UNIVERSITY OF CAPE COAST

TECHNICAL EFFICIENCY IN RICE PRODUCTION ON THE WETA IRRIGATION SCHEME IN THE KETU NORTH DISTRICT OF THE VOLTA REGION, GHANA

BY

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Signature: .... Date ....

Candidate's Name: Francis Kastro Kavi

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast

Signature .... Date ....

Principal Supervisor's Name: Prof. Henry De-Graft Acquah

Signature .... Date ....

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ABSTRACT

This study investigated technical efficiency in rice production on the Weta Irrigation Scheme in the Ketu North District of the Volta Region of Ghana during the 2014/2015 cropping season. A two-stage sampling procedure was used to select a sample of 290 rice farmers from a population of 1,024. Primary data, collected from 285 respondents using structured interview schedule, were used for the study. A translog stochastic frontier production function which incorporates a model for inefficiency effects, using the Maximum Likelihood Method was employed in the analysis of the data. Results indicated that the major input factors that significantly influenced the output of rice were land area under cultivation, fertiliser input, irrigation cost and equipment. The socio-economic characteristics of rice farmers which were significant determinants of technical efficiency in the study area were age, sex, farming experience and membership of a farmer based organisation. Low purchasing price of rice, lack of government support, difficulty in accessing capital and erratic rainfall patterns were identified as the major constraints faced by rice farmers in the study area. Furthermore, the mean technical efficiency index was estimated at 70.7 per cent which implies that the rice farmers were not fully technically efficient. Thus there was the opportunity for them to increase their output by 29.3 per cent via efficient reallocation of available resources. Also the results indicated decreasing returns to scale technology among the rice farmers. Finally, the study recommended among others that the Ministry of Food and Agriculture should introduce fertiliser subsidies and establish guaranteed prices for rice to encourage rice farmers to produce.

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DEDICATION

To my family

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LIST OF ABBREVIATIONS

AAGS	Accelerated Agricultural Growth and Development
AEA	Agricultural Extension Agent
CARD	Coalition for Africa Rice and Development
CRI	Crop Research Institute
CSRI	Council for Scientific and Industrial Research
DADU	District Agriculture Development Unit
DEA	Data Envelopment Analysis
DIP	Dawhenya Irrigation Project
FASDEP I&II	Food and Agriculture Sector Development Policy
FBO	Farmer – Based Organisation
GIDA	Ghana Irrigation Development Authority
GPRS I	Ghana Poverty Reduction Strategy I
GPRS II	Growth and Poverty Reduction Strategy II
GRIB	Ghana Rice Interprofessional Body
HHI	Herfindahl Index
IFPRI	International Food Policy Research Institute
J. H. S.	Junior High School
LRT	Likelihood Ratio Test
METASIP	Medium Term Agriculture Sector Investment Plan
MiDA	Millennium Development Agenda
MLE	Maximum Likelihood Estimate
MOFA	Ministry of Food and Agriculture

MRTS	Marginal Rate of Technical Substitution
NERICA	New Rice for Africa
NRDS	National Rice Development Strategy
NRI	Natural Resources Institutes
OLS	Ordinary Least Squares
PRA	Participatory Rural Appraisal
PTIPs	Pump-type Irrigation Projects
RTS	Returns – To – Scale
S.H.S	Senior High School
S.M.C.D	Supreme Military Council Decree
SARI	Savanna Agricultural Research Institute
TE	Technical Efficiency
TICAD	Tokyo International Conference on Africa Development
US	United States

CHAPTER ONE

INTRODUCTION

Background to the study

Rice is considered as the second most important grain food staple in Ghana, next to maize, and its consumption keeps increasing as a result of population growth, urbanization and change in consumer habits [Ministry of Food and Agriculture (MoFA, 2009)].. The total rice consumption in Ghana in 2005 amounted to about 500,000 tonnes and this is equivalent to per capita consumption of 22 kilograms per annum. According to MoFA, per capita consumption of rice per annum is estimated to increase to 63 kilograms by 2018 as a result of rapid population growth and urbanization.

Between 1996 and 2005, paddy rice production in Ghana was in the range of 200,000 and 280,000 tonnes (130,000 to 182,000 tonnes of milled rice) with large annual fluctuations. In 2010, rice was the 10th agricultural commodity in Ghana by value of production while it ranked 8th in terms of production quantity for the period 2005-2010 (MoFA, 2010). Average rice yield in Ghana is estimated to be 2.5 tonnes/hectare while the achievable yield is 6–8 tonnes/hectare. This significant yield potential can be tapped through improvements in agronomic practices and adoption of underutilized beneficial technologies. Also, rice occupies roughly 4 per cent of the total crop harvested area, although it accounts for about 45 per cent of the total area planted to cereals (MoFA, 2009). In addition to being a staple food mainly for high income urban populations, rice is also an important cash crop in the communities in which it is produced.

Rice is also the most imported cereal in the country accounting for 58 per cent of cereal imports (CARD, 2010) accounting for 5 per cent of total agricultural imports in Ghana over the period 2005-2009. Ghana largely depends on imported rice to make up for the deficit in rice supply. On the average, annual rice import in Ghana is about 400,000 tonnes (MoFA, 2009). It is therefore important for stakeholders in the food and agriculture sector to ensure increased and sustained domestic production of good quality rice for food security, import substitution and savings in foreign exchange.

Domestic rice production satisfies around 30 to 40 per cent of demand with a corresponding average rice import bill of US $450 million annually (MoFA, 2010). The massive dependency on rice imports has always been a concern for policy makers, especially after food prices soared in 2008. However, import duties and other taxes as well as interventions to boost productivity and quality of local rice do not seem to produce any substantial impact on Ghana’s import bill.

In May, 2008, Ghana was one of the first countries within the Coalition for Africa Rice and Development to launch its National Rice Development Strategy (NRDS) for the decade 2009 – 2018. The main objective of the NRDS is to double domestic production by 2018, implying a 10 per cent annual growth rate and enhance quality to stimulate demand for domestically produced rice. These increases will most likely come from utilizing potential irrigable lands and valley bottoms with water supply, promoting rice production, and increasing the productivity of existing growers.

The inability of local rice production to meet domestic demand can be attributed to the inability of the rice farmers to obtain maximum output from the resources committed to the enterprise (Kolawole, 2009). According to Rahman, Mia and Bhuiyan (2012), farm level performance can be attained in two alternate ways: either by maximizing output with the given set of inputs or by minimizing production cost to produce a prescribed level of output. The former concept is known as technical efficiency which is a measure of a farm firm's ability to produce maximum output from a given set of inputs under certain production technology. It is a relative concept in so far as the performance of each production unit is usually compared to a standard. The standard may be used on farm-specific estimates of best practice techniques (Herdt & Mandac, 1981) but more usually by relating farm output to population parameters based on production function analysis (Timmer, 1971).

A technically efficient farm operates on its frontier production function. Given the relationship of inputs in a particular production function, the farm is technically efficient if it produces on its production function to obtain the maximum possible output, which is feasible under the current technology. Put differently, a farm is considered to be technically efficient if it operates at a point on an isoquant rather than interior to the isoquant.

Technical efficiency in agriculture production is an important element in the pursuit of output growth. A high level of technical efficiency implies that output is being maximized given the available technology. In this situation, output growth will be achieved through the introduction of new technology that will shift the production frontier outward. A low level of technical efficiency, on the other hand, indicates that output growth can be achieved given current inputs and available technology. Therefore, it is important to determine the degree of technical efficiency among farmers, and if low technical efficiency is found, to investigate the factors that will increase efficiency.

Measurement of productive efficiency of a farm relative to other farms or to the best practice in an industry has long been of interest to agricultural economists. From an applied perspective, measuring efficiency is important because it is the first step in a process that might lead to substantial resource savings. These resource savings have important implications for both policy formulation and farm management (Bravo-Ureta & Rieger, 1991). For individual farms, gains in efficiency are particularly important in periods of financial stress since the efficient farms are likely to generate higher incomes and thus stand a better chance of surviving and prospering.

Statement of the problem

In an economy where resources are scarce and opportunities for new technologies are lacking, further increase in output can best be brought about through improvement in the productivity of the crop. In this context, technical efficiency in the production of a crop is of paramount importance.

Measurement of technical efficiency (TE) provides useful information on competitiveness of farms and potential to improve productivity, with the existing resources and level of technology (Abdulai & Tietje, 2007). Moreover, investigating factors that influence technical efficiency offers important insights on key variables that might be worthy of consideration in policy-making, in order to ensure optimal resource utilisation.

Several studies have been conducted on rice production in Ghana. However, most of these studies on rice focused on other areas rather than the technical efficiency of production. Examples are: “Impact of improved varieties on the yield of rice producing households in Ghana” (Wiredu, et al., 2010); “Cooking characteristics and variations in nutrient content of some new scented rice varieties in Ghana”(Diako et al., 2011), “Rice price trends in Ghana” (Amanor-Boadi, 2012) and “Patterns of adoption of improved rice technologies in Ghana’’(Ragasa et al., (2013).

Even though some studies have been conducted on technical efficiency in rice production in Ghana, most of these studies are concentrated in Northern Ghana; especially on the Tono Irrigation Scheme, for example Technical efficiency in rice production at the Tono irrigation scheme in Northern Ghana (Donkoh, Ayambila & Abdulai,2012).

Besides, in the Ketu North District rice is a major food crop and its production serves as a source of employment for many years. Yet, not much study has been conducted to determine the technical efficiency of rice farmers.

The aforementioned reasons informed a study to be conducted to determine the technical efficiency in rice production on the Weta irrigation scheme in the Ketu North District of the Volta Region of Ghana. This would fill the knowledge gap and inform policy decisions.

Objectives of the study

Generally, the study seeks to measure the technical efficiency in rice production in the Ketu North District of the Volta Region. The specific objectives include**:**

1. To estimate the level of technical efficiency of rice farmers in the district.

2. To analyse the determinants of technical efficiency.

3. To compute the output elasticities in rice production.

4. To identify and rank the constraints in rice production with respect to technical efficiency.

Research questions

The following research questions have been developed to guide the study.

1. What are the levels of technical efficiency in rice production in the district?

2. What are the output elasticities in rice production?

3. What are the determinants of technical efficiency?

4. What are the constraints to rice production in the district?

Hypotheses

The study seeks to test the following hypotheses:

1. H_0: The translog functional form does not represent the data more adequately than the Cobb-Douglas

   H_1: The translog functional form represents the data more adequately than the Cobb-Douglas

2. $H_{0:}$ Rice farmers are not fully technically efficient**.**

   H_1: Rice farmers are fully technically efficient.

3. H_0: The socio-economic characteristics of rice farmers have no significant influence on technical efficiency.

H_1: The socio-economic characteristics of rice farmers significantly influence technical efficiency.

4. H_0: There is no concordance among rice farmers regarding the constraints to rice production.

   H_1: There is concordance among rice farmers regarding the constraints to rice production.

Significance of the study

Farmers are rational and tend to make production decisions in favour of crops that yield the most benefits to them. Therefore, information on technical efficiency in rice production is essential to rice farmers. The findings of this study would help to better understand where public investments can best be directed to effectively increase technical efficiency of rice farmers in Ghana. Increased rice output will address food security issues in the country as well as improve farmers' livelihoods by increasing their incomes. Furthermore, determining the factors that influence technical efficiency will serve as a basis for policy and strategy development so as to enhance rice production in the country. Also, increased output of rice farmers will help reduce rice imports to save foreign exchange and strengthen the Ghana Cedi. Finally, the findings of this study would help fill the knowledge gap identified during literature review.

Delimitations of the study

The focus of this study was to estimate the levels of technical efficiency and its determinants among rice farmers on the Weta irrigation scheme in the Ketu North District of the Volta Region. It did not include other rice farmers in the district who were not on the irrigation scheme. Also, the scope of the study is delimited to the estimation of technical efficiency and its determinants among the rice farmers but not the allocative efficiency which takes into consideration the respective prices of the inputs.

Limitations of the study

In this study, data were collected from rice farmers most of whom were illiterates or had only primary education and hence could not keep accurate records. Also, all the items on the instrument had to be translated from English to Ewe for the respondents. Furthermore, production technology was assumed to be constant for rice farmers on the Weta irrigation scheme. All the above could negatively affect the quality of data collected as well as the accuracy of results obtained.

Organisation of the study

The study is organised into five chapters. The first chapter is the introductory chapter and it covers the background of the study, statement of the problem, objectives of the study, research questions, significance of the study, delimitations of the study, limitations of the study and the organisation of the study. Chapter two provides a review of related literature and the relevant variables of the study. The review also covers empirical studies related to the study. Chapter three describes the research methodology. The discussion of results of data analyses are presented in chapter four while summary, conclusions and recommendations are presented in chapter five.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

In this chapter, the relevant literature relating to the study has been reviewed. The review covers the following areas: theoretical framework, definition of technical efficiency, forms of efficiency, measurements of technical efficiency, requirement for a functional form, ou`tput elasticity, the determinants of technical efficiency, overview of the rice sector in Ghana, the constraints to rice production and conceptual framework.

Theoretical Framework

Kumbhakar and Lovell (2000) define technical efficiency as a measure of how well individuals convert inputs to output with a given level of technology and economic factors. Technical efficiency (TE_i) is given as the ratio of observed output (Y_i) to the corresponding frontier output (Y_i^*)with given levels of inputs and technology. Thus, ($TE_i = Y_i/Y_i^*$).Therefore, technical inefficiency exists if a farmer produces below the production frontier. This phenomenon is also influenced by inefficiency factors such as level of education, age of farmer, household size, and farming experience.

In this study, technical efficiency is considered from the angle where a farmer uses a minimum combination of inputs to produce a given level of output (an input-oriented measure of technical efficiency). This is shown in figure 1: From figure 1, the firm uses the combination of inputs(x_1, x_2) defined by point A to produce a given level of output (y_1^*, y_2^*). The same level of output could have been produced by combining smaller amounts of the inputs (Isoquant (y_1^*,y_2^*)). This is defined by point B and it lies on the isoquant. Therefore, the input-oriented level of technical efficiency (TEI) is defined by OB/OA. The distance BA shows the technical inefficiency of the farm firm and it represents the amount by which all inputs could be proportionally reduced without a decrease in output.

Farell (1957) defines allocative efficiency as the ability of a firm to choose the optimal combination of inputs given input prices. At point C, the marginal rate of technical substitution (MRTS) is equal to the ratio of the input prices (w_2/w_1).This implies that the input allocative efficiency is given by the fraction OD/OB (Coelli, 1995).

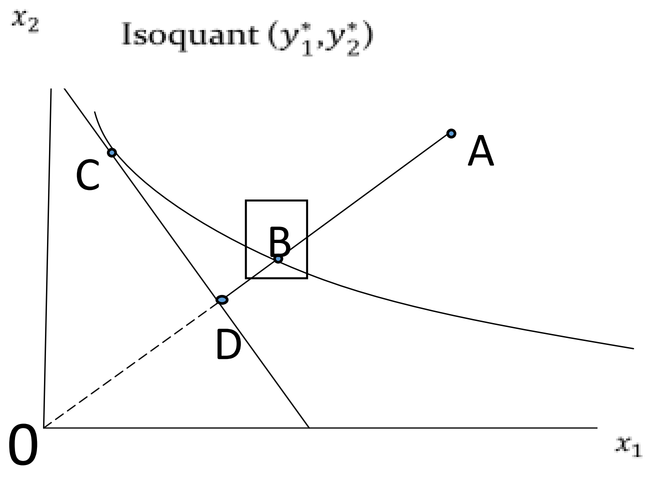

Figure 1: An input- oriented measure of technical efficiency

Source: Kumbhakar and Lovell (2000).

Definition of technical efficiency

One of the basic thrusts of economics of agricultural production at the micro level is to assist individual farmers or a group of farmers to attain their objectives through efficient intra-farm allocation of resources at a particular time or over a period. Efficiency is achieved either by maximizing output from given resources or by minimizing the resources required for producing a given output (Varian, 1992).The first analyses of efficiency measures were initiated by Farrell (1957). Drawing from Debreu (1951) and Koopmans (1951), Farrell proposed a division of efficiency into two components: technical efficiency, which represents a firm's ability to produce a maximum level of output from a given level of inputs, and allocative efficiency, which is the ability of a firm to use inputs in optimal proportions, given their respective prices and available technology. The combination of these measures yields the level of economic efficiency.

In microeconomics of production, technical efficiency is defined as "the maximum attainable level of output for a given level of inputs, given the current range of alternative technologies available to the farmer" (Ellis, 1993). Technical efficiency can be analysed using two approaches. These are the output-oriented and input-oriented approaches. The first one has output augmenting orientation, whereas the second one is targeted to conserve inputs (Koopmans, 1951). An output-oriented technical efficiency occurs when the maximum amount of an output is produced for a given set of inputs while an input-oriented technical efficiency occurs when the minimum amount of inputs are required to produce a given output level (Farrell, 1957). Therefore, technical efficiencies are derived from production functions or production possibility frontiers.

Forms of efficiency

Apart from the components of economic efficiency (technical and allocative efficiency), Leon (2001) came out with five additional categories of efficiency. These include:

1. Technological efficiency: the ability to produce an output by using the best technology available.

2. Pure technical efficiency: with the given amount of technology, output should not be produced in a manner such that inputs used would be more than necessary. The pure technical efficiency measure is derived by estimating the frontier output under the assumption of variable returns to scale.

3. Scale efficiency: the ability of the firm to produce at a suitable level by exploiting scale economies. Thus, management is able to choose the scale of production such that the optimum output is obtained. Inefficiency can arise when the size of a firm is too small or too large.

4. Dynamic efficiency: operating at the optimum level by incorporating innovations in products and processes.

5. Approach efficiency: it defines the ability of the firm to choose the appropriate technology with respect to the challenges that arises in the market.

Measurement of technical efficiency

Previous studies on efficiency of a farm can be classified broadly into three categories, namely; deterministic parametric estimation, non-parametric mathematical programming and the stochastic parametric estimation (Udo & Akintola, 2001). The use of non-parametric techniques are limited in efficiency measurement in agriculture despite the fact that non parametric methodologies can be used in situations where data are more limited and where production techniques are less well understood (Llewelyn & William, 1996). The non-parametric approach, which is the Data Envelopment Analysis (DEA) was initiated by Farrell (1957) and transformed into estimation techniques by Charnes, Cooper and Rhodes (1978). DEA is based on linear programming and consists of estimating a production frontier through a convex envelope curve formed by line segments joining observed efficient production units. No functional form is imposed on the production frontier and no assumption is made on the error term. The DEA is also useful for multiple-input and multiple- output production technologies (Khai & Yabe, 2011). However, the non-parametric approach is limited because it cannot separate the effects of noise and inefficiency during the calculation of technical efficiency, and is less sensitive to the type of specification error (Kebede, 2001). Thus it assumes the absence of measurement or sampling errors and deviations from the production frontier are under the control of the production unit being considered. Also, it is very sensitive to extreme values and outliers and lacks the statistical procedure for hypothesis testing (Nchare, 2005). .

