American Journal of Experimental Agriculture
6(5): 290-304, 2015, Article no.AJEA.2015.087
ISSN: 2231-0606

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Resource-Use-Efficiency among Smallholder Groundnut Farmers in Northern Region, Ghana

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Authors' contributions

This study was carried out in collaboration between all authors. Author GDA designed the study, performed the statistical analysis, and wrote the first draft of the manuscript. Author AMD and GASB were in charge of collection and management of the data. Author AMD managed the literature search whilst GASB streamlined the analysis of the study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2015/14924
Editor(s):
(1) Chrysanthi Charatsari, Department of Agricultural Economics, School of Agriculture, Aristotle University of Thessaloniki, Greece.
(2) Anonymous.
Reviewers:
(1) Balde Boubacar Siddighi, The United Graduate School of Agricultural Sciences, Tottori University. Bioproduction Science, Managerial Economics. Tottori University, Japan.
(2) Nguyen Khac Minh, Water Resources University, Vietnam.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=867&id=2&aid=7462

Original Research Article

Received 28th October 2014
Accepted 1st December 2014
Published 26th December 2014

ABSTRACT

The study analyses the efficiency of resource use by collecting cross-sectional data from 120 groundnut farmers in the Tolon district of the Northern region, Ghana, during 2013 major cropping season. It focuses on identifying the determinants of groundnut output growth, measuring the technical efficiency level of the farmers as well as how efficient farmers are with respect to the allocation of their inputs. The stochastic frontier analysis *(SFA)* was employed to examine the determinants of output and measure the technical efficiency level of farmers while the marginal value product marginal factor cost *(MVP-MFC)* approach was used to ascertain whether farmers are efficiently allocating their resources or not. The results from the stochastic frontier analysis indicated that labour and quantity of seeds exerted significant and positive effects on groundnut output whilst the area of land allocated to groundnut cultivation had negative and significant effect on groundnut output. Groundnut farmers in the study area had a mean technical efficiency score of

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about 84% indicating an output loss of 16% due to inefficiency. Various sources of efficiency include; education, farming experience, household size, membership of farmer-base-organization and farmers contact with extension personnel. Allocatively, farmers were over-utilizing labour and seeds sown while under-utilizing quantities of herbicides. The study therefore recommends that an effective farm level training programmes for rural farmers through an effective extension services could increase farmer's efficiency level and hence increase their profit level.

Keywords: Stochastic frontier analysis; marginal value product marginal factor cost; technical efficiency; resource-use-efficiency; groundnut farmers; Tolon district; Ghana.

1. INTRODUCTION

According to Government of Ghana (GoG) report [1], agriculture is a vital development tool employing about 70 percent in formal and informal sector of the economy. It has accounted for an average of about 30 percent of Gross Domestic Product (GDP) in the past decade and contributed to about 60 percent of export earnings. The main driving force behind this immense contribution of agriculture is the crop sector (including cocoa) accounting for about two-thirds of the agricultural sector. Bresinger et al. [2] reported that staple crops such as maize, yam, plantain, cassava, rice, sorghum, groundnuts and oilseeds dominate the agricultural crop sector with other crops such as vegetables and fruits contributing moderately to the overall crop sector growth.

Despite such significant roles, crop productivity in Ghana has remained low. Growth in agricultural output over the years has come as a result of increase in land under cultivation rather than improvement in yields. Studies in Ghana and other parts of Africa have shown that most farm yields are lower than their achievable yields with sufficient farm management practices. For instance, in Kenya, evidence shows yield gaps of 67% for maize, 78% for groundnuts and 67% for sorghum [3]. Moreover, the average yield of rice, groundnut, yam and maize in Ghana are estimated at 2.4 mt/ha, 1.5mt/ha, 15.3 mt/ha and 1.7mt/ha respectively whereas the potential have been estimated to be 6.5 mt/ha, 2.5 mt/ha, 49 mt/ha and 6 mt/ha respectively [4]. Biophysical factors, input utilizations, socio-economic factors, management practices, climatic conditions, policy and institutional constraints as well as inadequate efforts to transfer technological knowledge and market information asymmetry were identified as some of the major reasons ascribed to these yield gaps. According to Rockstrom et al. [5], low performance of rain-fed crop cultivation is not necessarily due to low physical potential, but largely to management related issues. Thus, most smallholder crop farmers in sub Saharan Africa (SSA) engage in subsistence agriculture using traditional method of production probably because most modern technologies and innovations are not accessible to them.

Groundnut (*Arachis hypogaea* L.) is one of the most agronomical important food legumes grown in the northern parts of Ghana. Many producers and consumers depend on this leguminous crop for their livelihood and nutritional value. Groundnut is considered as the 3[th] most important source of vegetable protein, 4[th] most important source of edible oil and 13[th] most important food crop in the world [6]. According to Girei et al. [7], groundnut seeds contain 50% high quality edible oil, 25% digestible protein and 20% carbohydrates. Its flour is use as ingredient in soup, confectioneries and pudding. Groundnut also provides high quality fodders and feeds for livestock, help in weeds control and soil water conservation. It also improves soil fertility by adding some organic matter into the soil and fixes atmospheric nitrogen into the soil.

In spite of the numerous uses of groundnut, availability of abundant land and human resources in the northern sector of Ghana; average yield per hectare for groundnut production has been on the decline over the years. It has been documented that the achievable yield of groundnut is 2.5 mt/ha with the average yield produced currently being 1.5 mt/ha [4]. The implication is that there is a gap for additional increase in output from the existing production level of groundnut. Therefore, it is of immense importance to overturn the preceding situation with the view to improving productivity and resource use among producers through the investigation of determinants of output and how various factors of production are allocated. It is against this background that the study intends to examine the resource-use-efficiency among groundnut producers in the Northern region of Ghana.

The remaining sections of this paper are presented as follows: Following this section is the presentation of the theoretical and empirical literature. The study area and the methodology are also described. The methodologies include a brief overview of the theoretical framework, sampling technique and data collection as well as the empirical model. The ensuing two sections present the results of the empirical findings and the conclusions as well as the policy recommendations.

