
MPP: Marginal Physical Product

Estimates of Allocative Efficiency

Given the level of technology and prices of both input and outputs, efficiency of resource use was further ascertained by equating the MVP to the productive MFC of resources. A resource is said to be optimally utilized if there is no significant difference between the MVP and MFC, that is if the ratio of MVP to MFC = 1 (unit). Table 4 reveals that the ratios of the MVP to the MFC were greater than unity (1) for all the input except family labour. This implies that farm size, seed, capital and fertilizer were under-utilized, while family labour was over-utilized (less than one). However the use of family labour was not rational given the negative ratio. This means that maize output was likely to increase and hence revenue if more of such inputs (farm size, seed, capital, fertilizer) are used, and decrease in the use of family labour, thereby attaining optimal allocative efficiency.

The underutilization of farm size and seed was earlier reported by Yusuf *et al.* (2010), while the under-utilization of capital in this study contradicts Ahmed (2009), in which the input was over utilized. Oluwatayo *et al.* (2008), reported over-utilization of family labour in their studies. This over-utilization of family labour could be attributed to the fact that it is free and readily available. The adjustments in the MVP for optimal resource (% divergence) in Table 16 indicates that for optimum allocation of resources, 91.5% increase in farm size is required, while approximately 90% and 91% increase in fertilizer and seed respectively is required. Similarly, 99% increase in capital is needed. Family labour was over utilized, and required approximately 370% reduction for optimal use in maize production.

Table 4. Estimated Allocative Efficiency Ratio (r)

Variable	Mean	MVP =MPP*Py	Px=MFC	MVP/MFC	Divergence %
Farm size (kg)	1.88ha	58801.3	5000	11.76	91.5
Improved seed (kg)	33.89kg	3287.8	300	10.96	90.9
Family labour (md)	534.08	-73.53	200	-0.37	370
Fertilizer(kg)	112.99kg	458.04	46	9.97	89.97
Capital(₦)	₦1059.66	134.30	1.18	113.8	99.1

Source: Computed from lead equation (+)

Conclusions and Recommendations

Findings from this study revealed that maize fanners were technically inefficient in the use of farm resources. The inefficiency of the farmers may be directly or indirectly linked to the high cost of Improved seeds, fertilizer and capital items. The implication of the study is that technical efficiency in maize production in the study area could be increased through better use of fertilizer, land and improved seeds. 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 maize production.

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