The deterministic parametric estimation of technical efficiency for a cross-section of producers was first introduced by Farrell (1957).The deterministic frontier approach also assumes that any deviation from the frontier is due to inefficiency. The limitations of this approach arise due to the fact that it ignores any random factors that may influence the efficiency of a firm. Thus, the results of a deterministic frontier approach are highly sensitive to the selection of variables and data errors (Bravo-Ureta & Pinheiro, 1997). Farrel suggested a method of measuring technical efficiency of a farm by estimating the production function of a farm that are fully efficient, that is a frontier production function. The efficiency however, is bounded between zero and one, where scores of one indicate full efficiency (Tanko, 2009; Ezekiel, Adedapo & Olapade, 2009; Kolawole, 2009; Udoh & Akintola, 2001; Bagi, 1984; Battesse & Coelli, 1995).

Aigner and Chu (1968) developed stochastic frontier models, which acknowledge the influence of random errors and data noise on agricultural production. This approach assumes that deviations from the production frontier may not be entirely under the control of farmers. In so doing, it helps distinguish the effects of stochastic noise from the effects of other inefficiency factors. It also allows hypothesis testing on the structure of production and efficiency. Also,Aigner, Lovell and Schmidt (1977) and Meeusem and Van den Broeck (1977) independently developed a stochastic frontier approach to overcome some of the limitations of the deterministic frontier approach. The stochastic frontier approach, an econometric estimation, is made up of an error term which consists of two components, one being random noise, which is factors beyond the farmer's control (e.g. weather conditions) and the other being a one-sided residual term representing inefficiency. The inefficiency component represents farmer-specific characteristics such as age of farmer and farming experience. A stochastic frontier production function representing a firm's production is given by:

$$Y_i = f(x_i, \beta) + \varepsilon_i \qquad \text{(i)}$$

Where Y_i is the output of the i^{th} farmer

x_i is a vector of the input quantities

β is a vector of unknown parameters to be estimated

$\varepsilon_i = (v - u)$ is the composite error term, where

v is a random error that captures the stochastic effects that are beyond the farmer's control; such as weather conditions and diseases. The v_s are assumed to be independent and identically distributed normal random errors having zero mean and unknown variance, σ^2_v. The u_s are non-negative random variables, called technical inefficiency effects, which are associated with technical inefficiency of production of the farmers which are assumed to be independent of the v_s such that u is the non-negative truncation (at zero) of the normal distribution with mean u_i, and variance, σ^2_u, where

u_i is defined by:

$$u_i=\delta_0+\delta_1 Z_1+\delta_2 Z_2+\delta_3 Z_3+\ldots+\delta_n Z_n \quad \text{(ii)}$$

Where, u_i = Technical inefficiency of the ith farmer,

δ_1-δ_n = Unknown parameters to be estimated,

Z_1-Z_n= Farmer-specific characteristics.

The econometric approach, however, gives good results only for single output and multiple inputs technologies (Kebede, 2001).Criticisms of the stochastic approach resides in the need to specify beforehand, the functional form of the production function and a distributional form of the inefficiency term. Since rice production in the study area is an example of single output and multiple inputs production, this study focuses on the use of an econometric approach, which is the Stochastic Frontier Approach for measuring technical efficiency. This choice was made on the basis of the variability of agricultural production which is attributable to climatic hazards, plant pathology and insect pests on the one hand, and, on the other hand, because information gathered on production is usually inaccurate since small scale farmers do not have updated data on their farm operations. Furthermore, in analysing farm level data where measurement errors are substantial and weather is likely to have a significant effect, the stochastic frontier method is usually recommended (Coelli, 1995).

Requirements for functional form specification

In order to analyse a production function, it is always necessary to specify a particular functional form that will depict the production technology. In most cases, the production function is known to be decomposed into a deterministic and a stochastic part. The deterministic part which is made up of observed inputs variables and unknown parameters become the algebraic function. Some criteria have been formulated by Lau (1978 & 1986) to help choose a particular functional form suitable for measuring certain economic relationships. These criteria have been categorized into:

1. Theoretical consistency: Estimating the parameters of a particular economic relationship involves the ability to choose an appropriate functional form that can represent observations of a production set. This implies that the functional relationship must be single valued, monotonic (additional units of an input will not decrease output) and concave (all marginal products are non-decreasing).

2. Domain of applicability: This relates to how the algebraic functional form fulfils all the theoretical conditions given the set of values of the independent variables. It further shows that a functional form must be well behaved in a range of observations, coherent with upheld hypotheses and acknowledge computational techniques to check those properties. Also, in order to predict relations, functional forms should be well matched with upheld hypotheses outside the range of observations.

3. Flexibility: A functional form is said to be flexible if the derived input demand functions and the derived elasticities of the chosen parameters are able to assume arbitrary values subject to only theoretical consistency with any given set of non-negative inputs. This principle permits available data the chance to give information about the critical parameters.

4. Computational facility: This principle implies that the functional form must be linear, uniform, parsimonious and representative. Thus, for estimation purposes functional forms should be linear-in-parameters and possible restrictions should also be linear. Again, any input demand function derived from the functional form should be represented in an explicit closed form so as to make calculation easy. To prevent methodological problems like multi-collinearity and loss of degree of freedoms, diverse functions should vary in parameters but should have the same 'uniform' algebraic form.

5. Factual consistency: This relates to how the modelled economic problem is consistent with other recognized empirical facts.

Lau (1978) noted that one should not expect a particular algebraic functional form to meet all the requirements of the above criteria. Generally, a functional form can be considered as a suitable description of the production possibility set when it is theoretically consistent and flexible.

In literature, four functional forms namely; the linear production function, the quadratic production function, the Cobb-Douglas production function, and the transcendental logarithmic (translog) production function are normally used to represent the technology of a data set (Henningsen, 2013).

1. The linear production function: It is known to be first order flexible as it has adequate parameters to provide a first-order differential approximation to an arbitrary function at a single point.

2. The quadratic production function: It has a second-order flexibility functional form as it has enough parameters to give a second-order approximation.

3. The Cobb-Douglas production function: the Cobb-Douglas production function is a first-order flexible extension of the quadratic production function.

This function is popular because its derivatives are simple. It can be linearized by transforming both sides of the function to natural logarithm. The corresponding coefficients in the function are equal to the output elasticities of the inputs and the sum of all the output elasticities gives the scale elasticity. The production technology portrayed by the Cobb-Douglas production function shows that output quantity becomes zero whenever a particular input quantity is zero. A restrictive property of this function is that input level variations do not cause output elasticities to change (Debertin, 2012).

4. The translog production function: It was introduced by Christensen, Jorgenson & Lau in 1971. It is a more flexible extension of the Cobb-Douglas production function as the Cobb-Douglas production function is “nested” into the translog production function. This function can accommodate any number of input sets and the elasticity of substitution of each pair of inputs may vary. It can be seen as a combination of the Cobb-Douglas function and the quadratic function. The translog production function would not become an appropriate functional form for analysing data sets when the output quantity of the data is positive whiles at least one of its input quantities is zero. This renders the weak and strict essentiality assumption incapable. Also, all translog production functions are continuous in nature and can be differentiated twice continuously. Generally, second order differentials are preferred to the first order differentials but this can result in muticolinearity problems as there would be more parameters to be estimated. However, Kopp and Smith (1980) asserted that the effects of functional forms on efficiency analysis are limited.

Econometric modelling of stochastic frontier methodology of Aigner, Lovell and Schmidt (1977) associated with the estimation of efficiency has been an important area of research in recent years. Basically, the studies are mostly based on Cobb-Douglas function and transcendental logarithmic (translog) functions that could be specified either as production function or cost function. The first application of stochastic frontier model to farm level agricultural data was by Battesse and Corra (1977). But technical efficiency of farms was not directly addressed in the work. Kalirajan (1981) estimated a stochastic frontier Cobb-Douglas production function using cross-sectional data and found the variance of farm effects to be a highly significant component in describing the variability of rice yield. Bagi (1984) used the stochastic frontier Cobb-Douglas production function model to investigate whether there were any significant differences in the mean technical efficiencies of part-time and fulltime farmers. Results showed no apparent significance, irrespective of whether the part-time and full-time farmers were engaged in mixed farming or crop cultivation only.

The main advantage of the translog is that it is flexible, which implies that it does not impose assumptions about constant elasticity of production nor elasticities of substitutions between inputs. The translog permits the partial elasticities of substitution between inputs to vary, that is, the elasticity of scale can vary with output and factor proportions, permitting its long-run average cost curve to take the traditional U-shape.

The explicit translog stochastic frontier production function used in this study is given in equation (iii):

$$\ln Y_i = \beta_0 + \sum_{i=1}^{n} \beta_i \ln x_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} \ln x_i \ln x_j + \left(v_i - u_i\right) \qquad \text{(iii)}$$

where in is the natural logarithm, Y_i is the output of rice (kilograms) produced during the 2014/2015 cropping season by the i^{th} farmer and the jth observation; x is a set of 'n' inputs used to produce a given output where n is number of inputs; v_i denotes random shocks; u_i is the one-sided non-negative error representing inefficiency in production.

After estimating technical efficiency, based on the stochastic production frontier, literature proposes two main approaches to analysing the factors influencing technical efficiency sources: the two-stage estimation procedure and the one-stage simultaneous estimation approach. The two-stage approach requires one to first estimate the stochastic production function to determine technical efficiency indicators and then, secondly, regress the derived efficiency scores on explanatory variables which usually represent the farm's specific characteristics using ordinary least square (OLS) method or Tobit regression. This two-step approach has been used by authors such as Pitt and Lee (1981), Kalirajan (1981), Parikh, Ali and Shah (1995), and Ben-Belhassen (2000) in their respective studies.

The major drawback with this approach is in the fact that, in the first step, the inefficiency effects, μ_s are assumed to be independent and identically distributed in order to use the approach of Jondrow, Lovell, Materov and Schmidt (1982) to predict the values of technical efficiency indicators. In the second step however, the technical efficiency indicators thus obtained are assumed to depend on a certain number of factors specific to the farm, which implies that the μs are not identically distributed, unless all the coefficients of the factors considered happen to be simultaneously null.

After becoming aware that the two-step approach displayed these inconsistencies, Kumbhakar, Gosh and McGuckin (1991) and Reifschneider and Stevenson (1991) developed a model in which inefficiency is defined as an explicit function of certain factors specific to the firm, and all the parameters are estimated in one-step using the maximum likelihood procedure. By following this second approach, Huang and Liu (1994) developed a non-neutral stochastic frontier production function, in which the technical inefficiency effects are a function of a number of factors specific to the firm and of interaction among these factors and input variables introduced in the frontier function. Battese and Coelli (1995) also proposed stochastic frontier production function for panel data in which technical inefficiency effects are specified in terms of explanatory variables, including a time trend to take into account changes in efficiency over time. The technical inefficiency effects are expressed as:

$$\mu_j = Z_j\delta \quad \text{(iv)}$$

Where; μ_j refers to the mean of the normal distribution that is truncated at zero to define the truncated normal distribution associated with the inefficiency effect for farm j, z is a vector of observed explanatory variables and δ is a vector of unknown parameters. Thus, the parameters of the frontier production function are simultaneously estimated with those of an inefficiency model, in which the technical inefficiency effects are specified as a function of other variables including socioeconomic and demographic factors, farm characteristics, environmental factors and non-physical factors. The one-step approach has since been used by such authors as Ajibefun et al. (1996), Coelli and Battese (1996), Audibert (1997), Battese and Sarfaz (1998), and Lyubov and Jensen (1998) in their respective studies to analyse the factors affecting the technical efficiency (or inefficiency) of agricultural producers.

The one-stage simultaneous estimation approach was adopted to analyse the factors that influence technical efficiency. The single stage approach was adopted because, relative to the two-step approach, the one-step approach presents the advantage of being less open to criticism at the statistical level, and helps in carrying out hypothesis testing on the structure of production and degree of efficiency (Nchare, 2005).

Output elasticities

The output elasticities calculated from the translog production function are given as**:**

$$\varepsilon_i = \frac{\partial \ln Y}{\partial \ln x_i} = \beta_i + \sum_j^n \beta_{ij} \ln x_j \qquad \text{(v)}$$

(Henningsen, 2013).

The return to scale of the technology, RTS can be calculated by the sum of the elasticities of scale, given by

$$\varepsilon = \sum_i \varepsilon_i \qquad \text{(vi)}$$

If the technology has increasing returns to scale (ε >1), total factor productivity increases when all input quantities are proportionally increased, because the relative increase of the output quantity y is larger than the relative increase of the aggregate input quantity x in equation (v).

If the technology has decreasing returns to scale (ε <1), total factor productivity decreases when all input quantities are proportionally increased, because the relative increase of the output quantity y is less than the relative increase of the aggregate input quantity x . If the technology has constant returns to scale ($\varepsilon = 1$), total factor productivity remains constant when all input quantities change proportionally, because the relative change of the output quantity y is equal to the relative change of the aggregate input quantity x. If the elasticity of scale (monotonically) decreases with firm size, the firm has the most productive scale size at the point, where the elasticity of scale is one (Henningsen, 2013).

Determinants of technical efficiency

The ability of farmers to combine inputs in an efficient manner to produce a maximum output is influenced by the decisions taken during the production process. These decisions which are influenced by farmer specific characteristics are examined to ascertain their impact on technical efficiency. The farmer specific characteristics include age, education, farming experience, sex, access to credit, household size, access to extension services, off-farm work and membership of a farmer based organization.

Age of farmer

In literature, the influence of age on technical efficiency tends to have conflicting views. It has been argued that a positive relationship exists between older farmers and technical inefficiency. Older farmers have a tendency to stick to their old methods of production and are usually unwilling to accept change. However, the younger generations of farmers prefer taking risks. On the other hand, older farmers are considered to be more technically efficient. Older farmers are known to be wealthier than the younger farmers as a result of the wealth they accumulate over the years in farming. So they are able to buy the necessary inputs to undertake production. Adequate inputs coupled with long years of farming enable them to produce efficiently (Ali, Imad & Yousif (2012). Battese and Coelli (1995) asserts that expected sign for age with respect to technical efficiency is not clear. Therefore, it is anticipated that age could have either a positive or negative influence on technical inefficiency.

Education

Education is viewed as an important stock of human capital. It enhances the literacy and skills of farmers and this helps them to process agricultural information in their production activities. Evidence suggests that higher levels of schooling lead to higher levels of productivity as education has been found to have significant positive relationship with productivity (Hayami & Ruttan, 1985). Lin (1991) has pointed out that better educated farmers are more eager and faster when it comes to the adoption of new technologies and modern practices. They are not much afraid of the risk involved in such technologies. Similarly, Welch (1970) identified two different ways in which education can affect agricultural productivity. The first is the "worker effect" and it reflects how well educated farmers are able to use a given amount of resources more efficiently. The latter, "allocative effect", also describes how an educated farmer obtains and deciphers information about costs and productive characteristics of other inputs. This improves farmers' access to information enabling them to pay and receive better prices for inputs bought and outputs sold. Therefore, it is expected that education will have a positive relationship with technical efficiency.

Farming experience

The age of a farmer is used as a proxy for measuring farming experience. Thus, experience gained by farmers increase as they advance in age. The numbers of years spent in farming can affect technical efficiency positively or negatively. Farmers with long years of farming are assumed to be more experienced in production activities. They are therefore able to make and take better decisions with regard to risk and inputs combination. Long years of farming experience can influence technical efficiency negatively in the sense that farmers may develop the habit of sticking themselves to the use of obsolete technology (Onyenweaku & Nwaru, 2005). It is anticipated that farming experience will either influence technical efficiency positively or negatively.

Farmers' household size

Household size, be it large or small constitutes the family labour especially in most developing countries. The availability of labour especially during the peak periods in farming activities influences the technical efficiency of farmers. Families with large size normally depend on their members to carry out production activities and therefore may rely less on hired labour. It has been found that a positive relationship exists between household size and technical efficiency, indicating that families with large household size are technically efficient than those with small household size (Jema, 2007). It is expected that households with less family size would be technically inefficient in production.

Sex of farmer

Regardless of women's significant contribution to agricultural productivity, their output level is often constrained by lack of access to productive resources. Women's ability to gain access to agricultural resources is influenced by socioeconomic factors such level of education, access to credit and extension service. In most developing countries, men hold much power and control when it comes to decision making in the household level. Therefore, decision making of most women are based on what their male counterparts think is best (Balk, 1997). The variable sex is known to be an important determinant of technical efficiency. It has been found that male farmers are technically efficient compared to the female household heads. This could be explained by the fact that male household heads are wealthier and therefore are able to acquire technologies that are costly (Onumah &Acquah, 2010). Therefore, it is expected that there would be a negative relationship between the variable sex and technical inefficiency.

Access to credit

Financial institutions, both formal and informal are means by which farmers gain access to credit. However, in most developing countries, farmers tend to depend more on the informal institutions for financial assistance. The collateral security expected by the formal institutions and the high interest rates are barriers to farmers' access to credit. Furthermore, uncertainties in agricultural production can affect the productivity of farmers negatively. These factors limit farmers in their ability to pay back loans (Heidhues, 1995). The ability of a farmer to adopt improved technologies depends on credit accessibility. Adequate and timely access to credit is important in agricultural productivity. These will determine the farmers' access to inputs such as machinery, improved seeds, labour and fertilizer among others. Therefore, it is expected that access to credit will have a negative influence on technical inefficiency.

Off-farm activities

Off-farm activity is an additional work engaged in by farmers apart from farming to supplement household income. Studies have shown that farmers who engage in other non-agricultural activities are likely to be less efficient as they may fail to pay much attention to farm production (Ali & Flinn, 1989). Therefore, it is expected that off-farm work will positively influence technical inefficiency.

Extension services

The sources of information available to farmers have been divided into two. These are interpersonal, the face to face exchange of information and impersonal sources where one or more persons are able to get into contact with many at a time such as the use of the mass media (Okunade, 2007). In today's agricultural development, the access to agricultural information is necessary for increasing production. It has been argued by Singh, Priya and Singh (2011) that farmers should have access to information regarding new methods of production, seeds, fertiliser use to enhance their output. Although, access to extension services enhances efficiency, it has been found that some extension systems perform poorly as a result of organisational inefficiencies, unsatisfactory program designs and ineffective system of information delivery (Binam, Toyne, Wandji, Nyambi & Akoa, 2004). Farmers who have extension contacts are expected to improve their efficiency levels.

Membership of farmer based organizations (FBOs)

Membership to FBO's serves as a platform by which information regarding the availability of inputs and market prices are disseminated. Also, members of FBO's benefit from education on good agricultural practices. Membership of farmers' association is known to reduce the inefficiency level of farmers (Idris, Siwar & Talib, 2013). The active participation of farmers in their various groups also gives them the chance to share modern agricultural practices with the other farmers. Therefore, a negative relationship between membership of FBO's and technical inefficiency is expected.

Empirical review

Various researchers have undertaken studies to estimate the efficiency levels in the agricultural sector (Russell & Young, 1983; Battese & Coelli, 1988);Parikh et al., 1995; Ajibefun et al., 1996; Heshmati & Mulugeta, 1996;Wang , Cramer & Wailes ,1996; Seyoum , Battese & Fleming, 1998; Obwona, 2000; Chirwa, 2003; Ajibefun & Aderinola, 2004; Nchare, 2005).