Literature Review

The conventional notion of efficiency can be credited to the prominent works of Farrel [8] who suggested that; technical, allocative and economic efficiencies constitute the main components of efficiency. Farmers ability to achieve a maximum output given similar input levels measure their technical efficiencies whilst the optimum use of these inputs up to the level at which their marginal value of productivity is equal to the marginal factor cost is referred to as allocative efficiency. However, technical and allocative efficiencies are the main components of economic efficiency. There are two main ways of estimating efficiency of a firm, parametric and non-parametric [9-12]. The parametric can be categorized into two main components namely; the deterministic frontier models and the stochastic frontier models. The most common non-parametric approach is the data envelope analysis (DEA).

The parametric method of estimation involves the econometric modeling of production frontier. The parametric accounts for measurement errors in both output and stochastic elements by decomposing the effects of noise from the inefficiency effects. It also allows the conventional statistical test to be carried out. Unlike the parametric, the non-parametric method has the ability to measure efficiency of multi-output cases and requires no functional form to specify the relationship between inputs and outputs [10,13]. The main goals of resource use efficiency measurement is to find ways of increasing output per unit input and attaining desirable transfer of factors of production in other to raise our economic standard of living. Many authors have analyzed the efficiency of resource use in the agricultural sector by using farm level data from many parts of the world.

Taphee and Jongur [14] used Cobb-Douglas stochastic frontier analysis to analyze the productivity and technical efficiency of groundnut production in northern Taraba state, Nigeria. The empirical results showed that farm size, quantity of fertilizer, quantity of seeds and family labour were the key determinants of groundnut production in the study area. Moreover, the inefficiency component of the groundnut production in the study area was attributed to the age of the farmer, farmers contact with agricultural extension officers as well as the size of the family. Korir et al. [15] examined the determinants of Bambara groundnut production in Western Kenya using the stochastic frontier analysis found out that farmers farm size, amount of labour used and quantity of seeds were the major factors influencing groundnut production in the study area. The empirical results also indicated that, on the average, groundnut farms in the study area could increase their output by 61.58 percent using the same input level. That is, the study found the mean technical efficiency to be 38.42 percent. Shehu et al. [16] in analyzing the determinants of production and technical efficiency among yam farmers in Benue State, Nigeria showed that land area, fertilizer utilization, quantity of seeds and family labour were the major inputs influencing the production of yam in the study area. The empirical results also predicted yam farmer’s efficiency to range between 67 percent and 99 percent with the mean efficiency level of 95 percent. Possible explanations to the variation of efficiency were attributed to factors such as educational attainment, membership of farmers association and household size. In a similar study conducted by Addai and Owusu [17] using stochastic transcendental (translog) production frontier to analyze the technical efficiency of smallholder maize farmers across the various agro-ecological zones of Ghana revealed that farm size and labour are the major factors influencing the production of maize in Ghana. Abdulai et al. [18] estimated the technical efficiency of maize production in Northern Ghana. Another study on the determinants of production and technical efficiency among cotton farmers in the Northern part of Ghana was conducted by Adzawala et al. [19]. The transcendental (translog) production frontier was used to estimate the production function. The empirical results revealed that farm size, labour and fertilizer utilizations are the main determinants of cotton production in the Northern part of Ghana.

Apart from the physical input factors that contribute to farmer’s level of production and efficiency, there are socio-economic, demographics, institutional and environmental factors that affect farmer's efficiency level [20]. These factors include age, sex, marital status, household size, educational attainment, access to credit, engagement in off-farm income, land tenure system, membership of farmer based organizations, farmers contact with extension officers, etc.

Educational attainment enhances farmer's managerial and technical skills. It is hypothesized to increase farmer's ability to synthesized information and utilize the existing technologies to attain high efficiency levels [8]. However, Owour and Shem [21] have shown negative relationship between education and farmers efficiency levels. This was in variance with a study by Donkoh et al. [22] on efficiency of irrigated rice farmers in Northern Ghana. They observed that farmers with more years of formal education tend to be less technically inefficient than their counterparts with less years of formal education. It was also indicated in the same study that male farmers are more technically efficient than female farmers. A study by Diiro [23] to examine the impact of off-farm income on technical efficiency of maize farmers in Uganda concluded that farmers engaging in off-farm economic activities are less technically efficient than farmers with no off-farm income. Credit availability enables farmers to purchase adequate inputs and on timely manner and hence expected to increase farmers level of efficiency. The positive relationship between credit accessibility and farmers efficiency level was empirically supported by Chukwuji et al. [24] in analyzing the technical efficiency of farmers in Delta State, Nigeria. Asante et al. [25] in analyzing the effects of NERICA rice adoption on technical efficiency of rice farmers found household size, farmers contact with extension officers and access to road network to have positive influence on the farmer's level of efficiency.

Resource-use or allocative efficiency has been documented in many agricultural related literatures. Taru et al. [26] analyzed the economic efficiency of resource use among groundnut farmers in Nigeria. The empirical results indicated that the ratio of marginal value productivity to marginal factor costs for quantity of seeds and labour were greater than unity indicating under utilizations of these resources. Another study conducted by Maikasuwa and Ala [27] in determining profitability and resource-use efficiency of yam production by women in Bosso local government area of Niger state, Nigeria, observed that fertilizer, labour and land were under-utilized. The under-utilization of fertilizer, land use and labour were also in line with a study conducted to examine the resource use efficiency of rice farmers in Jere local government area of Borno state, Nigeria by [28]. Another study conducted by Baiyegunhi et al. [29] in examining efficient allocation of resources among individual farms of different sizes in sorghum production in Kaduna state of Nigeria concluded that farm resources were inefficiently utilized for both small and large scales farmers. However, the study observed that quantity of seeds and fertilizers were under-utilized while the amount of labour employed was over-utilized.