These studies found positive correlations between the degree of technical inefficiency and education levels of farmers, age of farmers, land size, proportion of hired labour used, per capita net income and negative correlations between the degree of technical inefficiency and farmining experience and off farm employment.

A study conducted by Amaechi, Ewuziem and Agumanna (2014) estimated the technical efficiency of the small/semi-mechanized oil palm produce millers in Nigeria using the translog stochastic frontier production function model. A multi-stage sampling method was used to select 30 mills in the study area and cost route approach used in data collection. The estimates for the mills showed firm level mean technical efficiency of 70.62 per cent with a range of 37.48 per cent to 93.46 per cent. This wide variation in oil palm produce output of millers from the frontier output was found to have arisen from differences in miller’s management practices rather than random variability. This also implies that even under the existing technology, potentials exist for improving productive efficiency with proper utilization of available resources. Also, the estimated gamma value was 0.96; indicating that 96 per cent of the variation in output was attributed to technical inefficiency. Education, processing experience, membership of cooperative society, credit, capital, fruits throughput, petroleum energy and water were significant and positive determinants of technical efficiency while age, household size and interest on loans were negatively related to technical efficiency. Policies geared towards the enhancement of productive efficiency of this category of producers should appropriately address such issues as education, cooperativeness, and access to credit/capital, oil palm plantation rehabilitation, sustainable petroleum energy and supply of other necessary facilities.

In the Eastern Region of Ghana, Kuwornu, Amoah and Seini (2013) conducted a study to analyse technical efficiency of maize farmers. They estimated the coefficients of the inputs variables by employing the translog functional form. Some of the variables they hypothesised to influence technical efficiency included educational level, extension visits, credit in cash or kind, household size, farm experience, farmer based organisation (FBO) membership among others. Findings of the study revealed that FBO membership, frequency of meeting by members of FBOs, credit in cash or kind and formal training in maize farming were the key factors that influenced technical efficiency levels of maize farmers in that region. The coefficient of farmers who belonged to one group or the other was positive implying that they were less technically efficient than their colleagues who did not belong to any farmer based organisation. This outcome was associated with the fact that groups that meet throw less light on factors such as agronomic practices but spend much time on institutional factors such as favourable market outlets. Again, it was shown that farmers who had access to credit in cash or kind perform better in terms of production than their counterparts who had none.

The availability of credit enables farmers to acquire necessary inputs and take certain management decisions on time. Further, the study indicated that the mean technical efficiency level of maize farmers was 0.51 or 51 per cent. This implies that the difference between the actual and potential output is 0.49 or 49 per cent. Also, the output elasticity for maize production was estimated to be 0.47 indicating decreasing returns to scale.

Etwire, Martey and Dogbe (2013) used soybean farms to examine technical efficiency and its determinants in the Saboba and Chereponi Districts of Northern Ghana. The estimation of the technical efficiency level was carried out using the stochastic frontier model. It was found out that the Cobb-Douglas production function did not adequately fit the data. Therefore, it was concluded that the functional form that adequately represented the data was the translog production function. Further, the study showed a positive relationship between output levels of soybean and family labour as well as land. Based on this finding, output levels of soybean will increase if land under cultivation and family labour employed are increased up to a certain point, all other things being equal. Also, the output elasticities with respect to hired labour, seed and ‘other’ inputs were found to be negative. Thus, any further increase in seed, hired labour and ‘other’ inputs would influence output negatively. Farmer characteristics such as education and marital status had negative coefficients but were found to be statistically insignificant in determining technical efficiency. Age had a negative coefficient and was found to be statistically significant. This implies that younger farmers were less technically efficient as compared to older farmers.

Njeru (2010) examined the factors influencing technical efficiency in wheat farming in Kenya using a stochastic frontier production function in which technical inefficiency effects were assumed to be functions of both socioeconomic characteristics of the farmer and farm-specific characteristics. The paper used random sampling to interview 160 farmers comprising 97 large-scale farmers and 63 small-scale farmers. The results revealed existence of significant levels of technical inefficiencies in wheat production, especially among the large-scale farmers. The study found that the magnitude of technical efficiency varied from one farmer to another and ranged from 48.9 per cent to 95.1 per cent with a mean of 87.2 per cent. This implied that farmers lost the average, 13 per cent of their potential output to technical inefficiencies. There was variation depending on the size of farm with small-scale farmers attaining higher technical efficiency than the large-scale farmers. The main factors that influenced the degree of inefficiency were education levels, access to credit, and ownership of the capital equipment. Higher levels of education (12 years and above or secondary and above) significantly reduced inefficiency as did access to credit facilities and owning the farm equipment. The study recommended that farmers be educated on the use of better techniques such as use of certified seeds and application of recommended levels of fertilizer.

Ogunniyi and Ajao (2011) presented the analyses of cross-sectional data on swine production in Oyo state of Nigeria, a Cobb Douglas production function, in which the technical inefficiency effects were specified in terms of age, level of education and farming experience of the farmers was estimated for swine farmers in Oyo State of Nigeria. The stochastic frontier production function involved feed, family and hired labour, drug and total machinery cost.

The maximum likelihood estimate results revealed that feed, family labour, hired labour and drugs were the major factors associated with changes in output of swine. Given the specification of the Cobb Douglas stochastic frontier function, the results indicated that the technical inefficiencies of production of swine farmer were specifically related to age, level of education and farming experience. Furthermore, the coefficient for the age variable found to be positive implying that the older farmers are more technically inefficient than the younger farmers. Also, the coefficient for the level of education was positive implying that the higher the level of formal education of farmers, the more their technical inefficiency. However, the coefficient for farming experience was negative indicating that farmers with more experience tend to be less inefficient. It was evident from the Maximum likelihood Estimates of the parameters of the stochastic frontier production function that the sigma square ($\sigma^{2)}$ was statistically significant and more than zero at 5 per cent (0.05). This indicates a good fit and the correctness of the specified distributional assumption of the composite error term. More so, the variance ratio, gamma (ɣ) was estimated to be as high as 93 per cent, suggesting that 93 per cent of the variation in output level of the swine farmers was due to the technical inefficiency of the sample farmers.

Maganga (2012) adopted a stochastic production function approach to investigate technical efficiency and its determinants in Irish potato production in Malawi. The unknown frontier parameters were estimated using the method of maximum likelihood. It was reported that technical efficiencies of individual farmers ranged from about 0.45 to 0.98. This suggests that a wide difference exists among Irish potato farmers in their level of technical efficiency. The average level of technical efficiency was valued at 83 per cent, suggesting that farmers could improve their output level by 17 per cent with the existing technology. It was also concluded that non-farm employment, education, farm experience, household size, degree of specialization and frequency of weeding were significant in determining the variations in technical efficiency levels.

A study conducted by Awunyo-Vitor, Bakang and Cofie (2013) investigated the determinants of small-scale cowpea production in Ejura/Sekyedumase Municipality in the Ashanti Region using a stochastic frontier production function that incorporates inefficiency factors. Data for the study were collected from 200 randomly selected cowpea farmers within the district. A maximum likelihood technique was used to analyse the data. The results indicated that small-scale cowpea farmers were not fully technically efficient as the mean efficiency was 66 per cent. Farm size, seed, pesticides and labour were the major input factors that influenced changes in cowpea output. The result also shows that a farmer’s educational level, membership of farmer based organization and access to extension services significantly influenced their efficiency positively. The implications are that policies that would encourage cowpea farmers to join farmer based organizations and provide them with easy access to extension services are options that would improve the efficiency of the farmers. Also, the estimated gamma value was 0.71 or 71 per cent. This means that 71 per cent of the total variations in output were due to technical inefficiency in the study area.

Khai and Yabe (2011) used an econometric approach to analyse technical efficiency of rice production in Vietnam. A total of 3,733 rice farmers were interviewed. The Tobit model was used to determine the factors that influence technical efficiency. The study revealed that one variable that had an incremental effect on technical efficiency was the intensity of labour use. Thus, farmers tend to be less technically inefficient when more labour are utilised in rice production. It was also found that farmers who had access to irrigational facilities were more technically efficient as compared to those without irrigation. In addition, farmers who had no education or primary education were more technically inefficient than those who had secondary or higher education in Southeastern Nigeria. They found the average age of farmers to be 43 years. The estimated coefficients of land, labour and material inputs were found to have a positive relationship with output. Also, results from the maximum likelihood estimates showed that younger farmers, farmers who had access to credit and farmers with more years of schooling were more technically efficient. The estimated gamma value and the mean efficiency were 0.99 and 0.41 respectively.

Haider, Ahmed and Mallick (2011) in assessing technical efficiency of agricultural farms in Bangladesh used the Ordinary Least Square (OLS) and the Maximum Likelihood Estimation (MLE) methods to estimate the Cobb-Douglas production function parameters. Some of the major findings from this study were that the OLS as an estimation technique was inadequate in representing the data and that the intercept values of MLE were greater than the OLS estimates. In addition, the mean technical efficiencies of crop cultivating farms, fish cultivating farms and livestock cultivating farms were 69 per cent, 29 per cent and 66 per cent respectively. These suggest that all three areas of agricultural farming can improve their output levels with the given resources and technology. Again, in fish farming, only farming experience and access to credit were the factors that influenced efficiency although the coefficients of age, schooling years and family size were positive.

The Cobb-Douglas production function was employed by Adeyemo, Oke and Akintola (2010) to analyse the economic efficiency of small scale farmers in Ogun State, Nigeria. Two hundred cassava farmers were randomly selected for the study. It was revealed that about 90 per cent of the farmers were males and majority of the farmers had more than 10 years of farming experience. Farm size and quantity of planting stakes influenced output positively whilst quantity of fertiliser had a negative influence on output. The factors that influenced efficiency in cassava production were age, cost of fertiliser, cooperative, farming experience and educational level. The average technical efficiency was 89.04 with a minimum of 85.69 and a maximum of 100. Thus, cassava farmers were producing closely to the production frontier with small variations in output. The farmers were producing in the stage one of production as the return to scale was found to be 2.62.

Rahman, Mia and Bhuiyan (2012) found fertiliser, manure, irrigation cost, insecticide cost, area under production and experience to be the important factors to increase rice production in Bangladesh. In the technical inefficiency effect, age, education and family size had positive impact on efficiency effect, whereas land under household had negative impact on efficiency effect.

A study conducted by Enwerem and Ohajiana (2009) analysed the technical efficiency and the sources of inefficiency in large scale and small scale rice production in Imo State, Nigeria during the 2009 cropping season, using a stochastic frontier production function which incorporates a model for inefficiency effects. A sample of 160 farmers selected using the multi-stage stratified random sampling techniques were used to generate primary data with structured and validated questionnaire through the cost-route approach. Results showed that factors that affected the output of rice farmers were labour, capital, land and planting materials. Low capital base for investment, poor extension contact and poor access to credit were the major factors that influenced farmers' level of technical efficiency.

The mean technical efficiency scores were 0.65 and 0.69 for large and small scale farmers respectively, which implies that the mean technical efficiency index could be increased by 35 per cent and 31 per cent for large scale and scale farmers respectively through efficient reallocation of the available resources. The values of returns to scale were 2.255 and 2.011 for the large scale and small scale rice famers respectively, which implies increasing returns to scale, indicating that an increase in the use of the selected variables would result in more than proportionate increase in the production of rice. The value of sigma squared were 0.651 and 0.593 for large scale and small scale farmers which were equally statistically significant at 5 per cent level of probability indicating a good fit and correctness of the distribution assumption specified. The variance ratio (Gamma) which measures the effects of technical efficiency in the variation of observed output had values of 0.324 and 0.353 for large scale and small scale farmers respectively, which means that 32 per cent and 35 per cent of the total variations in the output of rice farmers were due to technical inefficiency.

Oyewo (2011) used the stochastic frontier model to estimate technical efficiency of maize production in Oyo State, Nigeria. In this study, it was concluded that a positive relationship exists between farm size, seeds and the level of maize output. This presupposes that as the use of these two inputs increases, output would also increase. It was also observed that level of education and years of farming experience had an inverse relationship to maize output.

The results from this study showed that farmers who had formal education were not many and so this could have accounted for the negative relationship with technical efficiency. Furthermore, the mean technical efficiency was estimated at 96 per cent and 12 per cent of the variations in maize output was due to inefficiencies. From Oyewo's results, it can be concluded that about 82 per cent of the differences in maize output was due to stochastic noise which is beyond the farmer's control.

Baten, Kamil and Haque (2009) used panel data to model technical inefficiency effects in a stochastic frontier production function. They assumed that the random variables followed a truncated normal distribution with a mean of zero and the parameters of the stochastic frontier function and that of the technical inefficiency effects were simultaneously estimated by the maximum likelihood method. The coefficients of labour and land area were found to be statistically significant in production. The mean level of technical efficiency was 0.51 from the period 1990 to 2004 and the technical efficiencies of individual producers ranged between 0.29 and 0.92. It was also established that the variable time and Herfindahl index (HHI) had a negative relationship with inefficiency. Smaller plantation sizes were found to be more efficient than the larger ones.

Al-hassan (2008) employed the stochastic frontier function to examine the technical efficiency level of rice farmers in Northern Ghana. A sample of 732 irrigators and non-irrigators rice farmers was used. The maximum likelihood estimator was used to estimate the parameters of the model. The average years of schooling showed that the highest level of education attained by the farmers was the primary school. It was also revealed that the average yield obtained by non-irrigators was higher as compared to the irrigators. Eighty six per cent of the differences in output were attributed to inefficiencies among the farms and 14 per cent accounted for random shocks which were beyond the farmers' control. Again, the mean technical efficiency was higher for non-irrigators. For both irrigators and non-irrigators, the main factors that influenced technical efficiency were education and extension contact.

Findings of a research conducted in Cross River State of Nigeria indicates that rice farmers operated at an increasing returns to scale as the value of the estimated output elasticity was 1.57. Also, the estimated gamma value was 0.77 suggesting that 77 per cent of deviations from the production frontier were as a result of inefficiencies in production and the remaining 23 per cent was due to factors that were beyond the farmers' control. It was also concluded that variables that had a positive and significant impact on technical efficiency were years of schooling, access to credit and membership of association. However, the coefficients of sex, age and household size had negative signs but were not significant. This investigation was undertaken by Idiong (2007) to estimate farm level technical efficiency in small-scale swamp rice production. The multistage random sampling method was used to select 56 respondents for the study.

Tijani (2006) estimated efficiencies on rice farms in Osun State, Nigeria and identified some socioeconomic factors which influenced productive efficiency. These technical efficiencies were estimated using the stochastic Frontier Production Function Approach applied to primary data. A tanslog production function was used to represent the production of the rice farms. The study showed that the levels of technical efficiency ranged from 29.4 per cent to 98.2 per cent with a mean of 86.6 per cent. This suggests that the average rice output fell 13.4 per cent short of the maximum possible level. Therefore, output could be increased by 13.4 per cent in the short run under the existing technology. The study also showed that these efficiencies are positively and significantly correlated with the application of traditional preparation methods and with off-farm income. The variance ratio (gamma) was estimated to be 51.3 per cent, implying that about 51 per cent of the discrepancies in between observed output and the frontier output were due to technical inefficiency.

This study adds to the existing body of literature by using the stochastic frontier approach to analyse the factors influencing technical efficiency among rice farmers on the Weta irrigation scheme in the Ketu North District in the Volta region of Ghana.

Overview of the rice sector in Ghana

Rice is fast becoming a cash crop for many farmers in Ghana (MiDA 2010; Osei-Asare, 2010). National and agricultural development plans and strategies, such as the Ghana Poverty Reduction Strategy (GPRS I), Growth and Poverty Reduction Strategy (GPRS II), Food and Agricultural Sector Development Policy (FASDEP) I and II, Medium Term Agriculture Sector Investment Plan (METASIP), and Accelerated Agricultural Growth and Development Strategy (AAGDS), have featured rice as one of the targeted food security crops. Annual per capita consumption of rice is growing rapidly, from 17.5 kilograms in 1999–2001 to 22.4 kilograms in 2002–2004 and 24 kilograms in 2010–2011 (MoFA 2011a), and rice demand is projected to grow at a compound annual growth rate of 11.8 per cent and maize at 2.6 per cent in the medium term (MiDA, 2010). Several estimates show very high levels of imports valued at US$500 million annually (Osei-Asare, 2010), putting much pressure on foreign currency reserves and food security in Ghana. Estimates show that imported rice comprises about 70 per cent of the quantity consumed in Ghana, or a 174 per cent import penetration ratio (Amanor-Boadu, 2012).

Following the Tokyo International Conference IV on Africa Development (TICAD IV) in May, 2008 an initiative, Coalition for Africa Rice Development (CARD) was launched. This strategy is an outcome of Ghana Government’s subscription to the vision of the initiative to double rice production in Africa.

The Ghana National Rice Development Strategy which covers the period 2008 to 2018 is a response to forestall the effects of the global food crisis. The strategy proposes to double rice production taking into consideration the comparative production capacities of the three major ecologies (rain fed upland, rain fed lowland and irrigated). Over the last 10 years (1999-2008), per capita rice consumption increased from 17.5 kilograms to 38.0 kilograms. By 2018, it is estimated that it will grow to 63 kilograms as a result of rapid population growth and urbanization.

In developing this strategy, National experts from multi-sectorial backgrounds with inputs from donor groups operating in Ghana have variously impacted on the development of production and manpower requirements and set objectives. The major constraints especially land development and land tenure arrangements, seed, fertilizer, inadequate human resource capacity, inadequate harvesting and post-harvest management technology, weak local rice marketing system and the role of Government and related agencies have been considered. A governance structure with many of the key actors in the rice sector has been considered and may be modified as the project unfolds. The role of government, public sector, private sector, NGOs have been considered crucial for the attainment of the goals of the strategy. The implementation plan which will be developed subsequent to the adoption of the NRDS will indicate the details of the action plans and funding.

Global rice imports have increased by 80 per cent from 2.5 billion tonnes (grain) in the early 1990s to 4.5 billion tonnes in 2004. During the same period, African countries increased rice imports by 140 per cent from 5 million tonnes in the early 1990s to 12 million tonnes in 2004. This is equivalent to about a quarter of the world import, with an import value estimated at US$2.5 billion. West African countries show the same increasing trend of rice import, increasing from 4 million tonnes (US$ 0.8 billion) in early 1990s to 8 million tonnes (US$1.6 billion) in 2004-2005, accounting for two-thirds of Africa's rice import (Amanor-Boadu, 2012).

Status of rice in national policies

Policy strategies over the years as captured in FASDEP I, GPRS I & II, METASIP, AAGDS and Ministry of Food and Agriculture policy documents have sought to promote rice production to address food security and poverty reduction. FASDEP II, which is an agriculture sector development policy guideline (2008 – 2010), targets reducing rice imports by 30 per cent through increasing production levels to 370,000 tonnes per annum to ensure food security and import substitution. Specific measures, among others, to reach this level of production are increased mechanization, increased cultivation of inland valleys and efficient utilization of existing irrigation systems. In addition, varietal improvement and increased seed production and utilization are to be pursued vigorously (MoFA, 2011).

Rice consumer preferences, per capita consumption and demand projections

There is a wide variation in rice consumer preference in Ghana on the basis of grain characteristics. However, most consumers prefer long grain perfumed rice of good taste, good appearance, and with whole grains, although broken grains have their place in specific local dishes. Health-conscious consumers patronize local brown rice while parboiled rice is preferred in the Northern regions of Ghana.

Annual per capita rice consumption during 1999-2001 was 17.5 kilograms on average. This increased to 22.6 kilograms during 2002-2004. In the same period, per capita rice consumption increased to around 8.9 per cent per annum, higher than the population growth of 2.5 per cent per annum. Assuming the same trend continues, per capita rice consumption will increase to 41.1 kilograms in 2010 and 63.0 kilograms in 2015. Based on population growth rate alone the current demand of about 500,000 tonnes per year is projected to increase to about 600,000 tonnes per year in 2015. However, taking both population growth and increase in per capita consumption together, rice demand will increase to 1,680,000 tonnes per year (Ragasa, et al., 2012).

Typology and number of rice farmers

Rice producers in Ghana are categorized by agro-ecologies namely: irrigated, rain fed lowland and rain fed upland. In general, the lowland rain fed system covers 78 per cent of the arable area; the irrigated system covers 16 per cent while the upland system covers 6 per cent. The majority of local rice production comes from the Northern (37 per cent), Upper East (27 per cent), and Volta regions (15 per cent). Production in the Northern and Upper East regions decreased in 2011 due to poor weather condition, but production in Volta continued to increase and did not seem to be affected by less rain in 2011.

In general, rice production and the area cropped with rice are increasing. Since 2007, production has been increasing at a faster rate than areas of cultivation; a proof that yields during this period have been trending upward. This growth is encouraging and may have been the result of the various initiatives to develop the rice sector in Ghana, including passage of the National Rice Development Strategy in 2009; various donor-funded projects, the majority of which were implemented in the period 2004–2009; and the national fertilizer subsidy program introduced in 2008, to which rice farmers had responded.

There was a jump in production and acreage starting in 2008, which could be a compounded result of these various initiatives. However, the national average yield has remained low, at 2.5 tonnes/hectare/year or 2.2 tonnes/hectare/season according to a survey by the Crops Research Institute (CRI), Savannah Agricultural Research Institute (SARI), and International Food Policy Research Institute (IFPRI), indicating significant opportunity to reach potential achievable yields of 6–8 tonnes/hectare (MoFA, 2011).

Potential for rice sector development

There is potential to develop the rice sector in Ghana. Rice demand is projected to grow (MiDA, 2010), and prices have been trending upward over time. The average wholesale price of local milled rice (100 kilogram bag) more than doubled, from GH₵55.00 in 2006 to about GH₵120.00 by 2011, while that of imported milled rice nearly tripled, from about GH₵60.00 to nearly GH₵169.00 (Amanor-Boadu, 2012). Considering a monthly salary for a middle-income earner in Accra of about GH₵400.00 per month, rice purchases account for a substantial portion of household income. These statistics indicate the economic viability and attractiveness of rice production, as confirmed by a policy analysis matrix calculated by Winter-Nelson and Aggrey-Fynn (2008) and Akramov and Malek (2011), although profitability becomes negative when subsidies and trade protection are removed and when family labour is included in the calculation (Amanor-Boadu, 2012).

Imported rice is priced higher than local rice, by about 15–40 per cent on average, and is mainly associated with better-quality long-grain perfumed rice of good taste and good appearance (translucent and with whole grains, although broken grains have their place in specific local dishes). Interviews among farmers in Ashanti region suggest that farmers sell a 50-kilogram bag of Jasmine 85 (perfumed and long grain) at GH₵90.00, while Sikamo (unperfumed local rice) sells at GH₵60.00 to GH₵70.00 per 50 kilograms bag (Amanor-Boadu, 2012).

The rice sector in Ghana is segmented into two distinct target markets of local and imported rice. Imported rice is more popular in urban centres in general. In Accra, there is a heavy preference for imported rice; 95 per cent of sample consumers were more familiar with imported varieties, and 71 per cent consumed only imported rice and never tried local rice (Diako et al., 2010). However, the adoption of fragrant local varieties by growers (e.g., Jasmine 85, Togo Marshall, and Aromatic short) nearer to Accra is giving access to consumers in the capital (Osei-Asare, 2010). In Accra, Kumasi, and Tamale, 86 per cent of sample consumers prefer imported rice, while a niche segment (14 per cent) prefers local rice (Tomlins et al., 2005). While the appearance of raw rice is critical to consumers' choice, taste and aroma determine consumer preference for cooked rice (Diako et al., 2010).

The reasons given for not purchasing locally cultivated rice were poor postharvest handling, unavailability, and the generally perceived poor quality. The 29 per cent who tried local rice did so because it is relatively cheaper than imported rice and is perceived it to be more nutritious than imported rice (Diako et al., 2010). A study by Diako et al. (2011) confirms that local varieties have a higher mineral content than imported varieties, although imported varieties have the advantage of being easier to cook and the expansion ratio is greater, which is another feature preferred by many consumers.

However, local rice is preferred in many rural areas where there is local production, especially in northern Ghana. In certain niche segments, health-conscious consumers purchase local brown rice while parboiled local rice is preferred in the Northern Region of Ghana. The study by Acheampong, Marfo and Haleegoah (2005) in Hohoe and Bibiani Districts in the Volta Region and Western Region respectively suggests a strong preference for local varieties, as consumers perceive that local rice contains more nutrients than imported rice. Moreover, sample consumers interviewed reported that local rice was consumed because it was more readily available than imported varieties. These findings suggest that there is existing demand for local varieties, that greater promotion of the nutritional advantages of local varieties could further boost purchases of local rice, and that improved post-harvest handling and quality standards could enable several local perfumed rice varieties to directly compete with imported rice.

On the supply side, vast potential irrigable lands, valley bottoms with water supply, and water bodies throughout the regions are available (Osei-Asare, 2010). It is also said that because rice has been grown in Ghana for centuries, there is indigenous knowledge of rice that can be tapped in developing suitable agronomic practices (Osei-Asare, 2010). In addition, the policy environment is also advantageous for rice production. The development of the rice sector seems to have received plenty of attention in Ghana over the years, as evidenced by numerous projects and programmes supporting the sector.

Rice research program

Rice research in Ghana is performed primarily by the Crops Research Institute (CRI) and the Savannah Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR). The University of Ghana and other universities also conduct both varietal research and testing and socioeconomic research on rice. Scientists at CRI and SARI reported that about 80–90 per cent of research work is on varietal improvement and testing (MoFA, 2011).

History of irrigation development in Ghana

Small scale irrigated agriculture practice across the country dates back as early as 1880 in Keta areas on land above flood level between the lagoon and the sandbar separating it from the sea. The method was so adopted in the area, in the sense that the natural condition was not in support of the principle of shifting cultivation in agriculture as practised elsewhere.

The first irrigation scheme in the country was set up by the government in 1920. This was an integral part of the then Winneba Water Supply Project (Smith, 1969). Soon after independence in 1959, the first national irrigation project in Dawhenya was established. However, available records reveal that Asutuare Irrigation Project was the pioneer scheme in 1967.

The 1950s and 1960s witnessed some water development schemes accounting for about 240 earth dams and dug-outs in the North and about 66 in the Ho-Keta plains of the South purposely to provide water for dry season irrigated agriculture. Currently, irrigation schemes are managed by the Ghana Irrigation Development Authority (GIDA) set up by Supreme Military Council Decree (S.M.C.D) 85, 1977 and their function is to provide for the development of irrigation and other related matters (Owusu, Nyantakyi & Borkloe, 2013).

Irrigation schemes in Ghana

There are about forty official irrigation schemes across the length and breadth of the country. The Ghana Irrigation Development Authority (GIDA) has 22 irrigation schemes cultivating rice under its jurisdiction covering about 14,100 hectares out of which 53 per cent are developed and about 5478 hectares is actually put under irrigation (Owusu, Nyantakyi & Borkloe, 2013).

Rice irrigation schemes in Ghana

The self-sufficiency policy, adopted in Ghana during the 1970s, resulted in the creation of the Ghana Irrigation Development Authority (GIDA) of the Ministry of Agriculture as a semi-autonomous organization in 1977. In GIDA, a lot of emphasis was placed on the development of large-scale irrigation projects for the production of rice. The ultimate aim was to reduce the country's dependency on imported rice.

Rice yields on the irrigation projects vary between 4.0–6.0 tonnes/hectare, with an average yield of about 4.6 tonnes/hectare. Yields of rice on irrigation schemes, and cropping intensity, are directly related to the amount of water available from season to season. It is estimated that the contribution of irrigated agriculture to the total national rice production needs to be about 24 per cent in order to satisfy national demand. Only seven of the schemes are seriously into rice irrigation. The others are shared schemes which incorporate mix cropping; involving rice and other crops especially vegetables (Owusu, Nyantakyi & Borkloe, 2013).

Constraints to rice production

The inability of farmers to produce maximum output from their resources can partly be attributed to production constraints. This section provides an empirical review of the constraints faced by rice farmers so as to propose government policies that seek to overcome the constraints to domestic production of rice.

A study conducted by Thahn and Singh (2006) surveyed 100 farmers in Punjab and West Bengal states of India and Giang and Vinh Long provinces of Vietnam. It found that the agro-ecological constraints faced by farmers, ranked from more to less serious were related to dependence on monsoon; land/soil problems; environmental pollution; lack of water and small land holdings. Under technical constraints, it was found that diseases (sheath blight, blast, and stem rot); pests; lack of proper varieties; post-harvest technology constraint; storage problems were the most serious constraints perceived by large percentage of respondents. Fertilizer problems; plant protection constraints; weed problems; lack of labour and poor processing were found to be other constraints as perceived by farmers. In case of socio-economic constraints, the study found that poor infrastructures; high cost of inputs; credit problems; low rice price; inadequate inputs and lack of trainings were the most important constraints as perceived by large percentage of farmers. Other constraints as perceived by lower percentages of farmers were poor extension services; lack of information and lack of helpfulness from local authorities/governments.

Obiri-Opareh (2008) analysed some factors that adversely affect rice production in Ghana as a whole and at some irrigation projects in particular, and measures put in place to address them. The study was based mainly on a field survey conducted at the Dawhenya Irrigation Project (DIP) between 2004 and 2007 as part of a policy study on irrigation agriculture in Ghana. The findings showed that the local rice industry had suffered from, among others, high cost of inputs and production constraints at the pump-type irrigation projects (PTIPs); particularly the high electricity tariffs that had resulted in closure of some irrigation schemes, including those at Dawhenya and Weija, difficulties in accessing credit, use of poor-yielding seed varieties, inappropriate agronomic practices, limited mechanisation, poor processing methods, and poor marketing strategies.

Omofonmwan and Kadiri (2007) examined the problems and prospects of rice production in the Central District of Edo State, Nigeria. It was found that the aged and illiterates dominate rice farming. The farming system was characterized by the use of crude implements, small farm holdings and subsistence. Other findings of the study were no extension workers, farmers' unawareness of new varieties of rice seedlings, high cost of fertilizers, diseases and attack from pests like birds, rodents. Yield per farm was low and financial return was correspondingly low.

Matanmi, Adesiji, Owawusi and Oladipo (2011) investigated the perceived factors limiting rice production in five selected villages in Patigi Local Government Area of Kwara State, Nigeria. The study area was purposively selected based on their known potentials for rice production. One hundred and ten rice farmers were selected for the study. An interview schedule was used to obtain information from the farmers. Frequency counts, percentage and means were used to analyze the data. The study revealed that the perceived limiting factors in rice production include lack of rice processing machines, financial constraints, illiteracy, poor access to inputs, pests and diseases, poor transportation, fluctuations in climate, lack of extension services and lack of storage facilities. It is recommended that government should assist the rice farmers with the provision of rice processing machines such as threshers and destoners and credit facilities so as to improve the quality and quantity of rice produced in the study area.

Alarima Adamu Masunaga and Wakatsuki (2011) conducted a study to examine the constraints to the adoption of sawah system of rice production in Nigeria. Data were collected from 124 randomly selected sawah-rice farmers.

Data were analysed using correlation and regression to determine the relationships between the study variables.

The results showed that respondents were predominantly male (98.80 per cent), married (98.80 per cent) and had Quranic education (62.70 per cent). Farm size ranged from 0.03 to 10 hectares, mean yield was 4.65 tonnes/hectare, and mean income was $1,041.38. Production and on-farm constraints affecting sawah development were water management and flood. Major economic constraints faced by sawah farmers were lack of viable financial agencies to support production, poor capital base and non-availability of loan. Regression analysis showed that the yield of sawah was negatively related to land acquisition constraints ($b=-0.34$, $p<0.05$) and technological constraints ($b = -0.43$, $p < 0.01$). This study concluded that problems faced by farmers were interwoven in which existence of one relates to the other. Addressing these problems will lead to increase in the rate of adoption of sawah rice production technology and ultimately rice productivity in Nigeria.

Musiime, et al. (2005) carried out a Participatory Rural Appraisal (PRA) to identify the major constraints to rice production which led to the increased rice yield gap in Bugiri district, Kampala, Uganda. Two rice growing villages; Nkaiza and Bupala for upland and paddy rice, respectively were used for the PRA based on two hypotheses: major constraints contributing to rice yield gap are both socio-economic and biophysical; the traditional banana-coffee crops still dominate the cropping systems. Informal discussions were held with farmers' groups in each of the villages on issues regarding major rice constraints, existing coping mechanisms, rice production, and the existing cropping systems. The major constraints were identified and ranked in their order of importance using a pair-wise ranking tool as water management (28.6 per cent), soil nutrient depletion (23.8 per cent), weeds (19.0 per cent), labor (11.9 per cent), pests and diseases (11.9 per cent), poverty (4.8 per cent) for wetland rice while weeds (33.3 per cent), change in rainfall patterns (23.3 per cent), soil nutrient depletion (20 per cent), labor (16.7 per cent), pests and diseases (6.7 per cent) was the order of importance of constraints for upland rice production. Generated coping mechanisms to the identified constraints were; draught animal power (for labor constraint), resistant varieties (insect pests & diseases), pests (bird chasing, rat traps), water management (planting at different periods), soil nutrient depletion (Fertilizer application and proper straw management), weeds (maintenance of recommended water levels, herbicide control) and changing rainfall patterns (early planting).

Conceptual framework

The conceptual framework represented by Figure 2 presents the relationships between the main variables of the study. The input factors such as land area under cultivation, labour, fertilizer, irrigation facilities and equipment directly affect the state of production of rice which includes farm size, farming methods used, the technology employed, among others. The socio-economic characteristics of the farmer such as age of farmer, farmer's educational background and household size also determine the state of production. For instance, the age of the farmer and household size influence the size of the farm. Constraining factors such as erratic rainfall patterns, high cost of labour, inadequate capital and low output price of rice directly affect the state of production. The state of production directly influences output of rice which, in turn, determines the level of technical efficiency of the farmer.

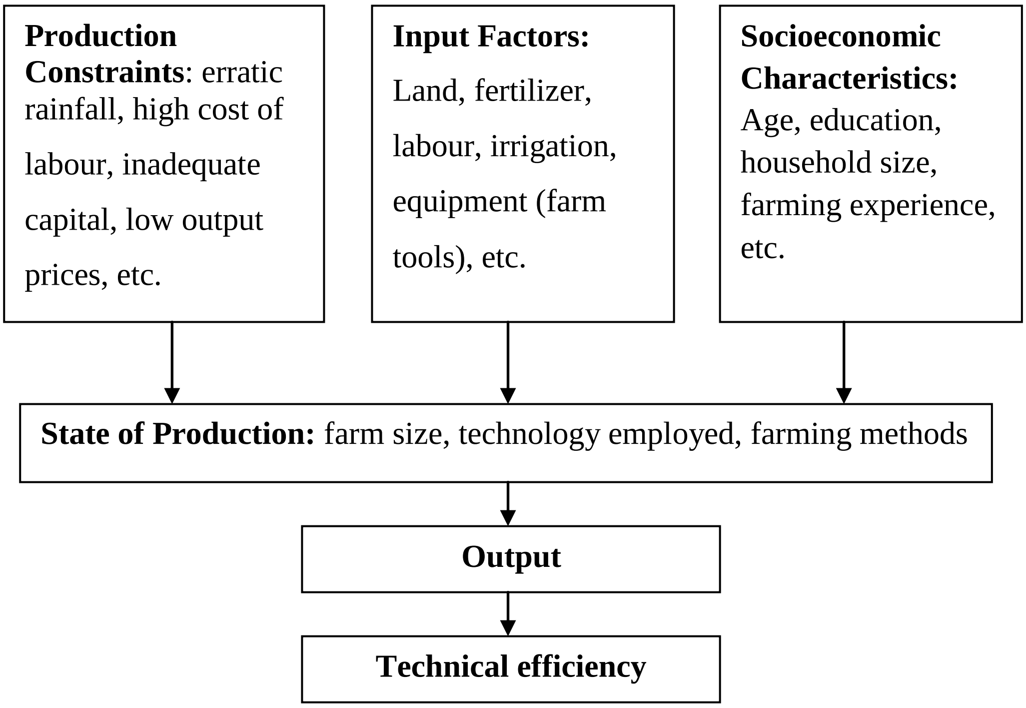

Figure 2: Conceptual framework

Source: Author’s construct, 2015

CHAPTER THREE

METHODOLOGY

Introduction

This chapter describes how the study was conducted. It talks about the study area, research design, population and sampling, research instrument, data collection procedure and the analysis of data.

Study area

The study was conducted in the Ketu North District of the Volta Region. The Ketu North District was one of the thirty two newly created districts in the Volta Region in 2008. It was carved out of the original Ketu District by a legislative instrument, L118 41 in 2008 in the district.

The Ketu North District is located between latitudes 6^{o} 03"N and 6^{o} 20"N and longitudes 0^{o} 49'E and 1^{o} 05'E. It shares boundaries with the Akatsi North District to the North and the Republic of Togo to the East. To the South, it is bounded by the Ketu South District and Keta Municipality and to the west it is bounded by the Akatsi South District. The district capital, Dzodze is about 80kilometres from Ho, the capital of Volta Region. The district has a surface area of about 754 square kilometres. Figure 3 shows the map of the district in national context.