2. METHODOLOGY

2.1 Study Area

The study was conducted in Tolon District in the Northern Region of Ghana, the largest region in the country in terms of land mass, constituting about 30% (70,390 km^2) of the total land area of the country. Tolon district shares borders' with North-Gonja to the west, Kumbugu district to the north, Central-Gonja to the south, whilst Tamale Metropolitan and Savelugu/Nanton District share the eastern boundaries with it. The district covers a total land mass of 2,741km^2 forming about 3.9% of the entire area of the Northern Region. The major economic activities are agriculture and its related works. The vegetation cover is basically Guinea Savanna interspersed with short drought resistant trees and grassland. The land is generally undulating with a number of scattered depressions. The soils are generally of the sandy loam type except in the low lands where alluvial deposits are found and support the cultivation of crops like groundnut, yam, cowpea, millet, sorghum, rice etc. The major tree species in the district include the sheanut, dawadawa, mango, which are economic trees and form an integral part of livelihood of its people.

2.2 Sampling Procedure and Data Collection

The information for the analysis was obtained from a cross-sectional primary data through an objective oriented structured questionnaire. The selection of the groundnut farm households followed a two-stage systematic random sampling. In the first stage, four groundnut producing communities (Tolon, Yogu, Nyankpala and Tali) were randomly selected from the list of major groundnut producing communities in the district. The second stage involved a random selection of one hundred and twenty (120) farm households across the four communities.

2.3 Analytical Technique

The study adopts the stochastic frontier analysis (SFA) and marginal value productivity-marginal factor cost (MVP-MFC) approach to achieve its objectives. The SFA was used to measure the ability of groundnut farmers to use a minimum quantity of inputs under a given technology to achieve a maximum level of output (Technical efficiency) while the MVP-MFC was used to measure their ability in achieving the best combination of different inputs in producing a given level of output considering the relative prices of these inputs (allocative efficiency). Thus, efficiency analysis in this study has been decomposed into two; technical and allocative efficiencies as documented in the literature of agricultural production efficiencies. Technical inefficiency arises when observed output from a given input mix is less than the frontier output. Allocative inefficiency arises when farmers fail to equalize their marginal returns with the true input market prices.

2.3.1 The SFA analysis

In stochastic frontier analysis, the farm is constrained to produce at or below the deterministic production frontier. The approach is preferred for efficiency studies in agricultural production due to the inherent stochastic nature of the agricultural systems. The stochastic frontier production function was independently proposed by Aigner et al. [30] and Meeusen and Van den Broeck [31]. The stochastic production function is defined by;

$$Y_i = f(x_i, \beta) + \varepsilon_i \text{ where } i = 1,2,3...,n \tag{1}$$

$$\varepsilon_i = v_i - u_i$$

Where Y_i represents the output level of the i^{th} sample farm; $f(x_i, \beta)$ is a suitable function such as Cobb-Douglas or transcendental (translog) production functions, x_i is a vector of inputs for the i^{th} farm and β is a vector of unknown parameter. ε_i is an error term made up of two components: v_i is assumed to account for random effects on production associated with factors such as measurement errors in production and other factors which the farmer does not have control over and u_i is a non-negative error term associated with farm-specific factors, which leads to the i^{th} farm not attaining maximum efficiency of production. Thus, u_i measures the technical inefficiency effects that falls within the control of the decision making unit.

Stochastic Frontier Analysis (SFA) has been used recently by many authors such as Donkoh et al. [22], Onumah et al. [32], Abdulai et al. [18], Danso-Abbeam et al. [33] and Onumah and Acquah [34]. The approach specifies technical efficiency of an individual farm as the ratio of the observed output to the corresponding frontier output conditioned on the level of inputs used by the farm. Technical inefficiency is therefore defined as the amount by which the level of production for the farm is less than the frontier output. Technical efficiency (TE) can be specified as;

$$TE = \frac{Y_i}{Y_i^*} = \frac{f(x_i;\beta)\cdot \exp(v_i - u_i)}{f(x_i;\beta)\cdot \exp(v_i)} = \exp(-u_i) \tag{2}$$

Where Y_i or $f(x_i, \beta)\cdot \exp(v_i - u_i)$ is the observed output and Y_i^* or $f(x_i, \beta).\exp(v_i)$ is the unobserved output. According to Battese and Coeli [35], the error term v_i is assumed to be identically, independently and normally distributed with zero mean and a constant variance, $N(0, \sigma_V^2)$. The error term u_i is also assumed to be distributed as truncation of the normal distribution with mean u_i and variance $N(u_i; \sigma_u^2)$ such that the inefficiency error term can be explained by exogenous variables specified as;

$$u_i = Z\delta_i + W_i \tag{3}$$

Where Z_i is a *(1 × M)* vector of explanatory variables, δ_i is an *(M × 1)* vector of unknown parameters to be estimated; and W_i are unobservable random variables. In this study, a single -stage maximum likelihood approach was used to estimate the technical efficiency levels of the groundnut farmers and the determinants of technical inefficiency simultaneously. This simultaneous estimation approach ensures that the assumption of identical distribution of the error term u_i is not violated. The maximum likelihood estimates of the stochastic frontier model provide the estimates of β and the gamma (γ), where the gamma explains the variation of the total output from the frontier output. The gamma estimate is specified as, $\gamma = \frac{\sigma_u^2}{\sigma^2}$, where γ lies between zero and one $(0 \le \gamma \le 1)$, σ_u^2 is the variance of the error term associated with the inefficiency and σ^2 is the overall variation in the model specified as the sum of the variance associated with the inefficiency (σ_u^2) and that associated with random noise factors (σ_v^2). Thus; $\sigma^2 = \sigma_u^2 + \sigma_v^2$.

The closer the value of the gamma (γ) is to one (1), the more the deviation of the observed output from the deterministic output which is as a result of inefficiency factors. However, if the value is closer to zero, then deviations are as a result of random factors and if the value lies between one (1) and zero (0), then deviations are as a result of both inefficiency and random factors.