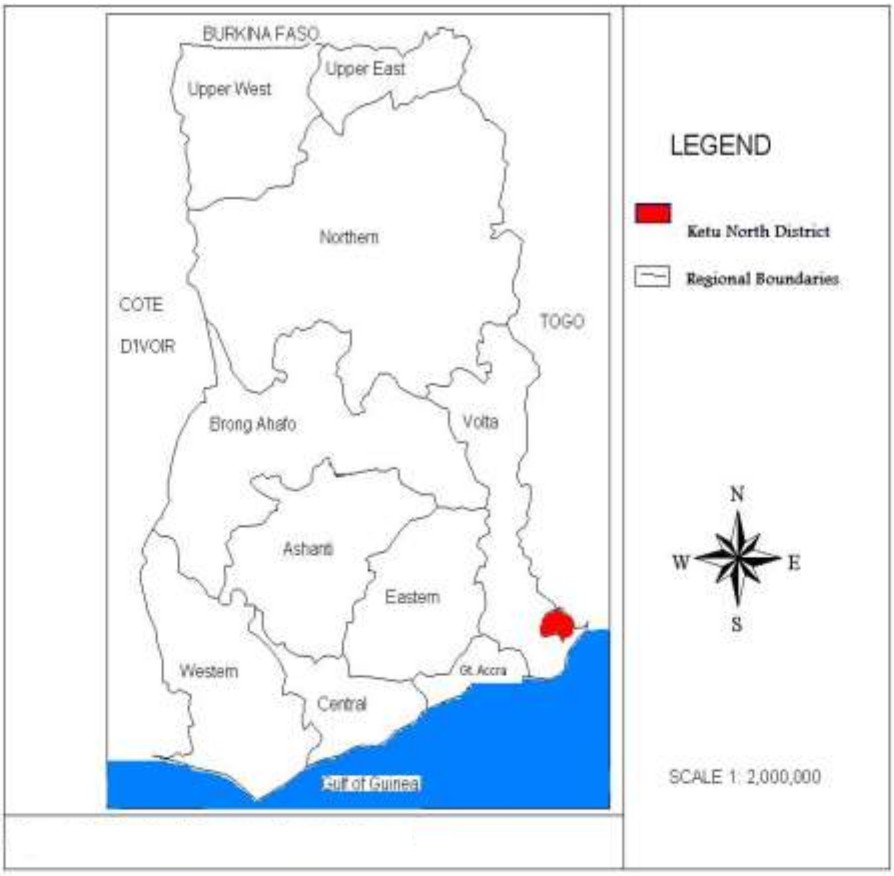

Figure 3: Ketu North District in national context.

Source: MoFA, Ketu North District, 2014

The area of the district is underlain by three main geological formations; namely, the Dahomenyan formation to the North made up of soil such as Tropical Grey and Black Earths, the Regosolic Groundwater Laterites, the Recent Deposits of the littoral consisting of the Tertiary formation comprising Savannah Ochrosols for its soil type. These soil types are suitable for the cultivation of different types of crop. (Ministry of Food and Agriculture, Ketu North District, 2014)

In terms of relief, Ketu North District is relatively low lying with altitudes around 66 metres. The plain nature of the terrain makes movement within the district easy. The Drainage of the district is towards the South and is dominated by several seasonal streams that flow in wide valleys between

Ohawu and Ehie to end in the swamplands of Afife. The major rivers include Kplikpa and Tsiyi. There are about six large fresh water reservoirs (dams) - Ohawu, Kporkuve, Dzodze, Tadzewu, Dekpor-Adzotsi and Lave as well as a few small community dugouts in the district.

The district experiences the dry Equatorial type of climate. The average monthly temperatures vary between 24℃ and 30℃, which are generally high for plant growth throughout the year. The mean annual rainfall for the district is around 800 millimetres. The rainfall is of double maxima type occurring from April to July and September to October. The dry season, which is mainly dominated by the dry harmattan winds, extends from December to February in the district. Generally, rainfall in the district is considered low and erratic particularly during the minor season (MoFA, Ketu North District, 2014).

The original vegetation of the district is Savannah woodland made up of short grassland with small clumps of bush and trees as well as mangrove forests in the marshlands are found in the district. However, the extensive farming activities in the district have, over the years, reduced the natural vegetation. Amid these are cultivated holdings of cassava, maize, coconut, oil palm, and velvet tamarind, the occasional baobab and fan palm. The decimation of the vegetation by population pressure may have adversely affected rainfall in the district. The physical characteristics of the Ketu North District contain a basket of potentials that can be tapped for the socio-economic development of the area. In terms of relief and drainage, the vast expanse of flat land is a potential for large scale mechanized farming. Road construction and other activities are also relatively less costly.

The water resources in the district could also be harnessed for irrigation purposes, especially for rice cultivation and dry season gardening aside its current use for the supply of potable water for some communities in the district. The high intensity of the sun in the area provides abundant solar energy, which is already being used by farmers for preservation and storage purposes (MoFA, Ketu North District Assembly, 2014).

The economic activities in the area include Ewe-Kente (the traditional cloth) produced by numerous weavers in the district. Handicrafts like works of metal; clay, fiber and wood dominate the relics and jewellery of the shrines in Ketu North. There are small-scale workshops with basic equipment located in the urban centres to produce metal products such as hand tools for farming and cassava graters. The linkage between processing and manufacturing on one hand, and the agriculture sector on the other is however weak (MoFA, Ketu North District, 2014).

In the area of financial services, there is one Commercial Bank in the district namely, the Ghana Commercial Bank located at Dzodze. There is also a branch of the Avenor Rural Bank located at Dzodze. These banks are expected to provide credit to promote agricultural production as well as commercial activities in the district. A large section of the population of the district, however, lacks access to banking services (MoFA, Ketu North District, 2014)

Based on estimates from the 2010 population census, the Ketu North District has a population of 99,913. The population of the district has always been experiencing growth over the years. From 1970 to 1984, the district experienced a population growth rate of 1.9 per cent. This growth rate remained unchanged for the1984 – 2000 censual year.

Another significant feature of the district population is its large labour force. The cohort that falls within the active labour force constitutes 52.5 per cent of the district population. This is a bit lower than the national active labour force of 55.2 per cent and higher than that of the regional figure of 52.2 per cent. This large active labour force could be positioned to harness and maximize the vast agricultural potentials of the district (MoFA, Ketu North District, 2014).

Agriculture is the mainstay of the Ketu North District economy. It employs about 70 per cent of the economically active labour force. Nearly every household in the District is engaged in farming or agricultural related activity. There are over 27,781 (13,752 males 14,029 females) members of household who are into agriculture. Farming in the district is largely carried out on small-scale basis. The average acreage cultivated ranges between 0.4-0.8 hectares for the major staples like maize, cassava, rice, cowpea and sweet potato, whilst the area under vegetable production is considerably smaller. Most farming households keep small ruminants like goats and sheep (MoFA, Ketu North District, 2014).

The crop sub-sector accounts for about 60 per cent of agricultural activities in the District. The crops in the sub-sector can be categorized as arable crops, plantation crops and vegetables. The soils in the area favour the production of a variety of crops. Currently, crops grown in commercial quantities in the district include maize, cassava, sweet potato, cowpea and rice (MoFA, Ketu North District, 2014).

Irrigated Rice production in the District, which is solely on the Weta Irrigation project, is under the management of Ghana Irrigation Development Authority (GIDA) and the developed area under production is 880 hectares out of the total land size of 950 hectares. There are a total of 1,024 farmers on the project with an estimated yield of 4.5-5.0 tonnes/hectare. From 2010, production on the Weta Irrigation Project has increased dramatically due to the double season cropping pattern adopted by the scheme (MoFA, Ketu North District, 2014).

The Weta Irrigation Project is located approximately between latitudes 6^{o} 04’ and 6° 08’ and longitudes 0^{o} 45’ and 0^{o} 55’ East at a distance 162 kilometres east of Accra. The project consists essentially of two (2) earthen dams situated on the lower reaches of the Agali and Kplikpa rivers that deliver water to the field by gravity. The Agali reservouir was constructed by the Soviets in 1962 and later rehabilitated in 1982 by the Chinese during the construction of the Kplikpa reservouir. The project headwork’s is an earth fill dam of height 11.5 metres and a crest level of 18.80 metres. The spillway level is at an elevation of 15.49 metres and the surface area at the spillway elevation is 544 ha. The reservouir capacity is 29.45 cubic millimetres. The dead storage is about 12.21 metres and the surface area at this elevation is 2.73 square kilometres. The dead storage capacity is 3.32 cubic metres. The spillway type is open with length of 50 metres and a design discharge of 320 cubic metres/second (Ghana Irrigation Development Authority, Ketu North District, 2014).

The essence of extension services is to upgrade the knowledge of farmers in improved techniques and modern methods of agriculture with a view to improving upon incomes and output. Extension services have not been within easy reach of the prospective farmer. According to the District Directorate of Agriculture, the district is zoned into eighteen agricultural operational areas. For an efficient extension service delivery, one operational area needs to be manned by One Agricultural Extension Agent (AEA).There are currently eight Agricultural Extension Agents (AEA) in the district expected to man the eighteen operational areas. If the entire district should be covered, then one operational area would be just too big for one AEA to cover. It is no wonder therefore that majority of the farmers do not have access to their services. Farmer- Extension ratio is too high (3,500:1) in those areas that have access to their services. These are in areas where the AEAs are resident. In these cases, they attend to other farmers outside their operational areas based on demand through phone calls as well as home visits. (MoFA, Ketu North District, 2014).

Research design

The study employed cross-sectional survey research design to measure the technical efficiency of rice farmers. In this design, a sample of the population was selected from which data were collected to answer research questions of interest. It is called cross-sectional because the information that were gathered about the phenomenon represent what existed at only one point in time. A cross-sectional study is one that produces a 'snapshot' of a population at a particular point in time. The single 'snapshot' of the cross-sectional study provides researchers with data for either a retrospective or a prospective enquiry (Louis, Lawrence & Keith, 2007). This research design is appropriate as it makes inference about the effect of one or more explanatory variables on the dependent variable by recording observations and measurements on a number of variables at the same point in time (Gay, 1992).

Population

Amedahe (2002) defines population as the target group about which the researcher is interested in gaining information and drawing conclusions. The target population was all rice farmers in the Ketu North District of the Volta Region. The accessible population for the study included all the 1,024 rice farmers on the Weta irrigation scheme in the Ketu North District.

Sample size and sampling technique

Hummelbrunner, Rak and Gray (1996) explain sampling as selecting a portion of the population that is most representative of the population. The study employed a two-stage sampling technique to select the participants for the study. The rice farmers on the Weta Irrigation Scheme were grouped into 11 sections by the Irrigation Development Authority. Considering each section as a cluster, six sections were selected at random at the first stage. At the second stage, a total of 290 rice farmers were chosen from the six sections using proportionate random sampling technique to form the sample for the study. A sampling frame was obtained from the Irrigation Development Authority. The computer software programme known as excel was then used to generate a list of randomly selected numbers within a specified range. Rice farmers with those randomly selected numbers were then identified and interviewed. This sample size was determined using the sample size determination table produced by Krejcie and Morgan (1970). However, out of the 290, only 285 rice farmers were reached, giving a response rate of 98.3 per cent.

Instrumentation

The structured interview schedule was developed by the researcher and used to collect data relating to technical efficiency in rice production from the respondents (farmers). It contained both open-ended and close ended questions. A structured interview is an interview in which the specific questions to be asked and the order of the questions are predetermined and set by the researcher. It is based on a strict procedure and a highly structured interview guide which is no different from a questionnaire. The structured interview is, in reality, a questionnaire read by the interviewer as prescribed by the researcher. The rigid structure determines the operations of this research instrument and allows no freedom to make adjustments to any of its elements such as content, wording or order of questions (Amedahe, 2002).

Data were collected on socio-economic characteristic of farmers, input and output quantities and the constraints faced by rice farmers. The structured interview schedule comprised four sections; namely, A, B,C and D. Section A covered the farm and farmer- specific characteristics such as the age of the farmer, sex of farmer, household size, educational level, marital status, off-farm work, farming experience and years of formal education. Section B of the interview schedule dealt with the production activities of the farmer such as methods of weed control, access to technical training, access to credit, access to agricultural extension services and number of times of producing rice in a cropping year. Section C of the interview schedule provided information on the inputs used and the output obtained by the farmer. These included information on land, labour, materials used for planting, fertilizer, equipment, chemical use and output obtained. The last section, D covered the constraints that farmers face in the production of rice in the district. This included input, production, and marketing constraints.

Pre-testing of instrument

Sarantakos (1997) defines a pre-test as small tests of single elements of the research instrument which are predominantly used to check eventual 'mechanical' problems of the instrument. The instrument was pre-tested before it was used for data collection. The pre-test was undertaken in November, 2014 using 30 respondents who cultivated rice in the South Tongu District. This helped to check the adequacy of response categories, ambiguity and respondents' interpretation of certain questions, thereby making it possible for adjustments to be made where necessary. Inaccuracies identified during the pre-testing were corrected before the actual data collection took place.

The reliability of the instrument was established using the Cronbach's alpha reliability coefficient. The reliability coefficient was estimated at 0.75. According to Cohen, Manion and Morrison (2007), the widely acceptable minimum standard of internal consistency is 0.70. Therefore, the reliability coefficient of 0.75 is interpreted as high; implying that the individual items or sets of items on the instrument would produce results consistent with the overall instrument.

Data collection procedure

Data were collected by the researcher and two field assistants during the 2014/2015 cropping season. The selection of the field assistants took into consideration their level of education and their ability to speak the local language of the farmers. A visit was paid to the study area by the researcher with an introductory letter from the Department of Agricultural Economics and Extension, University of Cape Coast to inform the District Director of Agriculture, the Irrigation Scheme Manager, the Sectional Heads and the rice farmers about the study a month ahead of the data collection date. A two-day training programme was organised to equip the field assistants with interviewing skills and to explain to them the various items on the instrument. A second visit was paid to the study area to agree on the date and duration for data collection with the rice farmers and their Sectional Heads a week before data collection began. Data collection was done for a period of two months.

Description of output and input variables for the study

Output: This refers to the total quantity of rice harvested during the 2014/2015 cropping season and it is measured in kilogram per hectare.

Land: It is the area of the farm allocated to the production of rice and this variable was measured in hectares. The amount of land used was expected to have a positive influence on output.

Labour: This includes both family and hired labour and it was measured as person-days per hectare of farm from land preparation to harvesting. It was expected that labour would have a positive influence on output.

Equipment: The cost of farm tools and machinery involved in the production process. It is measured in Ghana cedi (GH₵) per hectare. The use of equipment was anticipated to increase output.

Seed: The quantity of rice seeds planted and it was measured in kilograms (kg) per hectare. The plant population of rice is influenced by the quantity of seeds planted per hectare of land which will, in turn, influence output.

Pesticide: The quantity of agrochemicals (fungicides and insecticides) used per hectare of land and it was measured in litres per hectare. Its influence on output could be positive or negative.

Weedicide: This is the quantity of chemicals applied to control weeds before and after planting. It was measured in litres per hectare of farmland. Like pesticides, the use of weedicides can influence output positively or negatively.

Fertilizer: The amount of fertilizer applied on rice plots in kilograms per hectare during the 2014/2015 cropping season. It was expected that fertiliser will have a positive effect on yield.

Irrigation cost: This was measured as the amount (in Ghana cedi) spent on irrigation per hectare per cropping season. This was expected to increase output.

Description of farmer- specific variables for the study

Educational level: It is measured by the number of years of schooling by the farmer. Education promotes the adoption of better management practices and resource use which contributes to the efficiency levels of farmers. Findings from a study by Ahzar (1991) show that education enables one to make better choices regarding input combination and use of existing resources. Hence, it is anticipated that education would influence technical efficiency positively.

Age: It was measured in years and it is used as a proxy for farming experience. Chukwuji, Inoni and Ike (2007) have indicated that older farmers are less efficient than the younger ones. This has been attributed to the fact that older farmers are less willing to adopt new ideas in their production activities.

Sex: It was measured as a dummy variable; one, if the farmer was a male and zero, if the farmer was a female. Male farmers were expected to be more technically efficient than female farmers.

Extension services: It shows whether the farmer had access to extension services during the cropping season. It was measured as a dummy variable; one, if farmer had access to extension service and zero, if otherwise. Extension services provided to farmers enable them to learn better farm management practices and efficient use of resources.

Off-farm activities: It indicates whether the farmer engaged in other economic activities aside from rice farming during the 2014/2015 cropping season. Those who engage in different economic activities at the same time are not fully committed to any of the activities thereby leading to technical inefficiency. However, the additional income earned from off-farm activities can be used to purchase farm inputs. It was measured as a dummy variable and had a value of one, if the farmer engaged in other off farm work whilst a value of zero indicates that rice production was a full time occupation.

Access to credit: It was measured as a dummy variable; one if the farmer had access to credit, and zero if otherwise. Access to credit, defined as the availability of loans and other financial aids to the farmer helps to ease the financial constraints faced by farmers. Farmers who have access to credit tend to have higher technical efficiency than those who do not have access to credit (Binam et al., 2004).

Household size: It includes the number of people who were living with the farmer during the 2014/2015 cropping season. It was expected that large family size would have a positive relationship with technical efficiency as they provide labour for farming activities.

Experience: The number of years engaged in rice farming. Bozoglu and Ceyhan (2007) have concluded that farmers with more years of farming experience reduce their technical inefficiency level by ensuring the optimal usage of time and inputs. Therefore, it was expected that farming experience would have a significant relationship with rice output.

Membership of farmer based organization. This indicates whether the rice farmer belongs to a farmer based organization or not. It was measured as a dummy variable and had a value of one if the farmer belonged to an organization and zero if otherwise. This variable was expected to increase the yield of rice.

Data analysis

Descriptive statistics, including the mean, frequencies, charts and standard deviation were used to describe the socio-economic characteristics of farmers. The stochastic production frontier analysis, a parametric approach in measuring technical efficiency was employed in this study. The transcendental logarithmic (translog) form of production function was then fitted to the production function to estimate technical efficiency level of rice farmers and the determinants of technical efficiency simultaneously (Research questions one and two). Research question three was also analysed using the translog stochastic frontier production function. The Kendall's coefficient of concordance was employed to analyse the constraints to rice production (Research question four). Data were analysed using the SPSS version 21 and the R programming software.

Specification of the models

The explicit translog stochastic frontier production function used in this study is given in equation (vii):

$$\ln Y_i = \beta_0 + \sum_{i=1}^{8} \beta_i \ln x_i + \frac{1}{2}\sum_{i=1}^{8}\sum_{j=1}^{8} \beta_{ij} \ln x_i \ln x_j + \left(v_i - u_i\right) \tag{vii}$$

Where; Y_i is the output of rice (kilograms) produced in 2014/2015 cropping season by the i^{th} farmer; x is a set of eight input categories namely: land area (hectares), labour (person-days), seed (kilograms), weedicides(litres), pesticides(litres), equipment(GH₵), fertiliser(kilograms) and irrigation cost(GH₵); β denotes the unknown parameters to be estimated; v_i denotes a random error that captures the stochastic effects that are beyond the farmer's control. ; u_i is the one-sided non-negative error representing inefficiency in production.

The inefficiency model of the stochastic frontier function is given by:

$$u_i = \delta_0 + \sum_{i=1}^{9} \delta_i Z_i \tag{viii}$$

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 \tag{ix}$$

Where,

u_i denotes farm specific inefficiency

δ denotes a set of parameters to be estimated

Z_1 denotes farmers' educational level (years of schooling)

Z_2 denotes age of the farmer (years)

Z_3 denotes sex of the farmer (dummy variable, 1 = male, 0 = female)

Z_4 denotes access to extension services (dummy variable; if yes = 1, no = 0)

Z_5 denotes off-farm work (dummy variable; if yes =1, no = 0)

Z_6 denotes access to credit (dummy variable; if yes =1, no =0)

Z_7 denotes household size (number)

Z_8 denotes farming experience (number of years of rice production)

Z_9 denotes membership of farmer based organisation (dummy variable, if yes =1, no =0)

The translog function was adopted in order to estimate the level of technical efficiency in a way consistent with the theory of production function after preliminary testing for the most suitable functional forms of the model under the data set available using the generalised likelihood ratio test(Griffiths, Hill & Judge, 1993). The generalised likelihood- ratio test statistic is of the form:

$$LR = -2\left[ln\left\{L\left(H_0\right)\right\} - ln\left\{L\left(H_1\right)\right\}\right] \qquad \text{(x)}$$

where, $L\left(H_0\right)$ and $L\left(H_1\right)$ are values of the likelihood function under the null and alternative hypotheses respectively. Asymptotically, the test statistic has a Chi-square distribution with the degree of freedom equal to the difference in the number of parameters between the models. Here, the null tested was that the Translog functional form does not represent the data more adequately than the Cobb-Douglas. The results of the likelihood ratio test presented in Table 1 show a p-value of 0.05676 which is statistically significant at the 10 per cent significance level indicating the rejection of the Cobb-Douglas functional form in favour of the more flexible translog. Thus the null hypothesis was rejected.

Table 1: Likelihood ratio test

Model	Log Likelihood value	Degree of freedom	Chi-square	P- value
Cob-Douglas	-18.9452	-	-	-
Translog	4.4345	33	46.76	0.05676**

**-------Significant at 10%

Source: Field survey data, 2015

The Cobb-Douglas production function is not used in this study because although it is simpler and easier to estimate, it makes several restrictive assumptions. It is assumed that the elasticity coefficients are constant, implying constant shares for the inputs. The elasticity of substitution among factors is unity in the Cobb-Douglas form. Moreover, this being linear in logarithm, the output is zero if any of the inputs is zero (Henderson& Quandt, 1971). Also, in order to reduce the chance of using a too restrictive functional form, the translog functional form was used in this study.

In this study, the Maximum Likelihood Estimation (MLE) approach was used to obtain the estimates for equations (vi) and (ix), using the computer programme,’R’ by the simultaneous estimation procedure proposed by Reifschneider and Stevenson (1991) and subsequently by Battesse and Coelli (1995).

The maximum likelihood (ML) method is defined as the value of the parameter that maximises the probability (or likelihood) of randomly drawing a particular sample of observations (Coelli, Rao, O'Donnell & Battese, 2005). It makes some distributional assumptions about the two error terms. Thus, it helps to model the impact that external factors may have on the distribution of the inefficiencies. The Maximum Likelihood estimator is preferred to other estimators such as the ordinary least squares and the corrected ordinary least squares because it is asymptotic. Thus, it has many desirable large sample properties. With the maximum likelihood estimation, a value is chosen for β such that the value makes the observations the most likely observations and that there is a high concord between the model and the observations. This makes the method more unique, nearly unbiased with large sample, and consistent as it brings the estimated parameter very close to the true value of the parameter.

Aside from the estimate of the β value, the ML estimation also generates the gamma (γ) value. The gamma computes the total variation of observed output from the frontier output. It is expressed as the ratio of the variance of the error associated with inefficiency (σ_u^2) to the total variation in the model (σ^2). The total variation of the model is defined as the addition of the variance of the error associated with inefficiency (σ_u^2) and the errors associated with the stochastic noise, σ_v^2, that is,

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 \qquad \text{(xi)}$$

The gamma estimate is specified as:

$$\gamma = \frac{\sigma_u^2}{\sigma^2} \qquad \text{(xii)}$$

Gamma (γ) takes a value between zero and one, that is, 0<=γ<=1. Variations in the observed output are attributed to inefficiency factors if the gamma value is equal to one. On the other hand, deviation from the frontier output is entirely attributed to statistical noise (random factors) if the gamma value is equal to zero (Battese &Corra, 1977; Coelli, 1995). Therefore, results would be equal to that of the ordinary least square results if the parameter gamma becomes zero whereas the noise term becomes irrelevant if the value of the gamma becomes one.

The Kendall's coefficient of concordance was used to rank the constraints faced by farmers in rice production. Kendall and Smith (1939) provide a descriptive measure for which the concordance between rank orders within an individual rank structure can be assessed. This measure which is known as the Kendall's coefficient of concordance is a non-parametric statistic. It is a measure of agreement among several "judges" who assess a given set of objects. These "judges" could be variables or characters. It is used to identify a given set of constraints from the most critical to the least so as to measure the degree of agreement among respondents. In this study, the most important constraints to rice production were identified and assessed for severity on a scale of one to five (1 = very high constraint; 2 = high constraint; 3 = low constraint, 4 = very low constraint, 5= no constraint). The rankings were then subjected to the Kendall's coefficient of concordance measure so as to know the degree of agreement of rankings by different rice farmers. After computing for the total rank score for each constraint, the constraint with the least score was interpreted as the most pressing constraint whereas the constraint with the highest score was ranked as the least constraint. Mathematically, it is expressed as:

$$W = \frac{12\left[\sum T^2 - \frac{\left(\sum T\right)^2}{n}\right]}{nm^2(n^2-1)} \quad \text{(xii)}$$

Where (W) represents the coefficient of concordance which is defined as the ratio of the sum of squared deviations of rank totals from the average rank total to the maximum possible value of the sum of squared deviations of rank totals from the average rank total; T represents the sum of ranks for constraints being ranked; m represents the number of rice farmers; n represents the number of constraints being ranked. The F distribution was used to test for the significance of the Kendall's coefficient of concordance (Tetteh, Adjetey & Abiriwie, 2011). Mathematically, the F-ratio is given as:

$$F = \left[(m-1)W / (1-W)\right] \quad \text{(xiv)}$$

From the above equation, the degree of freedom for the numerator is given as:

$$(n-1) - \left(2/m\right) \quad \text{(xv)}$$

Likewise, the degree of freedom for the denominator is given as:

$$m-1\left[(n-1) - 2/m\right] \quad \text{(xvi)}$$

On the other hand, one can compute for the Kendall's coefficient of concordance by using the sum of squares of rank totals instead of the sum of squared deviations of rank totals from the average rank total. It can be expressed in the form given by (Legendre, 2005) as:

$$S = \frac{12\sum_{j=1}^{m} R_j^2}{m^2 n\left(n^2 - 1\right)} - 3\frac{n+1}{n-1} \qquad \text{(xvii)}$$

When perfect agreement exists between the values of the ranking variable, W = 1. When W = 0, then it means that there is maximum disagreement between the values of the ranking variable. Kendall's coefficient of concordance does not take negative values. It takes a value between zero and one ($0 \leq W \leq 1$). Here, the null hypothesis tested is that there is no agreement among farmers in the ranking of the constraints. The null hypothesis is rejected if the computed F-value exceeds the tabulated, showing that the respondents are in agreement with each other on the ranking of the constraints.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results of the analysis of data collected from the respondents. The chapter consists of four sections; namely description of the socioeconomic characteristics of rice farmers, the levels of technical efficiency of rice farmers, the determinants of technical efficiency, the elasticities of inputs and constraints faced by farmers in rice production in the study area. Finally, the chapter presents the results of tests of hypotheses.

Description of socioeconomic characteristics of rice farmers

The socio-economic characteristics presented in this section include age, sex, educational background, marital status, household size, number of years engaged in rice farming, access to extension, off-farm work and membership of a farmer-based organization. Table 2 shows the distribution of respondents by age. As indicated in Table 2, 28.8 per cent of respondents were less than 40 years. Also, it can be observed that majority of the rice farmers representing 63.5 per cent fell within the age group of less than 50 years. The mean age of 46.8 years could be classified as youthful, active and productive age that can contribute immensely to rice production in the study area and in the nation as a whole. This would generate income for the youth because rice is a cash crop. This finding lends support to the finding of Enwerem and Ohajianya (2013) who found that 77.5 per cent of small scale rice farmers in the Imo State of Nigeria fell within the age bracket of 41-50 years. The finding is also consistent with the finding of Donkoh, Ayambila and Abdulai (2012) that the mean age of rice producers on the Tono irrigation scheme was 38.2 years; which was described as a youthful adult population.

Table 2: Distribution of respondents by age

Age of Farmers (Mean=46.8)	**Frequency**	**Percent (%)**
20 – 29	11	5.6
30 – 39	52	23.2
40 – 49	107	34.7
50 – 59	72	25.6
60 – 69	43	10.9
Total	**285**	**100**

Source: Field survey data, 2015.

The sex distribution of the respondents was also analysed. The results in figure 4 show that majority of the respondents; representing 59.6 per cent were males while females were in the minority, representing 40.4 per cent. From the results, rice production was dominated by males in the study area. The finding is also consistent with that of Donkoh, Ayambila and Abdulai (2012) that males outnumbered females in the production of rice on the Tono irrigation scheme in the northern region of Ghana. In addition, the finding is consistent with that of Enwerem and Ohajianya (2013) who found that rice production among small scale farmers in the Imo state of Nigeria was male dominated.

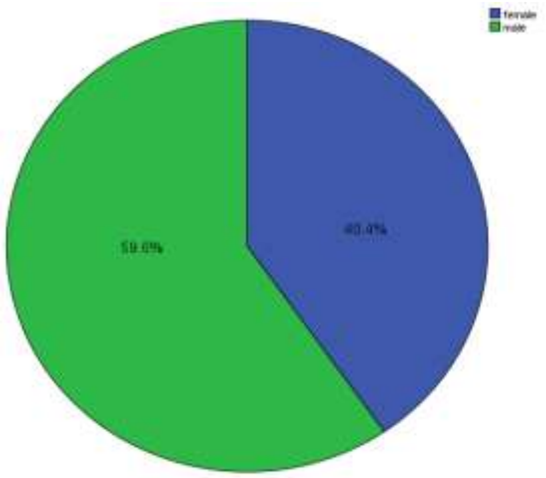

Figure 4: Distribution of respondents by sex

Source: Field Survey Data, 2015

The educational background of farmers which plays an important role in the adoption of technologies by farmers was also analysed. The results are presented in Table 3. As shown in Table 3, 37.5 per cent of the respondents had primary education while 33.0 per cent had middle school or junior high school education. Formal education is seen as a foundation for farmers to become better managers of agricultural resources. It is known to influence the kind of information accessed and the planning that takes place at the household level (Moyo & Chambati, 2009). The results further indicate that more than half of the respondents, representing 56.4 per cent had no formal education or attained only primary school education. This could negatively affect record keeping on farm operations.

Table 3: Distribution of respondents by educational background

Educational background of farmer	Frequency	percent (%)
No formal education	54	18.9
Primary education	107	37.5
Middle school / JHS	94	33.0
O' level / SHS	27	9.5
Tertiary	3	1.1
Total	**285**	**100.0**

Source: Field survey data, 2015

The household sizes of the respondents were also analysed. The results are presented in Table 4. As shown in Table 4, majority of the rice farmers representing 56.5 per cent had house hold sizes of more than five persons. The mean household size of six persons implies that most of the labour could be supplied by the household members.

Table 4: Distribution of respondents by household Size

Household size (mean=6)	Frequency	Percent (%)
1-5	124	43.5
6-10	130	45.6
11-15	25	8.8
16-20	5	1.8
21-25	1	0.3
Total	285	100.0

Source: Field survey data, 2015

Another socioeconomic characteristics analysed was marital status. Results in Table 5 show that most of the rice farmers, representing 90.2 per cent were married.

Table 5: Frequency distribution of rice farmers by marital Status

Marital Status	Frequency	Percent (%)
Single	9	3.2
Married	257	90.2
Divorced	1	0.4
Widowed	18	6.2
Total	**285**	**100.0**

Source: Field survey data, 2015.

Respondents were asked whether they had access to extension or not. The distribution of respondents by their access to extension services is illustrated in Figure 5. Figure 5 shows that 69.8 per cent of the respondents had access to extension services in the study area. This implies that majority of the farmers had access to information on rice production which could help enhance their output.

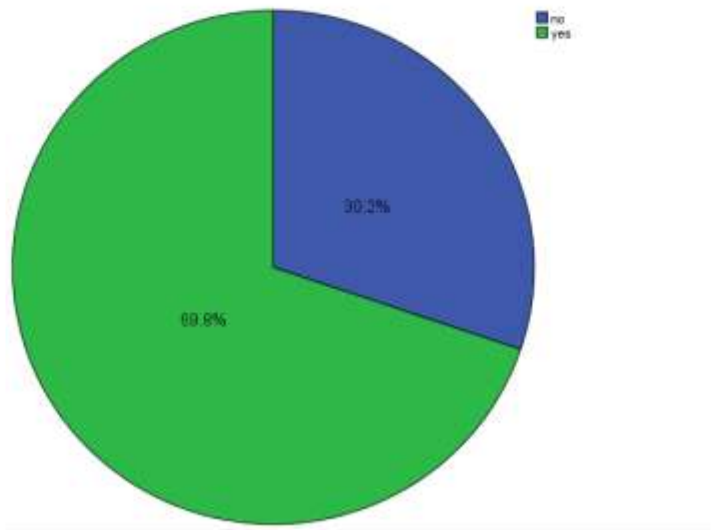

Figure 5**:** Distribution of respondents on their access to extension services
Source: Field survey data, 2015

Figure 6 reveals that 158 of the respondents, representing 55.4 per cent did not engage in off-farm work which could earn them extra income. This could affect farm work positively since much time would be spent on the farm instead of on non-farm activities (Ali & Flinn, 1989).

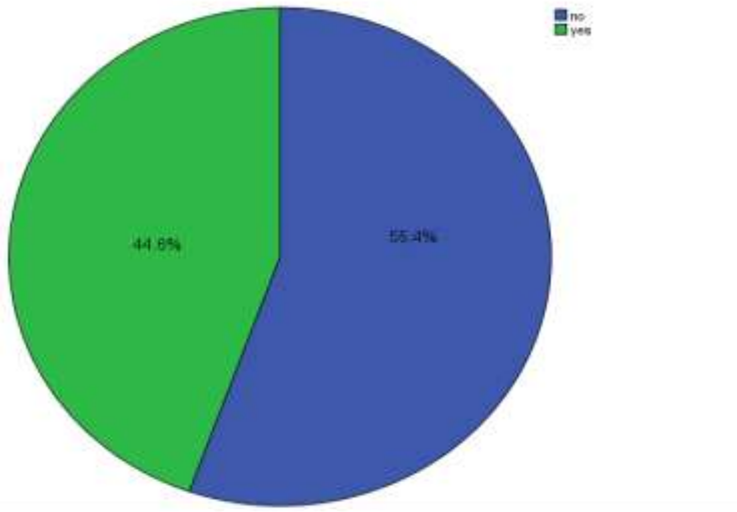

Figure 6: Distribution of respondents by off-farm work

Source: Field survey data, 2015

It can be observed from Figure 7 that majority of the respondents, representing 88.1 per cent did not belong to any farmer based organization. This might affect their efficiency negatively since membership of a farmer based organization is known to reduce the inefficiency of farmers since information on appropriate farming practices would be shared among the farmers (Idris, Sirwar & Talib, 2013).

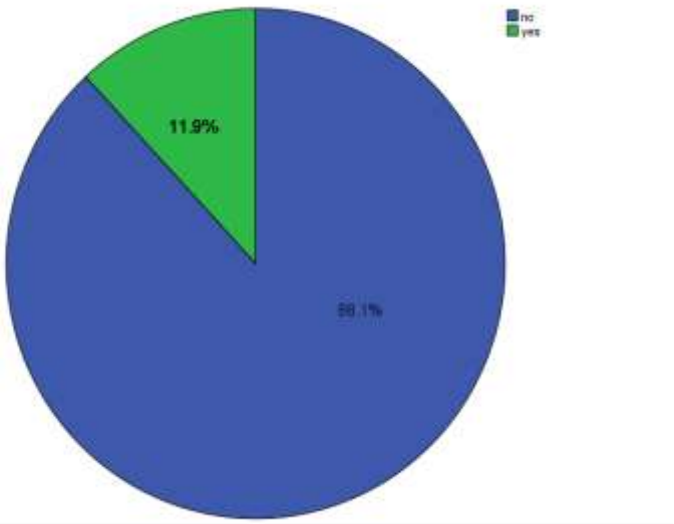

Figure 7: Distribution of respondents by membership of a farmer based organization.

Source: Field survey data, 2015

Respondents were also asked to state the variety of rice cultivated. The results presented in Figure 8 show that only two varieties of rice, namely; Jasmine 85 and Togo marshal were cultivated by farmers in the study area. As indicated in Figure 8, majority of the rice farmers, representing 63.2 per cent cultivated Jasmine 85 while only 36.8 per cent cultivated the Togo marshal. Jasmine 85 was more popular among the rice farmers because it was more high -yielding and had a better taste and aroma than the Togo marshal (MoFA, Ketu North District, 2014).

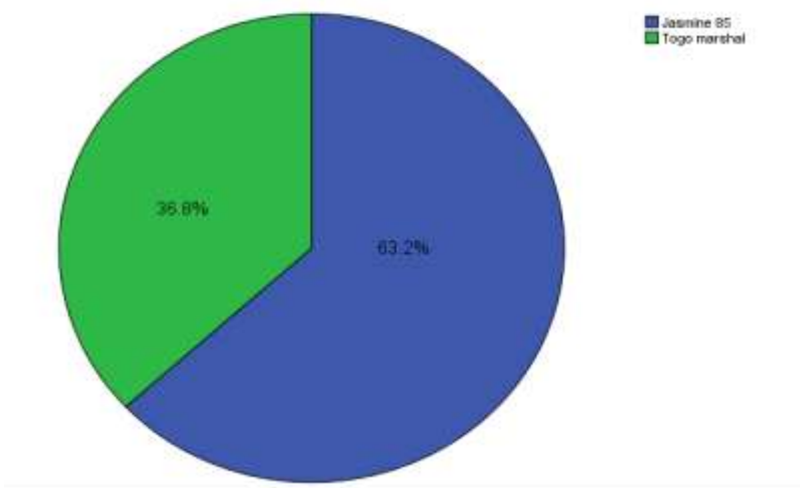

Figure 8: Distribution of respondents by the variety of rice cultivated

Source: Field survey data, 2015

Table 6 presents the summary statistics of farmer-specific characteristics as well as production parameters. It can be observed from Table 6 that on average, rice farmers in the study area had 19 years of farming experience, with a minimum of 2 years and a maximum of 36 years. Table 6 also shows that the mean number of years of formal education was 5 years with a minimum of zero and a maximum of 13 years. Also, the mean extension contacts was twice a year. This is relatively low considering the importance of extension in agriculture. The low extension contacts imply that not much information got to the farmers as far as innovations and technologies are concerned. Table 6 also indicates that on average, rice farmers in the study area produced an output of 6059.9 kilograms of rice per hectare using an average of 1.66 hectares of land, 21.15 litres of weedicide per hectare, 492.33 kilograms of fertilizer per hectare, 16.98 litres of pesticide per hectare, 625 person days of labour per hectare, 275 kilograms of seeds per hectare, GH¢608.50 worth of irrigation facilities per hectare and GH¢40.75 worth of equipment per hectare. The minimum output of rice was 3250 kilograms/hectare and the maximum was 22000 kilograms/hectare. The large variation in output of rice in the study area can be attributed to variations in their levels of technical efficiency.