2.3.2 Allocative efficiency analysis

In other to evaluate the extent to which groundnut farmers in the study area are putting their resources into efficient use, the study adopts the marginal-value-productivity-marginal-factor- cost analysis. This method has been used by many authors (Sienso et al. [36], Gani and Omonona [37], Oladeebo and Ambe-Lamidi [38]), where the marginal value productivities *(MVPs)* for each input used were computed and such computed *MVPs* were then compared with their respective acquisition cost, marginal factor cost *(MFC).*

For transcendental logarithmic (translog) production function, we estimate the factor elasticities (β_i) and the marginal physical products from the *OLS* estimates of the translog production function with respect to each input used. We then use the β_i and the *MPP* to compute *MVP* and *RUE* as shown in equation [4, 5, and 6] below.

$$MVP = MPP \cdot P_Y \tag{4}$$

Where

$$MPP = \beta_i \cdot Y_i / X_i \Rightarrow MVP = \left(\beta_i \cdot Y_i / X_i\right) \cdot P_Y \tag{5}$$

Where Y_i is the mean groundnut output of the i^{th} farmer, X_i is the mean input used and P_Y is the price of output. The resource-use-efficiency *(RUE)* of each of the measurable input used in groundnut production was computed by the ratio of the marginal value of productivity *(MVP)* to that of the marginal factor cost *(MFC).* Thus,

$$RUE = \frac{MVP}{MFC} \tag{6}$$

Where *RUE* denotes resource-use-efficiency and *MFC* represent the price of the measurable factor inputs at their geometric means.

Decision rule

i. $RUE = 1$, implies that resources are used efficiently by groundnut farmers in the study area.
ii. $RUE > 1$, implies resources are under-utilized and increasing the rate of use of that resource will help increase productivity.
iii. $RUE < 1$, implies resources are over-utilized and reducing the rate of use of that resource will help improve productivity.

2.3.3 The empirical model specification

In estimating the stochastic production frontier function of groundnut production in the study area, we used the transcendental (translog) production function developed by Christensen et al. [39], after a preliminary test of hypotheses had suggested that Cobb-Douglas production function was inadequate representation of the data. The transcendental logarithmic (translog) production function had been used consistently in many recent agricultural efficiency related studies such as [22,32,36].

Following Battese and Coeli [35], the transcendental stochastic frontier model can be expressed as;

$$\ln Y = \beta_0 + \sum_{j=1}^{4} \beta_j \ln X_{ji} + \sum_{j\leq}^{4}\sum_{k=1}^{4} \beta_{jk} \ln X_{ji} \ln X_{ki} + V_i - U_i \quad (7)$$

Where *Y, X_1, X_2, X_3* and *X_4* denotes the output level (kilograms), farm size (acres), quantity of seeds sowed (kilograms), quantity of herbicides (liters) and labour use (man-days) respectively.

The empirical model for the inefficiency model can also be specified as;

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + W \quad (8)$$

Where Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7 and Z_8 are sex of the farmers (categorized as 1 for male and 0 for female), age of the farmer, number of years in formal education, marital status, number of years in farming, household size, farmer belonging to any farmer-base-organization and the number of extension visits respectively. W_i is the error term and δ_i is the vector of parameters to be estimated.

2.3.4 Specification of hypotheses

In estimating the stochastic frontier model for groundnut farmers in the study area, three main null hypotheses were conducted to examine the appropriateness of the specified model used, the absence of inefficiency and the significance of socio-economic factors in explaining inefficiency among groundnut farmers. The three hypotheses are presented as follows;

1. $H_0 : \beta_{ji} = 0$ The coefficients of the square values and the interaction terms in the translog model sum up to zero

   $H_1 : \beta \neq 0$ The coefficients of the square values and the interaction terms in the translog model do not sum up to zero

2. $H_0 : \gamma = \delta_0 = \delta_1 .... \delta_8 = 0$

   There are no inefficiency effects

   $H_1 : \gamma = \delta_0 = \delta_1 ..... \delta_8 \neq 0$

There are inefficiency effects

3. $H_0 : \gamma = 0$

   Inefficiency effects are stochastic

   $H_1 : \gamma \neq 0$

   Inefficiency effects are non-stochastic

These hypotheses were tested by the use of the generalized likelihood-ratio test statistic specified as;

$$LR(\lambda) = -2[\{\ln L(H_0)\} - \{\ln L(H_1)\}] \quad (9)$$

Where $L(H_0)$ and $L(H_1)$ are the likelihood functions under null and alternate hypotheses respectively. If the given null hypothesis is true, then the test statistic (λ) has a chi-square distribution of degree of freedom which is equal to the difference between the estimated parameters under (H_1) and (H_0). However, if the null hypothesis involves $\gamma = 0$, then the asymptotic distribution involves a mixed chi-square distribution [40].

3. RESULTS AND DISCUSSION

3.1 Demographic Characteristics of the Sampled Farm Households

Tables 1 and 2 present the descriptive statistics of the sampled farm households. Out of the 120 household heads interviewed, 90 were females and 30 were males representing 75% and 25% respectively. On the average, there were 12 people per household and the average age of a household head was 35.5 years as indicated in Table 2 below. This indicates a relatively economic active adult population who has the ability to work very hard to increase the productivity level of groundnut in the region and the country as a whole if well aggravated. This is in contrast to a study by (FASDEP II) [41] that stated that Ghanaian farming population is generally old, as farming does not seem to attract the younger population. Moreover, majority (88.3%) of the farming population had primary education (6 years) with only 11.7% being able to attain junior high school and senior high school. Table 2 further indicated that, on the average farmers had been in groundnut farming for about 29 years. In Ghana, over 92% of the farming population farm on small scale [22].

This situation is not different from the one pertaining in the study area, considering the fact that farm size ranges between 1-9 acres with the mean farm size of 2.8 acres. From Table 2, the average total output of groundnut is about 82 kg while mean quantity of groundnut seeds sowed per plot (seed density) was about 44 kg.

3.2 Test of Hypotheses

As indicated in section 2.3.4, the study seeks to test three main hypotheses. The tests of these hypotheses are presented in Table 3. Table 3 indicates that the decision to use Cobb-Douglas frontier function was rejected in favour of transcendental logarithmic (translog) frontier function since the generalized likelihood-test statistic is significantly different from zero. This means that the results from the translog model are more accurate and adequate representation of the data, given the assumptions of the frontier model. The result of the second hypothesis revealed that the frontier production function was more appropriate to fit the data than the average response production function. Moreover, findings from the third hypothesis suggest that inefficiency effects are present in the model so the decision to exclude them was discarded.

3.3 Groundnut Stochastic Frontier Production Function Analysis

Results for the estimation of stochastic frontier production of groundnut in the study area are presented in Table 4 below. The estimated sigma squared of 0.24 indicates a “good fit” and the appropriateness of the specified distributional assumption of the composite error term rather than the average response specification. Gamma measures the level of inefficiency in the variance parameter, that is, the difference between the frontier output and the observed output. The estimated gamma value of 0.83 indicates that 83% variation in groundnut output was due to inefficiency in input use and other farm practices whilst 17% of the deviations of the actual output from the frontier output came from random factors. Some of these factors could be in the form of pest and disease infestation, unfavorable weather conditions and statistical errors in data collection and measurement.

Table 4 also measures groundnut productivity in terms of output elasticities. Output elasticities responded positively to the amount of labour and quantity of seeds used and negatively to the area of farm land allocated to groundnut farming. The results further demonstrated that a percentage increase in the amount of labour and quantity of seeds sown increase groundnut output by 7.84% and 5.84% respectively. These findings are consistent with the results of similar studies conducted recently by Taphee and Jongur [14] and Ani et al. [42]. In the case of farm size, a percentage increase in farm land allocated to groundnut farming decreases output by 7.80%. The inverse relationship between output and farm size could partly be attributed to poor farm management practices. For example, farmers may not effectively combine land with other factors of production such as labour and seeds as they expand their farm lands. This is in contrast to some other studies in other parts of Ghana and other African countries which indicated that, farm size is an increasing function of output [43,36,23,44]. However, some other studies in Ghana by Donkoh et al. [22] and Adzawala et al. [19] found similar results in relation to rice and cotton respectively.

The squared variables in the translog stochastic frontier function indicate the effect of continuous use of that variable on output. The interaction terms indicate a complementarity or substitutability of the inputs employed on the farm. A significant positive coefficient of interaction term means the two variables are complements whilst a significant negative term means the two variables are substitutes. The results indicated that continuous use of quantity of seeds have a negative significant influence on groundnut output whilst the continuous use of land, labour and herbicides have no significant effects on output. Moreover, Table 4 indicates that quantity of labour employed has a significant complementarity with quantity of seeds sown. Similarly, farm land allocated to groundnut farming is complementary to quantity of herbicides used on the farm.

3.4 Level of Technical Efficiencies

Table 5 shows a considerable variation of efficiency index across groundnut farms in the study area. The predicted farm efficiency levels ranged between 20.04% and 98.65%. The mean technical efficiency was estimated to be about 84%. This implies that, the average groundnut farmer in the study area produces about 84% of the potential output given the current technology available. That is, groundnut farmers in the study area produce at a level below 16% of the frontier output. Thus, in the short run, there is enough room for groundnut farmers to increase their production by 16% by adopting new technologies, farm practices and efficient combination of inputs. Similar results have been documented by Taphee and Jongur [14] who estimated the mean technical efficiency of groundnut farmers in Northern Taraba State of Nigeria to be 97%. However, this is far higher compared with the results obtained by Ani et al. [42] who estimated the mean technical efficiency of groundnut farmers in Nigeria to be 3.78%. The findings further revealed that majority (73.33%) of the farmers operated with technical efficiency level of 70% and above, whilst only few (14.16%) had technical efficiency level of 50% and below.

3.5 Determinants of Technical Inefficiency

The results presented in Table 6 identify the sources of variation in technical efficiency estimates. The variables used in the technical inefficiency model are the determinants of technical inefficiency rather than efficiency. This implies that a positively signed variable reduces technical efficiency level whilst a negatively signed variable increases technical efficiency level.

The coefficient of education was negatively signed and significant at 10% indicating that farmers who had more years of formal education were more technically efficient than their counterparts with less years of formal education. Recent studies by Mapemba et al. [45] had established that education is a variable that sharpens farmers' managerial skills and hence, improves their efficiency level. Similar result was documented by Asante et al. [46]. Farmer's level of experience also had a negative sign signifying an increasing function of technical efficiency. This could partly be attributed to the fact that farmers with longer years in farming are able to draw from their past experiences to suit their farming practices and conditions. The negative and significant coefficient of frequency of extension visit suggests that farmers who have the opportunity to frequent extension services reduce their level of technical inefficiency. Thus, increasing the frequency of extension contacts with farmers by a unit reduces their level of inefficiency by 0.27 units. Other researchers such as Parkh et al. [47] and Seyoum et al. [48] have documented similar findings.

The coefficient of household size exhibits a negative function of farmer's efficiency level as it is positively signed and significant at 5%. The size of the coefficient indicates that farmers with larger family size are less technically efficient than their counterparts with smaller family size. Thus, increasing farm household size by a percentage increases farmer's inefficiency level by 0.155%. This is contrary to our *a priori* expectation that farmers with larger family size will have more family labour which may in turn increase their level of efficiency. The possible explanation is that farming and for that matter groundnut cultivation is not the only economic activity performed by the farmers in the study area; therefore household labour may allocate more of their time to other farming and non-farming activities. Ani et al. [42] also found household size to have positive influence on technical inefficiency of groundnut farmers in Benue State, Nigeria.

The coefficient of farmer-base-organization has negative significant effect on farmer's technical efficiency level. That is, members of farmer-base-organization are less technically inefficient than non-members of farmer-base-organization. This could be due to the fact that farmer-base-organization members receive input and support services from many donors and NGO's. The results of the study oppose to the one conducted by Addai et al. [49] who documented that there is no significant difference in terms of technical efficiency between members and non-members of farmer-base-organization.