Table 6: Summary statistics of production parameters and farmer characteristics

Variable	Minimum	Maximum	Mean	Standard deviation
Output(kg)/ha	3250.00	22000.00	6059.85	4082.75
Land area(ha)	0.80	4.00	1.66	1.77
Fertilizer(kg)/ha	187.50	1000.00	492.33	163.55
Seed(kg)/ha	75.00	600.00	275.00	101.88
Pesticide(litres)/ha	2.50	40.00	16.98	7.78
Weedicide(litres)/ha	10.00	35.00	21.15	6.38
Labour(person days)/ha	195.00	1350.00	625.01	282.95
Irrigation cost(Gh¢)/ha	150	1240	608.50	236.65
Equipment(Gh¢)/ha	17.50	70.00	40.75	12.05
Farming experience (years)	2.00	36	18.58	1.77
Years of formal education(years)	0.00	13.00	5.58	3.58
Extension contacts(number)	0.00	6.00	2.34	1.77

Source: Field survey data, 2015.

Technical efficiency levels of rice farmers

The maximum likelihood estimates of the stochastic frontier translog production parameters are presented in Table 7. It can be observed from Table 7 that only inputs of land, equipment, fertilizer and irrigation costs were statistically significant at 5 per cent. This implies that, among the eight inputs, only land, equipment, fertilizer and irrigation cost were important factors that influenced the output of rice in the study area. The other inputs, namely; labour, seed, weedicide and pesticide were not important factors that affect the yield of rice in the study since they were statistically insignificant. Among the significant inputs, however, only equipment cost has a negative sign.

The negative sign on equipment cost implies that an increase in equipment cost would result in a decrease in rice output. In other words, rice output in the district would increase when equipment cost decreases. This finding is contrary to the finding of Bempomaa (2014) that equipment cost contributed positively to maize output in the Ejura-Sekyedumase District of the Ashanti Region. This could be due to the use of heavy equipment such as tractors and power tillers by the rice farmers on small land holdings. This is because heavy farm equipment such as tractors and tillers could not be utilised to their full capacity on small landholdings such as 0.8 hectares. Moreover, it was found that most of the farmers had too many equipment relative to the size of their farms. Therefore, these equipment could not be put to optimum use.

Fertilizer input has a positive sign and this implies that an increase in the quantity of fertilizer would result in an increase in output of rice in the study area. This finding confirms that of Rahman, et al. (2012) who found fertilizer to be significant with a positive coefficient among marginal, small and medium scale rice farmers in Bangladesh. Also, the variable, land is significant with a positive sign. This implies that an increase in the area of land under cultivation would lead to an increase in the output of rice. Irrigation cost was also significant with a positive sign. This means an increase in irrigation cost would result in an increase in output. This is because the amount paid for irrigation was proportional to the land area under cultivation which contributed positively to output. These findings are consistent with those of Rahman, et al. (2012) who found that land area under cultivation and irrigation cost were significant and positively contributed to output of rice among marginal, small, medium and large scale rice farmers in Bangladesh.

In the case of the squared values of the input variables, none of them was significant. However, three of them, namely land, fertilizer and irrigation cost had positive signs while the remaining five inputs had negative signs. The squared values in a translog model shows the long term effects of the input variables on output. For instance, the fact that land and land squared were both positive imply that an increase in the area of land under cultivation would lead to an increase in output both in the short and long term. This finding is contrary to that of Donkoh, Ayambila and Abdulai (2012) who found that continuous increase in land area under cultivation would lead to a decrease in output of rice on the Tono irrigation scheme both in the short and long term.

Also, an increase in fertilizer and irrigation cost would result in increase in output both in the short and long term since the square of these variables were positive. On the other hand, since labour and labour squared were negative it can be said that increasing the quantity of labour would lead to a decrease in output both in the short and long runs. Similarly, an increase in seed rate, weedicide, pesticide and equipment cost would lead to a decrease in output.

The interaction terms explain the substitutability or complementarity of the variables. A parameter with a positive sign implies that the two variables are complementary, while a parameter with a negative sign means that the two variables are substitutes. From Table 6, the statistically significant parameters with a positive sign are the interactions between seed and irrigation cost at 5 per cent; and weedicide and equipment at 10 per cent. Those with negative signs are land and seed at 5 per cent; seed and weedicide at 10 per cent and equipment and irrigation at 10 per cent.

The positive sign on the interactions between seed and irrigation cost implies that seed was complementary to irrigation therefore the two inputs would be more productive when used together. Weedicide use was also complementary to equipment in the study area. The implication is that these pairs of inputs jointly contribute positively to output in the study area. On the other hand, seed was a substitute to land and weedicide as equipment and irrigation costs were substitutes. The interactions between these pairs of inputs yielded less productive results when used together in the study area.

Diagnostic statistics and gamma parameters

Table 7 also shows that the estimate of sigma-squared (σ^2) value of 0.097 is statistically significant and different from zero at 0.1 per cent. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term. The gamma value (γ) is a measure of inefficiency in the variance parameter and ranges from zero to one. From Table 7, the translog model used in the study area estimated gamma at approximately 0.92 or 92 per cent. This implies that 92 per cent of the variations in output of rice were due to technical inefficiency in the study area. In other words, the presence of technical inefficiency among the sample farmers explains about 92 per cent of the variation in the output level of rice in the study area.

The results of the diagnostic statistics therefore confirm the relevance of the stochastic parametric production function and the maximum likelihood estimate employed in the study.

Table 7: Maximum likelihood estimates of the mean scaled translog stochastic frontier production function parameters

Variable	Parameter	Coefficient	standard error	z – value
Intercept	β_0	0.3745***	0.01147	3.2651
ln(mland)	β_1	0.4421**	0.2267	1.9501
ln(mlabour)	β_2	- 0.0509	0.0735	- 0.6928
ln(mseed)	β_3	- 0.0320	0.0824	- 0.0185
ln(mweedicide)	β_4	- 0.0014	0.0771	-0.0185
ln(mpesticide)	β_5	-0.0915	0.0704	- 1.2986
ln(mequipment)	β_6	- 0.1415**	0.0804	-1.7592
In(mfertilizer)	β_7	0.1460**	0.0796	1.8343
ln(mirrigation)	β_8	0.3722**	0.2158	1.7248
½ [In(mland)] ^{2}	β_9	4.0325	2.5886	1.5578
½ [ln(mlabour)]^2	β_{10}	-0.4927	0.3277	-1.3774
½ [ln(mseed)] ^{2}	β_{11}	-0.4819	0.4463	-1.0797
½[ln(mweedicide)]^2	β_{12}	-0.5294	0.4882	-1.0846
½ [lnmpesticide)] ^{2}	β_{13}	-0.1739	0.1390	-1.2424
½[ln(mequipment)]^2	β_{14}	-0.8909	0.5639	-1.2424
½ [ln(mfertilizer)] ^{2}	β_{15}	0.2037	0.4236	0.4810
½ [ln(mirrigation)]^2	β_{16}	-2.2893	1.7236	-1.3282
ln(mland)*ln(mlabour)	β_{17}	-0.6767	0.7013	-0.9649

Table 7 continued

Variable	Parameter	Coefficient	standard error	z – value
ln(mland)*ln(mseed)	β_{18}	-1.4844*	0.6942	-2.1383
ln(mland)*ln(mweedicide)	β_{19}	0.0178	0.8931	0.0199
ln(mland)*ln(mpesticide)	β_{20}	0.2296	0.3181	0.7218
ln(mland)*ln(mequipment)	β_{21}	0.9574	0.9948	0.9624
ln(mland)*ln(mfertilizer)	β_{22}	-0.4546	0.7729	-0.5881
ln(mland)*ln(mirrigation)	β_{23}	-2.8567	1.7729	-1.6098
ln(mlabour)*ln(mseed)	β_{24}	0.4329	0.2725	1.5885
ln(mlabour)*ln(mweedicide)	β_{25}	0.1598	0.3252	0.4915
ln(mlabour)*ln(mpesticide)	β_{26}	-0.0202	0.2059	-0.0983
ln(mlabour)*ln(mequipment)	β_{27}	-0.2544	0.3709	-0.6858
ln(mlabour)*ln(mfertilizer)	β_{28}	-0.0283	0.3723	-0.0761
ln(mlabour)*ln(mirrigation)	β_{29}	0.4979	0.6004	0.8293
ln(mseed) *ln(mweedicide)	β_{30}	-0.5679**	0.3155	-1.7998
ln(mseed)*ln(mpesticide)	β_{31}	0.1011	0.1643	0.6155
ln(mseed)* ln(mirrigation)	β_{34}	1.5351*	0.6115	2.5104
ln(mweedicide)*ln(mpesticide)	β_{35}	-0.0239	0.2084	0.1148
ln(mweedicide)*ln(mequipment)	β_{36}	0.6058**	0.3686	1.6473
ln(mweedicide)*ln(mfertilizer)	β_{37}	0.2742	0.3086	0.8889
ln(mweedicide)*ln(mirrigation)	β_{38}	0.0224	0.7602	0.0295
ln(mequipment)*ln(mfertilizer)	β_{39}	0.1992	0.3035	0.6564
ln(mequipment)*ln(mirrigation)	β_{40}	-1.3375**	0.7098	-1.8844
ln(mfertilizer)*ln(mirrigation)	β_{41}	0.1897	0.6354	0.2986
Variance parameters				
Sigma squared	σ^2	0.0973***		
Gamma	γ	0.9191***		
Log likelihood value		4.4345		

Significant codes:
***--------Significant at 0.1%
**-- ------ Significant at 10 %
*---------- Significant at 5%
Source: Field survey data, 2015.

Frequency distribution of technical efficiency of rice farmers

Table 8 shows the frequency distribution of technical efficiency of rice farmers. The mean level of technical efficiency of rice farmers was 70.7 per cent with a minimum of 29.6 per cent and a maximum of 96.3 per cent. This shows that there was a wide disparity among rice farmers in their level of technical efficiency. This, in turn, indicates that there was an opportunity to improve the existing level of production of rice in the study area through enhancing the level of technical efficiency of rice farmers.

The mean level of technical efficiency further implies that the level of output of rice in the study area could be increased on an average by about 29.3 per cent if appropriate measures are taken to improve the level of efficiency of rice farmers. In other words, there was a possibility of increasing the yield of rice by about 29.3 per cent using the available resources in an efficient manner without introducing a new technology.

The results in the table 8 also show that 45.26 per cent of the respondents operated below the mean level of technical efficiency. Thus the null hypothesis that rice farmers in the Ketu North District are not fully technically efficient is not rejected.

Table 8: Frequency distribution of technical efficiency of rice farmers in the Ketu North District

Technical Efficiency (%)	Frequency	Percentage
(%)		
<50	26	9.12
50 – 59	44	15.44
60 – 69	59	20.70
70 – 79	61	21.40
80 – 89	63	22.11
>89	32	11.23
Total	**285**	**100**
Mean technical Efficiency		70.7
Minimum		29.6
Maximum		96.3

Source: Field survey data, 2015

Elasticity of output

Determination of elasticity is necessary for the estimation of the responsiveness of output to input. Table 9 shows results of the translog stochastic frontier production function. It can be observed from Table 8 that input elasticity of land area under cultivation was 0.44. This means that a 1 per cent increase in land area under cultivation would increase yield of rice by 0.44 per cent. Also, a 1 per cent increase in the quantity of fertilizer would increase output by 0.15 per cent and a 1 per cent increase in irrigation cost would increase output by 0.37 per cent. However, coefficients of elasticity of labour, seed, weedicide, pesticide and equipment were negative. The implications are that a 1 per cent increase in labour would decrease output by 0.05 per cent; a 1 per cent increase in the quantity of seed planted would decrease output by 0.03 per cent; a 1 per cent increase in the quantity of weedicide would decrease output by 0.001 per cent; a 1 per cent increase in the quantity of pesticide would decrease output by 0.09 per cent and finally, a 1 per cent increase in the cost of equipment would decrease output by 0.14 per cent. Moreover, all the inputs used in the production of rice in the study area were found to be inelastic; a 1 per cent increase in each input resulted in less than proportionate increase in output.

Furthermore, the return- to-scale indicated in Table 9 is 0.642. The return-to-scale of the technology is given by the sum of the elasticities of all the inputs. If all inputs are varied by the same proportion, the return-to -scale indicates the percentage by which output will increase. The return- to -scale of 0.642 is less than one and indicates a decreasing return to scale. This implies that if all inputs are proportionally increased by 1 per cent, output of rice would increase by only o.642 per cent. It is called a decreasing return to scale because the relative increase in output is less than the relative increase in the aggregate input quantity. The result further indicates that rice farmers were operating at the irrational stage of production (stage III) in the study area.

Table 9: Elasticity of output and return-to-scale

Input variable.	**Elasticity**	**Return -To- Scale (RTS)**
ln(mland)	0.442	0.642
ln(mlabour)	-0.051	
ln(mseed)	-0.032	
ln(mweedicide)	-0.001	
ln(mpesticide)	-0.092	
ln(mequipment)	-0.142	
In(mfertilizer)	0.146	
ln(mirrigation)	0.372	

Source: Field survey data, 2015.

Determinants of technical efficiency

The determinants of the technical efficiency are discussed using the estimated (δ) coefficients associated with the inefficiency effects in Table 10. Variables with negative coefficients have negative relationships with inefficiency while those with positive coefficients have positive relationships with inefficiency. The results show that age, sex, farming experience and membership of farmer based organization were the only significant determinants of the level of technical efficiency in the study area. Education, extension contact, off farm occupation, access to credit and household size were not statistically significant. This means that these factors were not important determinants of technical efficiency in the study area. Furthermore, the insignificance of extension visits has not come as a surprise. This is because even though most of the rice farmers had access to extension services in the study area, the mean extension contacts was found to be only twice in a year. This might be due to the low extension agent-farmer ratio in the study area (1:3500) which could make extension services ineffective (MoFA, Ketu North District, 2014). However, the positive sign on extension means that rice farmers who had access to extension services were less technically efficient than those who had no access to extension. This is, however, contrary to the apriori expectation.

Among the significant inefficiency sources, only age has a positive sign. This implies that older farmers were less technically efficient than younger farmers. This finding lends support to the finding of Maganga (2012) who found that older farmers were less technically efficient than younger farmers in the production of Irish potato at the Dedza District of Malawi. The finding is also consistent with that of Njeru (2010) who found that older wheat farmers were less technically efficient than younger ones in the Uasin Gishu District of Kenya. This could be explained by the fact that older farmers have the tendency to stick to their old methods of production and are usually unwilling to accept change. This finding is however contrary to the position of Ali, Imad and Yousif (2012) that adequate inputs coupled with long years of farming enable older farmers to produce more efficiently. Furthermore, the finding contradicts that of Etwire, Martey and Dogbe (2013) who found younger soybean farmers in the Saboba and Chereponi Districts of Northern Ghana to be less technically efficient than older ones.

The negative sign on the sex variable means that male farmers were more technically efficient than female farmers in the study area. This finding is consistent with that of Donkoh, Ayambilah and Abdulai (2012) who found male farmers to be more technically efficient than female farmers in the production of rice on the Tono irrigation scheme in the Northern Region of Ghana. This could be explained by the fact that male farmers are wealthier and therefore are able to acquire technologies that are costly (Onunmah & Acquah, 2010). Female farmers are also known to have more responsibilities at home than male farmers. These, coupled with their biological child bearing role could reduce efficiency in production because less time would be devoted to management of the farm.

The negative sign on experience implies that farmers with more years of farming experience are more technically efficient than those with less farming experience. Again, this finding confirms that of Maganga (2012). Farmers with longer years of farming may combine inputs more optimally leading to high technical efficiency than the less experienced farmers.

Finally, the coefficient of the dummy variable for membership of a Farmer-Based Organisation (FBO) is negative and statistically significant at 10 per cent. This implies that rice farmers who belonged to a farmer based organisation were more technically efficient or less technically inefficient than those who did not belong to any farmer based organisation. This finding lends support to that of Awunyo-Vitor, Bakang and Cofie (2012) who found that cowpea farmers who belonged to a farmer based organisation were more technically efficient than those who did not. Membership of a farmer based organization is part of social capital. It also affords farmers the opportunity to share information on modern rice production practices through interactions with other farmers (Awunyo-Vitor, Bakang & Cofie, 2012). The finding is however contrary to that of Kuwornu, Amoah and Seini (2013) who found membership of farmer based organization to positively influence technical inefficiency in maize production in the Eastern Region of Ghana.

The maximum likelihood estimates of the inefficiency model indicate that the socio-economic characteristics of the rice farmers significantly influence technical efficiency in the study area. Thus the null hypothesis that the socioeconomic characteristics of rice farmers has no significant effect on technical efficiency is rejected.

Table 10: Maximum likelihood estimates of the inefficiency model.

Variable	Parameter	Coefficient	Standard Error	Z-Value
Intercept	δ_0	0.0346	0.2723	0.1269
z- Education	δ_1	0.0034	0.0063	0.3623
z- Age	δ_2	0.0115*	0.0047	2.4381
z- Sex	δ_3	-0.1807*	0.0715	-2.5262
z- Extension	δ_4	0.0262	0.0701	0.3733
z- Off farm	δ_5	0.1005	0.0686	1.4662
z – Credit	δ_6	-0.0589	0.1135	-0.5195
z-Household size	δ_7	0.0051	0.0090	0.5637
z- Experience	δ_8	-0.0125*	0.0056	-2.2385
z-FBO membership	δ_9	-0.2119**	0.1224	-1.7326

Significant codes: * ------- Significant at 5%
**------- Significant at 10%

Source: Field survey data, 2015

Constraints to rice production

The views of respondents were sought on the seriousness of the constraints faced in rice production in the study area. The constraints were tabulated and ranked on a 5-point Likert scale as follows: 1-Very high constraint; 2-High constraint; 3-Low constraint; 4-Very low constraint; 5- No constraint. The result is presented in Table 11. The Kendall's coefficient of concordance (Kendall's W) of 0.598 shows that an agreement exists among the rice farmers on the ranking of constraints to rice production at 1 per cent significant level. This implies that rice farmers in the study area agreed on the rankings of the constraints that limit them in the production of rice. Therefore the null hypothesis that there is no concordance among the rice farmers on the ranking of the constraints they faced in rice production is rejected in favour of the alternative.

Table11: Kendall's W test statistics

W	285
Kendall's W[a]	0.598
Chi-square	2896.49
Df	17
Asymp.sig.	0.000***

Significant codes:

***------- Statistically significant at 1%

a-----------Kendall's coefficient of concordance.

Source: Field survey data, 2015

It can be observed from Table 12 that the first three constraints faced by rice farmers were low purchasing price of rice, lack of government support and difficulty in accessing capital. These constraints were interrelated. For instance, lack of government support in the form of provision of capital for production compels farmers to access loans from unscrupulous moneylenders at exorbitant interest rates. Most of these money lenders also buy and sell rice for profit therefore they dictate the price. Moreover, the dire need for money to settle debts owed by the farmer to friends and relatives compels them to sell their produce at the prevailing market price which is usually low. The farmers had, therefore, become price takers. Further, the low price offered could not cover production cost, making it difficult for farmers to purchase the required inputs for the next season. This finding confirms the finding of Matanmi et al. (2011) who cited financial constraints and access to inputs as serious challenges facing irrigated rice productions at the Kwara State, Nigeria. The finding is also consistent with those of Alarima, et al. (2011) and Bempomaa (2014) who found that lack of financial agencies to support production; poor capital base and low purchasing price of rice were the major constraints facing rice and maize production in Nigeria and Ghana respectively.

The next constraint faced by rice farmers was the erratic nature of rainfall in the study area. Although the rice farmers were on an irrigation scheme, inadequate rainfall makes irrigation water unavailable since the water level in the dams becomes very low during the minor raining season. On the other hand, excessive rainfall leads to flooding. This finding lends support to that of Musime et al. (2005) that change in rainfall pattern was a major constraint limiting rice production in the Bugiri District, Kampala, Uganda.

At the bottom of the table is the constraint of lack of storage facilities. In fact, almost all the respondents did not see this as a problem because all the sections on the irrigation scheme had a place for storage. Also, there was ready market for rice and the financial pressure on farmers to sell their produce to enable them pay debts could not permit them to store their produce for some time to attract higher prices.

Table 12: Ranking of constraints faced by rice farmers

Constraints	Mean Rank
Low purchasing price of rice	4.07
Lack of government support	4.41
Difficulty in accessing to capital	4.70
Erratic rainfall	5.50
Price fluctuations	6.43
High cost of labour	6.00
Difficulty in land preparation	8.45
Pests and diseases	9.32
Lack of marketing associations	9.27
Difficulty in weed control	9.45

Table 12 continued

Constraints	Mean Rank
Difficulty in acquiring fertilizers	9.47
Difficulty in acquiring pesticides	9.66
Difficulty in applying chemicals	12.20
Difficulty in land acquisition	12.37
Difficulty in Planting of seeds	13.99
Difficulty in acquiring planting materials	14.39
Lack of market for rice	15.32
Lack of storage facilities	16.01

Source: Field survey data, 2015

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents a summary of the study; that is, the research problem and the main findings of the study. The chapter also presents the conclusions drawn based on the findings and recommendations based on the conclusions.

Overview of the research problem

The research problem investigated was the technical efficiency of rice production on the Weta Irrigation scheme in the Ketu North District of the Volta Region of Ghana. Generally, the study sought to estimate the level of technical efficiency and the determinants of technical efficiency in rice production. Data were collected from 285 rice farmers through interviews and this constituted the unit of analysis. The cross-sectional survey research design was used for the study. Primary data were collected from the respondents using the structured interview schedule. A pre-test was done in the South Tongu District of the Volta Region to establish the reliability of the instrument. Descriptive statistics, namely; percentages, frequency, mean and standard deviation as well as the translog stochastic frontier analysis, an econometric model were employed in the analyses of the research questions and tests of hypotheses. The analyses were done using the SPSS version 21 and the 'R' programming software.

Summary of main findings

It was found from the results of the analyses that majority of the rice farmers, representing 63.5 per cent were within the age group of less than 50 years and the mean age was 46.8 years. Rice production in the district was dominated by males, representing 59.6 percent. Most of the respondents representing 90.2 per cent were married and the mean household size was six persons. Also, majority of the rice farmers, representing 56.4 per cent could not attain the middle school or junior high school level of education. This figure comprised 18.9 per cent of the respondents who had no formal education and 37.5 per cent who had only primary education. Furthermore, the mean extension contacts was twice a year even though majority of the farmers, representing 69.8 per cent had access to extension services. Most of the respondents, representing 88.1 per cent did not belong to any farmer based organization while 55.4 per cent did not engage in any off-farm economic activity.

Two major rice varieties were cultivated in the study area namely; Jasmine 85 and Togo marshal, with the majority of farmers, representing 63.2 per cent cultivating the Jasmine 85. On average, 1.66 hectares of land, 625 person days of labour per hectare, 492kilograms of fertilizer per hectare, 21 litres of weedicide per hectare, 17 litres of pesticide per hectare, 275 kilograms of seeds per hectare, Gh¢41 worth of irrigation and GH¢16 worth of equipment were combined to obtain a yield of 6060 kilogram of rice per hectare.

Also, results indicated that rice farmers in the study area were not fully technically efficient. Variations in output were attributed to inefficiency in production as well as random variables outside the farmer’s control; with the former contributing a higher percentage (92 per cent). There was a wide variation in technical efficiency with a minimum of 29.6 per cent and a maximum of 96.3 per cent. The mean technical efficiency score was 70.7 per cent. Therefore, 29.3 per cent of output was lost to inefficiency and other factors.

Furthermore, the results indicated that the significant input factors that affected the output of rice were land, fertilizer, irrigation and equipment. Of these, only equipment affected rice output negatively while land area under cultivation, fertilizer and irrigation cost positively influenced output. Also, all the inputs used in the production of rice were found to be inelastic and the farmers were found to be producing at decreasing returns to scale.

Results of the technical inefficiency model indicated that the socio economic variables that significantly influenced technical efficiency were age, sex, farming experience and membership of a farmer based organization. Of these, only age had a negative relationship with technical efficiency while sex, farming experience and membership of a farmer based organisation influenced technical efficiency positively.

Finally, empirical results showed that low purchasing price of rice, lack of government support, difficulty in accessing capital and erratic rainfall patterns were the major constraints faced by rice farmers in the study area.

Conclusions

Based on the findings, the following conclusions are drawn:

Firstly, rice farming on the Weta irrigation scheme in the Ketu North District was male dominated and the male farmers were more efficient in rice production than female farmers. 56.5 per cent of the rice farmers had household sizes of more than five persons. This implies that most of the labour could be supplied by the household members. Majority of the rice farmers were in the age group of less than 50 years, implying a youthful adult population engaged in rice production in the study area.

Most of the respondents, representing 56.4 per cent constituted those who had no formal education and those who attained only primary or elementary school education. This could negatively affect record keeping on farm operations as well as the farmers' ability to understand and adopt innovations in farming. This could, in turn, affect farmers' efficiency negatively. Majority of the farmers belonged to a farmer based organizations which would enable them to share information on modern practices in rice production. This could explain why farmers in the study area who belonged to a farmer based organization were more technically efficient in rice production than those who did not belong to any farmer based organization. Most of the rice farmers had access to extension services which was rather inadequate and the main variety of rice which was cultivated by the farmers was Jasmine 85.

Secondly, rice farmers in the study area were not fully technically efficient. With the mean technical efficiency estimated at 70.7 per cent, there was an opportunity for the rice farmers to increase their output by 29.3 per cent through efficient reallocation of the available resources.

Thirdly, in the study area, land area under cultivation, fertilizer input and irrigation cost were significant and had positive effects on output while equipment cost was also significant but affected output of rice negatively. Furthermore, all the input variables were inelastic and this implies that 1percent increase in each input would result in less than proportionate increase in output in the study area. Also, rice farmers were producing at decreasing returns- to- scale.

Fourthly, the socio-economic characteristics of rice farmers which were significant determinants of technical efficiency in the study area were age, sex, farming experience and membership of a farmer based organization.

Finally, the major constraints faced by rice farmers in the study area were low purchasing price of rice, lack of government support, difficulty in accessing capital and erratic rainfall patterns. All other things being equal, if these constraints are removed or minimised rice farmers on the Weta irrigation scheme would be more efficient in production.

Recommendations

From the conclusions drawn, the study recommends that:

1. Since rice production in the Ketu North District was male dominated, the Ministry of Food and Agriculture should formulate policies targeted at empowering male farmers by improving their access to agricultural inputs, especially, land, fertilizer and irrigation facilities to increase their efficiency in rice production. Also, training of farmers on how to improve upon their production activities through the efficient combination of inputs should be intensified through demonstration farms within the vicinity of farmers since the farmers were not fully efficient in production. More Agricultural

Extension Agents should be employed by the Ministry of Food and Agriculture to facilitate the training of farmers.

2. Furthermore, the Ministry of Education should bring formal education to the doorstep of farmers by establishing basic and second cycle schools in the farming communities to equip the youth with knowledge and skills to get the maximum benefits from innovations in farming.

3. The Irrigation Development Authority should expand the land area under irrigation and provide adequate irrigation facilities to increase farmers' land holdings on the irrigation scheme. This is because the study established that increased land area under cultivation and irrigation cost positively influenced output of rice.

4. Furthermore, the Ministry of Food and Agriculture should adopt appropriate measures such as introducing a fertilizer subsidy that will ensure the availability of fertilizers at affordable rates to farmers. This would increase fertilizer use resulting in increased yield. Also, farmers should be educated on optimum use of equipment so as to increase output.

5. In order to improve efficiency in rice production on the Weta Irrigation Scheme, farmers need to organise themselves into groups since group membership positively influenced their efficiency.

6. The government, through the Ministry of Food and Agriculture, should make rice production attractive to the youth by providing them with incentives such as soft loans that would enable them take farming as a business. This is because it was established from the study that younger rice farmers were more efficient than older ones.

7. The government should establish guaranteed prices for rice and provide credit facilities to encourage the rice farmers to produce.

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APPENDIX A

UNIVERSITY OF CAPE COAST

SCHOOL OF AGRICULTURE

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

INTERVIEW SCHEDULE FOR RICE FARMERS IN THE KETU NORTH DISTRICT

TOPIC: TECHNICAL EFFICIENCY IN RICE PRODUCTION IN THE KETU NORTH DISTRICT OF THE VOLTA REGION, GHANA.

INTRODUCTION: This interview schedule is designed with the sole aim of gathering information relating to technical efficiency in rice production and its determinants. All information will be used for academic purposes only. Information obtained from this interview shall be treated as strictly confidential. Thank you in advance for your cooperation.

Name of community: ………………………………………………

Date of interview: ……………………………………

SECTION A: FARMER- SPECIFIC CHARACTERISTICS

1. Age of farmer at last birthday: ………… years

2. Sex of farmer: (i) Male (ii) Female

3. Marital status of farmer:
(i) Single (ii) Married (iii) Divorced (iv) Widowed

4. Educational background of farmer: (a) No formal education (b) Primary
(c) Middle/JHS [ ] (d) O'level/SHS (e) Tertiary

5. Years of formal education ……………………..

6. Household size: ……………. (number)

7. Number of years engaged in rice farming: …………… years

8. Do you engage in other economic activity apart from rice farming?

(i) Yes (ii) No

9. If yes, what other economic activity are you engaged in?..

SECTION B: PRODUCTION ACTIVITIES

10. Do you have access to extension services? (i) Yes (ii) No

11. If yes, how often? ……………………………

12. Do you have access to credit? (i) Yes (ii) No

If yes from where? (I) bank (ii) credit union (iii) money lenders (iv) family(v) friends

Others (specify)…………………………….

13. Do you belong to any farmer organisation? (i) Yes (ii) No

14. If yes which farmer organization do you belong to?......................................

15. Methods of land preparation: (i) Slash and burn (ii) Use of weedicides followed by farm implements (iii) Use of weedicides only (iv) Use of farm implements only

16. Methods of weed control: (i) Use of weedicides (ii) Use of cutlass

(iii) Use of hoe (iv) Hand picking of weeds (iv) Other (specify)……………

17. Have you received any technical training in rice production over the past three years?

(i)Yes (ii) No

18. If yes, who provided the training? (i) Fellow farmers (ii) AEAs (iii) Media (iv)others(specify) ……………....................

19. Do you cultivate rice in both major and minor seasons? (i) Yes (ii) No,

If no, why? ………………………………………………………………

SECTION C: INPUT AND OUTPUT DATA

<u>FIXED INPUTS</u>

26. LAND

Kind of land ownership: (i) Farmer's own land (purchased or gift)

(ii) Family land (iii) Rent (iv) Leased (v) Sharecropping

(vi) Others (specify) …………………….

Item	**Size (acres)**	**Cost per acre (GH₵)**	**Total cost (GH₵)**
Land			

20. EQUIPMENT

Tools	Number	No. of months/years used	Unit cost (GH₵)	Total Cost(GH₵)
a. Cutlass				
b. Hoe				
c. Sprayer				
d. Tractor/Tractor service				

21. IRRIGATION COST

Item	**Cost per month(GH₵)**	**Total(GH₵)**

VARIABLE INPUTS

22. PLANTING MATERIALS

Item	**Quantity (kg)/acre**	**Unit cost (GH₵)**	**Total cost (GH₵)**
Seeds			

23. Source of rice seeds for production: (i) Farmers' own seeds (ii) Certified seed growers (iii) Friends/Family (iv) Government (v) Others (specify) ………….

24. LABOUR INPUTS IN RICE PRODUCTION

Please indicate the number of persons, hours and days used in production activities.

Type of labour		Number of persons	Hours used per person per day	Days worked per crop season	Wage per person per day (GH₵)
a.Family	Male				
	Female				
	child (under18)				
b.Hired					

25. FERTILIZER INPUT

Type of fertilizer	Quantity (kg)/acre	Unit cost (GH₵)	Total Cost (GH₵)
a.NPK			
b.Ammonia			
c.Urea			
d.Others (specify)			

26. PESTICIDE USE

Type of pesticide	Quantity used (litres) per acre	Unit cost (GH₵)	Total cost (GH₵)
a. Fungicide			
b.Insecticide			
c.Rodenticide			

34. WEEDICIDE USE

Weedicide	Quantity Litres/acre	Unit Cost GH₵	Total Cost GH₵
a)Pre-planting weedicide			
b)Post-planting weedicide			

OUTPUT OF RICE

Season	Harvested area(acres)	Quantity harvested (kg)	Quantity sold (kg)	Price/kg (GH₵)
Major				
Minor				

SECTION D: CONSTRAINTS TO RICE PRODUCTION

27. INPUT, PRODUCTION AND MARKETING CONSTRAINTS

Input constraint	**Response**	**Production constraints**	**Response**	**Marketing constraints**	**Response**
Cost of labour		Land preparation		Purchasing price of rice	
Land acquisition		Pest and disease control		Price fluctuations	
Acquisition of fertilizer		Weed control		Availability of storage facilities	
Pesticide acquisition		Agro-Chemical application		Government support	
Access to capital		Rainfall		Formation of marketing association	
Acquisition of seeds		Planting of seeds		Market for Rice	
Others (specify)		Others (specify)		Others (specify)	

Scale: 1 = very high constraint; 2 = high constraint; 3 = low constraint; 4 = very low constraint, 5=no constraint

APPENDIX B

TECHNICAL EFFICIENCY SCORES OF INDIVIDUAL RICE FARMERS ON THE WETA IRRIGATION SCHEME

FARMER NO.	TE (%)	FARMER No.	TE (%)	FARMER NO.	TE (%)
1	89.08	46	54.95	91	63.23
2	73.59	47	71.81	92	38.57
3	44.87	48	70.31	93	57.97
4	90.27	49	49.62	94	83.15
5	91.80	50	78.91	95	95.11
6	89.35	51	74.53	96	67.23
7	91.71	52	78.93	97	77.54
8	71.75	53	88.02	98	66.94
9	90.91	54	81.23	99	61.82
10	83.16	55	32.54	100	52.85
11	66.83	56	75.55	101	80.99
12	90.22	57	51.41	102	88.28
13	86.31	58	69.11	103	85.90
14	58.23	59	72.64	104	86.79
15	73.84	60	49.07	105	74.34
16	86.42	61	87.28	106	94.90
17	92.88	62	69.81	107	29.59
18	47.11	63	54.58	108	67.30
19	68.10	64	46.65	109	93.77
20	56.30	65	56.69	110	61.56
21	86.96	66	55.64	111	49.93
22	58.75	67	69.62	112	93.50
23	91.62	68	75.88	113	87.11
24	58.24	69	55.24	114	51.13
25	64.57	70	60.82	115	84.66
26	61.68	71	69.93	116	72.14
27	89.29	72	64.49	117	64.19
28	69.75	73	64.03	118	60.08
29	80.69	74	78.24	119	76.98
30	75.83	75	81.98	120	91.95
31	53.35	76	61.40	121	92.56
32	61.90	77	50.35	122	56.98
33	50.21	78	80.66	123	86.74
34	73.17	79	89.69	124	49.64
35	89.00	80	71.39	125	89.99
36	51.23	81	72.02	126	90.45
37	74.53	82	79.24	127	82.91
38	37.88	83	72.81	128	51.76
39	44.73	84	60.59	129	88.85
40	91.79	85	92.15	130	68.06
41	79.53	86	69.51	131	82.09
42	64.64	87	76.35	132	62.57
43	74.18	88	83.75	133	87.86
44	63.65	89	60.20	134	34.67
45	54.10	90	67.23	135	58.27

FARMER NO.	TE (%)	FARMER NO.	TE (%)	FARMER NO.	TE (%)
136	62.96	181	59.76	226	75.00
137	60.04	182	86.25	227	74.62
138	93.51	183	52.06	228	72.76
139	43.15	184	68.85	229	85.03
140	64.71	185	89.59	230	61.87
141	47.69	186	56.93	231	66.91
142	59.01	187	87.63	232	52.37
143	70.87	188	68.71	233	60.19
144	95.12	189	84.67	234	74.23
145	87.63	190	86.55	235	69.55
146	67.65	191	64.65	236	86.12
147	43.82	192	72.45	237	80.71
148	44.27	193	61.76	238	69.00
149	66.80	194	76.03	239	58.10
150	57.02	195	82.91	240	61.34
151	41.96	196	91.90	241	89.41
152	54.98	197	94.09	242	81.59
153	81.26	198	71.18	243	83.03
154	48.12	199	87.40	244	55.82
155	63.65	200	61.37	245	77.43
156	85.61	201	96.27	246	49.03
157	38.18	202	69.76	247	83.25
158	76.25	203	50.78	248	88.69
159	42.78	204	74.10	249	81.03
160	71.12	205	63.09	250	83.90
161	68.33	206	85.59	251	60.46
162	89.09	207	52.84	252	62.43
163	64.03	208	77.09	253	43.10
164	90.41	209	66.55	254	60.51
165	52.34	210	85.47	255	47.55
166	87.38	211	71.75	256	87.53
167	92.01	212	90.58	257	69.37
168	62.87	213	81.80	258	96.33
169	59.72	214	71.34	259	95.32
170	71.17	215	78.75	260	73.00
171	85.84	216	63.16	261	87.39
172	72.04	217	68.30	262	74.07
173	70.61	218	60.60	263	88.08
174	49.27	219	53.12	264	75.48
175	64.11	220	74.47	265	86.68
176	60.32	221	77.61	266	78.68
177	71.62	222	84.14	267	53.40
178	83.05	223	93.77	268	79.47
179	93.67	224	85.74	269	78.52
180	86.35	225	88.52	270	40.09

FARMER NO.	TE (%)
271	49.11
272	54.52
273	55.85
274	73.82
275	54.54
276	38.06
277	63.47
278	87.68
279	85.50
280	55.32
281	52.83
282	57.95
283	69.24
284	92.06
285	51.31

APPENDIX C

SAMPLE SIZE DETERMINATION TABLE

POPULATION	SAMPLE	POPULATION	SAMPLE	POPULATION	SAMPLE
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	282
210	136	1100	285	1000000	384

APPENDIX D

DAM AT DEKPOR

APPENDIX E

WETA RIC EFARMS