In contrast to other studies like Addai et al. [49] and Donkoh et al. [22], age and sex were estimated in this study to have no significant influence on inefficiency level of groundnut production. While Addai et al. [49] concluded that older farmers are less technically inefficient; Donkoh et al. [22] stressed that male farmers are technically more efficient than their female counterparts.

3.6 Resource-use-efficiency Estimation

In this study, resource-use-efficiency of groundnut farmers was measured by the ratio of the marginal-value-productivity *(MVP)* of each input used to their respective prices. Thus, the marginal-value-productivity is the yardstick for judging how resources are allocated. Inputs are said to be well allocated under pure competitive condition when there is no divergence between their *MVP* and their unit price. The *MVP* for each input was determined by multiplying the *MPP* of each input by the mean price of the groundnut output. In this study, we measured resource-use-efficiency for three inputs namely; seeds, labour and herbicides. Resource-use-efficiency for land was not considered because land is a fixed input and its adjustment depends on long term profitability. The results of the resource-use-efficiency estimations are presented in Table 7 below. The results suggested that all the variable inputs under consideration were not used efficiently.

The ratio of *MVP/MFC* for labour and quantity of seeds were less than unity indicating over-utilization of these inputs, hence increasing the quantity of labour and seeds usage would decrease output and profit level. However, quantities of herbicides were under-utilized with an efficiency score of 3.183. The under-utilization of herbicides may be due to the high cost of herbicides in the study area.

Table 1. Distribution of respondents by demographic characteristics

Variable	Range	Respondents	Percentages
Age	19-29	38	31.7
	30-39	44	36.6
	40-49	22	18.3
	50-59	10	8.3
	60+	6	5.0
	Total	120	100
House hold size	1-9	56	46.7
	10-19	37	30.8
	20-29	23	19.2
	30-39	3	2.5
	40-49	1	0.8
	Total	120	100
Education	1-6	106	88.3
	7-12	14	11.7
	Total	120	100
Male		30	25
Female		90	75

Source: Field Survey, 2014

Table 2. Descriptive statistics of variables

Variable	Minimum	Maximum	Mean	Std. deviation
Sex	0	1	0.73171	0.44488
Marital status	0	1	0.94309	0.23262
Age (years)	19	75	35.46341	10.89239
Educational level (years)	0	12	3.00293	2.76423
Experience (years)	17	43	28.82927	6.8577
Household size	1	40	11.7561	7.67938
Farmer base organization	0	1	0.52032	0.50163
Extension services	0	1	0.07317	0.26148
Output (bowls; 2.5kg/bowl)	25.7	520	82.83902	106.1756
Farm size (acres)	1	9	2.76423	1.50317
seeds (kg)	13	214.5	43.84553	24.63914
Herbicides (litres)	1	9	2.743902	1.499133
Labour (man-days)	28	400	132.2358	88.22754

Source: Field survey, 2014

Table 3. Results of hypotheses tested

Test type	Test statistic	P-value	Decision rule
Functional form test	16.80	0.079	Reject H_0: Translog is appropriate
Frontier test	25.06	0.016	Reject H_0: Frontier is appropriate
Inefficiency test	28.42	0.0001	Reject H_0: Inefficiency effects are present in the model

Source: Field Survey, 2014

Table 4. Maximum likelihood estimates of the stochastic frontier production function

Variable	Parameter	Coefficient	Std error	P-value
Constant	β_0	-8.039284	4.544821	0.077
Labour	β_1	7.844772	4.700776	0.095
Herbicides	β_2	1.120254	1.529197	0.464
Seeds	β_3	5.835798	2.658528	0.028
Farm size	β_4	-7.803223	4.331920	0.072
(labour)(labour)	β_{11}	-0.459161	0.280501	0.102
(Herb)(Herb)	β_{22}	-1.631556	1.294464	0.208
(Seeds)(Seeds)	β_{33}	-1.660833	0.505938	0.001
(Farm size)(Farm size)	β_{44}	-1.475826	1.796383	0.411
(Labour)(Herbicides)	β_{12}	-0.304701	1.103999	0.783
(Labour)(Seeds)	β_{13}	0.925123	0.420090	0.028
(Labour)(Farm size)	β_{14}	0.609402	1.130474	0.590
(Herbicides)(Seeds)	β_{23}	-2.681500	1.657997	0.106
(Herbicides)(Farm size)	β_{24}	3.098044	1.714294	0.071
(Seeds)(Farm size)	β_{34}	2.420524	1.584224	0.127
Sigma- squared		0.2447		
Gamma		0.8305		
Log likelihood function		-24.039		

*Source: Field Survey, 2014. *** = 1% significance level, * = 10% significance level*

Table 5. Frequency distribution of technical efficiency index

Efficiency score	Percentage (%)	Frequency	Cumulative
20 - 30	3.33	4	4
31 - 40	5.00	6	10
41 - 50	5.83	7	17
51 - 60	12.51	15	32
61 - 70	15.00	18	50
71 - 80	13.33	16	66
81 - 90	20.00	24	90
91 - 100	25.00	30	120
Maximum	100	120	
Mean	98.65		
Minimum	83.89		
	20.04		

Source: Field Survey, 2014

Table 6. Determinants of technical inefficiency in groundnut production

Variable	Parameter	Coefficient	Std Error	P-value
Constant	δ_0	0.887395	0.3966230	0.027
Sex	δ_1	0.003213	0.0042131	0.447
Age	δ_2	0.011479	0.0090036	0.205
Education	δ_3	-0.004783	0.0025706	0.065*
Marital status	δ_4	0.001923	0.0039016	0.623
Experience	δ_5	-0.653460	0.9199170	0.000***
Household size	δ_6	0.154586	0.0679238	0.025**
Membership of FBO	δ_7	-0.113706	0.0579535	0.052**
Contact with extension service	δ_8	-0.272325	0.1397614	0.054**

*Source: Field survey, 2014. *** = 1% significance level, * = 10% significance level*

Table 7. Resource-use-efficiency estimates

Variable	MFC(GH¢)	MVP	RUE = MVP/MFC	Decision rule
Labour	4.5/man-day	0.6205	0.865	Over-utilization
Seeds	10/22.5kg	0.308	0.308	Over-utilization
Herbicides	10/22.5kg	3.183	3.183	Under-utilization

Source: Field survey, 2014

4. CONCLUSIONS AND RECOMMENDATIONS

The focus of this study was to estimate the resource-use-efficiency in the Northern region of Ghana. The results indicated that amount of labour and quantities of seeds have positive effects on output of groundnut in the study area. However, farm size allocated to groundnut farming was estimated to have a negative effect on output. The mean technical efficiency was estimated to be 83.89% with majority of groundnut farmers achieving efficiency score of 73% and above. The sources of variation in the technical inefficiencies of farmers include education, experience, household size and frequency of extension visits. The study further demonstrated that groundnut farmers in the study area exhibited positive decreasing return to scale implying that, increase in the factors of production produce less than proportionate increase in output. The resource-use-efficiency analysis had indicated that none of the variable inputs employed by the farmers was efficiently utilized. The study therefore recommends a farm level policy directed towards the stimulation of extension work through motivation to give the rural farm households the needed training on farm management to improve productivity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Government of Ghana. Budget Statement and Economic Policies of the Budget for a brighter future; 2009. Available:http//www.mofep.gov.gh
2. Breisinger C, Diao X, Thurlow J, Al-Hassan RM. Potential impacts of green revolution in Africa – The case of Ghana, Paper presented at the 27th IAAE Conference, Beijing; 2009.
3. Asekenye C. An Analysis of Productivity Gaps among Smallholder Groundnut Farmers in Uganda and Kenya. Master's Thesis: Paper 323; 2012. Available:http://digitalcommons.uconn.edu/gs_theses/323
4. Facts and Figures, Statistics, Research and Information Directorate, Ministry of Food and Agriculture (MoFA). Accra, Ghana; 2012.
5. Rockström J, Barron J, Fox P. Water productivity in rain-fed agriculture: Challenges and opportunities for

smallholder farmers in drought-prone tropical agro-ecosystems; in Kijne JW, Molden D, Barker R. Water productivity in agriculture: Limits and opportunities for improvement. Comprehensive Assessment of Water Management in Agriculture Wallingford, UK, CABI International. 2003;(1):145-162.
6. Taru VB, Kyagya IZ, Mshelia SI. Profitability of groundnut production in michika local government area of adamawa state, Nigeria. Journal of Agricultural Science. 2010;1(1):25-29.
7. Girei AA, Duana Y, Dire B. An Economic Analysis of Groundnut (*Arachis hypogea*) Production in Hong Local Government Area of Adamawa State, Nigeria. Journal of Agricultural and Crop Research. 2013; 1(6): 84-89.
8. Farrell MJ. The measurement of productive efficiency. Journal of Royal Statistical Society. 1957;3:253-290.
9. Battese GE. Frontier production functions and technical efficiency: A survey of Empirical Applications in Agricultural Economics. Agricultural Economics. 1992;7:185-208.
10. Coelli T, Rao DSP, O"Donnell CJ, Battese GE. An Introduction to Efficiency and Productivity Analysis. Springer. New York, USA; 2005.
11. Ray SC. Data Envelopment Analysis: Theory and Techniques for Economics and Operation Research. Cambridge University Press, New York; 2004.
12. Zhu J. Quantitative models for performance evaluation and benchmarking: Data Envelopment Analysis with Spreadsheets and Excel Solver. Kluwer Academic Publishers, Boston; 2003.
13. Battese GE, Broca SS. Functional forms of stochastic frontier production functions and models for technical inefficiency effects: A comparative study for wheat farmers in Pakistan. Journal of Productivity Analysis. 1997;8:395-414.
14. Tapheel GB, Jongur AAU (2014) Productivity and Efficiency of Groundnut Farming in Northern Taraba state, Nigeria. Journal of Agriculture and Sustainability. 2014;5(1):45 – 56.
15. Korir MK, Serem AK, Sulo TK, Kipsat, MJ. A Stochastic Frontier Analysis of Bambara Groundnut Production in Western Kenya. 18th International Farm Management Congress, Methven, Canterbury, New Zealand. 2013;3:74 – 80.
16. Shehu JF, Tashikalma AK, Gabdo GH. Efficiency of resource use in small scale rain-fed upland rice production in Northwest Agricultural Zone of Adamawa State, Nigeria. 9th Annual National Conference of Nigeria. Association of Agricultural Economics (NAAE) Held at ATBU, Bauchi, Nigeria; 2007.
17. Addai KN, Owusu V. Technical Efficiency of Maize Farmers across the Various Agro Ecological Zones. Journal of Agriculture and Environmental Sciences. 2014;3(1): 149 – 172.
18. Abdulai S, Nkegbe PK, Donkoh SA. Technical efficiency of maize production in Northern Ghana. African Journal of Agricultural Research. 2013;8(43);5251-5259.
19. Adzawla W, Fuseini J, Donkoh SA. Estimating technical efficiency of cotton production in Yendi Municipality, Northern Ghana. Journal of Agriculture and Sustainability. 2013;4(1):115-140.
20. Kumbhakar SC, Bhattacharya A. Price distortion and resource use efficiency in indian agriculture: A Restricted Profit Function Approach. Review of Economics and Statistics. 1992;74:231-239.
21. Owuor G, Shem OA. What Are the Key Constraints in Technical Efficiency of Smallholder Farmers in Africa? Empirical Evidence from Kenya. A Paper Presented at 111 EAAE- IAAE Seminar Small Farms: Decline or persistence' University of Kent; 2009.
22. Donkoh SA, Ayambila S, Abdulai S. Technical Efficiency of Rice Production at the Tono Irrigation Scheme in Northern Ghana. American Journal of Experimental Agriculture. 2013;3(1):25-42.
23. Diiro MG. Impact of Off-farm Income on Agricultural Technology Adoption Intensity and Productivity. Evidence from rural maize farmers in Uganda. International Food Policy Research Institute, Uganda Food Support Programme. Working Paper 11; 2013.
24. Chukwuji CO, Inoni OE, Ike PC. Determinants of technical efficiency in Gari in Delta State, Nigeria. Journal of Central European Agriculture. 2007;8(3):327-336.
25. Asante BO, Wiredu AN, Martey E, Sarpong DB, Mensah-Bonsu A. NERICA Adoption and Impacts on Technical Efficiency of Rice Producing Households in Ghana:

Implications for research and development. American Journal of Experimental Agriculture. 2014;4(3):244-262.

26. Taru VB, Kyagya IZ, Mshelia SI, Adebayo EF. Economic Efficiency of resource use in groundnut production in Adamawa State of Nigeria. World Journal of Agricultural Sciences. 2008;4(s):896 – 900.
27. Maikasuwa MA, Ala AL. Determination of Profitability and Resource-use Efficiency of Yam Production by Women in Bosso Local Government Area of Niger State, Nigeria. European Scientific Journal. 2013;9(16): 198 – 205.
28. Tijani BA, Abubakar M, Benisheik KM, Mustapha AB. Resource Use Efficiency in Rice Production in Jere Local Government Area of Borno State, Nigeria. Nigerian Journal of Basic and Applied Science. 2010;18(1):27 – 34.
29. Baiyegunhi LJS, Fraser GCG, Adewumi MO. Resource Use Efficiency in Sole Sorghum Production in Three Villages of Kaduna State, Nigeria. African Journal of Agricultural Research. 2010;5 (3):172-177.
30. Aigner DJ, Lovell CA, Schmidt P. Formulation and estimation of stochastic frontier production function Model. Journal of Econometrics. 1977; 1(1): 21-37.
31. Meeusen W, Van den Broeck J. Efficiency Estimation from Cobb–Douglas Production Functions with Composed Error. International Economic Review. 1977; 18(2):435–443.
32. Onumah JA, Al-Hassan RM, Onumah EE. Productivity and technical efficiency of cocoa production in Eastern Ghana. Journal of Economics and Sustainable Development. 2013;4(4):106 – 118.
33. Danso-Abbeam G, Aidoo R, Agyemang KO, Ohene-Yankyera K. Technical Efficiency in Ghana's Cocoa Industry: Evidence from Bibiani -Anhwiaso-Bekwai District. Journal of Development and Agricultural Economics. 2012;4(10):287-294.
34. Onumah EE. Acquah HD. frontier analysis of aquaculture farms in the Southern Sector of Ghana. World Applied Sciences Journal. 2010; 9(7): 826-835.
35. Battese GE, Coelli TJ. A Model for Technical Inefficiency Effects in a stochastic frontier production function for panel data. Empirical Economics. 1995;20(2):325-32.
36. Sienso G, Asuming-Brempong S, Amegashie DPK. Estimating Efficiency of Maize Farmers in Ghana. Asian Journal of Agricultural Extension, Economics & Sociology. 2014; 3(6): 705-720.
37. Gani BS, Omonona BT. Resource Use efficiency among small - scale. irrigated maize producers in Northern Taraba State of Nigeria. Journal of Humun Ecology. 2009; 28(2):113-119.
38. Oladeebo JO, Ambe-Lamidi AI. Profitability, Input Elasticities and Economic Efficiency of Poultry Production among Youth Farmers in Osun State, Nigeria. International Journal of Poultry Science. 2007; 6(12):994-998.
39. Christensen LR, Jorgensen DW, Lau LJ. Transcendental Logarithmic Production Frontiers. Review of Economics and Statistics. 1973;55:28-45.
40. Coelli TJ. Estimators and Hypothesis Tests for a Stochastic Frontier Functions: A Monte Carlo Analysis. Journal of Productivity Analysis. 1995;6:247-268.
41. Food and Agriculture Sector Development Policy (FASDEP II). Ministry of Food and Agriculture, MoFA. Accra, Ghana; 2007.
42. Ani DP, Umeh JC, Weye EA. Profitability and Economic Efficiency of Groundnut Production in Benue State, Nigeria. African Journal of Food, Agriculture, Nutrition and Development. 2013;13(4): 8091 – 8105.
43. Suresh A, Reddy TRK. Resource-use Efficiency of Paddy Cultivation in Peechi Command Area of Thrissur District of Kerala: An Economic Analysis. Agricultural Economics Research Review. 2006;19:159-171.
44. Nkegbe PK. Technical Efficiency in Crop Production and Environmental Resource Management Practices in Northern Ghana. Environmental Economics. 2012;3(4):43 – 51.
45. Mapemba DL, Maganga MA, Mango N. Farm household production efficiency in Southern Malawi: An Efficiency Decomposition Approach. Journal of Economics and Sustainable Development. 2013;4(3):236 – 245.
46. Asante BO, Villano RA, Battese GE. The effect of the adoption of yam minisett technology on technical efficiency of yam farmers in the forest-savanna transition zone of Ghana. African Journal of Agricultural and Resource Economics. 2014;9(2):75-90.
47. Parikh A, Shah K. Measurement of technical efficiency in the North-west Province of Pakistan. Journal of

Agricultural Economics. 1995;4(5):133-137.
48. Seyoum ET, Battese GE, Fleming EM. Technical Efficiency and Productivity of Maize Producers in Eastern Ethiopia: A study of Farmers within and outside the Sasakawa Global 2000 project. Agricultural Economics. 1998;(19):341-348.
49. Addai KN, Owusu V, Danso-Abbeam G. Effects of farmer – Based- organization on the technical efficiency of maize farmers across Various Agro - Ecological Zones of Ghana. Journal of Economics and Development Studies. 2014;2(1):141–161.

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