UNIVERSITY OF CAPE COAST

TECHNICAL EFFICIENCY IN MAIZE PRODUCTION IN EJURA SEKYEDUMASE DISTRICT

BY

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DECLARATION

Candidate's Declaration

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

Candidate's Signature:…………………..…. Date:……………

Name: Beatrice Bempomaa

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.

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ABSTRACT

Inefficiencies in maize production do not only have adverse effect on the output of maize but it also poses a serious threat to income generation, food security and the general welfare of the people. Therefore, the aim of this study is to examine the level and determinants of technical efficiency of maize farmers. The proportionate stratified and simple random technique was used to select 306 maize farmers. Descriptive statistics was used to describe farm and farmer specific characteristics and the stochastic frontier model was also used to estimate the level and determinants of technical efficiency.

Findings indicate that land, labour and fertiliser influenced output positively whilst seeds and agrochemicals negatively affected output. The mean technical efficiency was found to be 67%, indicating that farmers could improve the productivity of maize by 33% without requiring extra inputs. Farmers were also operating at an increasing returns to scale as the estimated returns to scale was 1.22.

The study also indicated that farmer specific characteristics such as age, sex and off-farm work activities were significant determinants of technical efficiency. Major constraints limiting maize farming were the purchasing price of maize, access to capital, price fluctuations, availability of labour and rainfall pattern. The Ministry of Food and Agriculture through the agricultural extension agents should organise educational programmes for maize farmers on the need to improve upon their production activities through the efficient combination of inputs given that the farmers were producing below the frontier.

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DEDICATION

To my guardians, Prof. Alfred Coleman and Mrs. Mary Coleman.

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LIST OF ACRONYMS

AEAs	Agricultural Extension Agents
AUC	Africa Union Commission
BCC	Banker, Charnes and Cooper
CCR	Charnes, Cooper and Rhodes
CIMMYT	International Maize and Wheat Improvement Centre
DFA	Deterministic Frontier Analysis
DMUs	Decision Making Units
FBOs	Farmer Based Organisations
GDP	Gross Domestic Product
GHS	Ghana Cedi
GSS	Ghana Statistical Service
GPRS	Growth and Poverty Reduction Strategy
IITA	International Institute of Tropical Agriculture
MiDA	Millennium Development Authority
MLE	Maximum Likelihood Estimate
MoFA	Ministry of Food and Agriculture
OLS	Ordinary Least Square
QPM	Quality Protein Maize
RTS	Returns to Scale

SFA	Stochastic Frontier Analysis
SPSS	Statistical Product and Service Solutions
TE	Technical Efficiency

CHAPTER ONE

INTRODUCTION

Background to the Study

Agriculture plays a vital role when it comes to the growth and development of the Ghanaian economy. This sector ensures poverty reduction especially for the rural communities by generating employment and income to farmers. Again, the agricultural sector guarantees the availability of food. This becomes an important factor when dealing with domestic inflation because it arises as a result of increases in food prices. Agriculture contributes significantly to the nation's Gross Domestic Product (GDP) although it contribution has been declining recently. According to Ghana Statistical Service (2013) report at basic prices, agriculture's contribution to GDP in 2008 was 31.0 and this figure rose to 31.8 in 2009. However, these figures fell to 29.8, 25.3, 22.7 and 21.3% for 2010, 2011, 2012 and 2013 respectively. In Ghana, the agricultural sector is divided into five main parts. These are crops, forestry, cocoa, fisheries and livestock. Crops form the largest subsector in the agricultural sector and it contributes about 66.2 percent to Gross Domestic Product (Ministry of Food and Agriculture, 2010).

Taking initiatives to promote the growth of the agricultural sector is one of the most effective ways of reducing poverty, hunger and malnutrition.

In the pursuit to enhance agricultural productivity, it is imperative that we come out with a road map through which that goal could be achieved. This leaves us with the questions: do we enhance productivity through the introduction of new technologies or do we improve existing technologies? Over the years much attention has been given to the development and the adoption of new technologies. This initiative is believed to enhance farm output and increase income levels of farmers. However, growth in output cannot only be achieved through technological innovation but also through the efficiency in which such technologies are used. This has made researchers and policy makers recognise the importance of efficiency as a way of fostering production. Empirical evidence shows that the gap between actual and potential outputs could be closed by utilising minimum inputs to achieve a possible maximum output (Audibert, 1997).

Audibert (1997) points out that productivity in developing countries could be increased by improving the technical efficiency of farm managers. Technical efficiency relates to factor product transformation. A technically efficient farm always produces on the frontier; hence, technical inefficiency exists if a farmer produces below the production frontier. Measures of technical efficiency identify the best-practice producer and the best-practice producer is given an index measure of 100 percent or 1.0 whilst those who do not operate at the optimum level are given an index of less than 100 percent. For instance, a producer with a technical efficiency index of 60 percent or 0.60 would have to increase output benchmarked by 40 percent 0r 0.40 by using the same inputs to obtain maximum output of 100 percent. However, not all maize farmers are able to utilize minimum quantity of required inputs to produce the maximum quantity of output with the available technology. This is due to random factors such as bad weather and other farm related specific factors (Esparon and Sturgess, 1989). Technology is constant, but the only thing that continues to change is decision making. Decision making is also a function of socioeconomic characteristics such as education, age, experience among other factors.

In GPRS II, attention was drawn to the fact that Ghana could foster short term growth in agriculture by concentrating on the production of other crops such as cereals, vegetables and fruits for the exports market in addition to the production of traditional crops like cocoa (Growth and Poverty Reduction Strategy, 2005). Interventions associated with the maize sector included mechanisation programme, fertiliser subsidy, buffer stock scheme and block farm programmes.

Maize is the world's most widely grown cereal and it can be cultivated with the simplest to the most mechanised production technologies. Maize is the largest staple crop in Ghana and it represents a significant portion of food intake among Ghanaians. It is a crop deemed necessary when combating the problem of food insecurity and moreover it is the largest commodity crop after cocoa. Since maize is cheaper than other cereals such as rice and wheat, it is more affordable to the vast majority of the population, and therefore occupies a major position in agricultural development agenda of several countries in Africa. The poultry and livestock sector also depends on maize as it forms a major portion of animal feed.

In Ghana, the production of maize is normally undertaken by peasant farmers under rain fed conditions and traditional ways of farming (Millennium Development Authority, MiDA, 2010). One of the climatic factors that affect agricultural productivity is rainfall. Most farmers depend on rainfall as the main water supply for their production and therefore sudden changes in water supply have drastic effect on crop yield. The side effects of rainfall may manifest in two ways. First too much of it will lead to flooding and second the inadequacy of it will lead to drought. Tisdell (1996) asserts that variability in rainfall increases the level of environmental stress which affects agricultural output negatively. The quantity, timing and control over water supply are paramount in agricultural production as the efficiency of other inputs also depends on it. The right amount of rainfall is needed at the right time during the cultivation of maize. The excessive or inadequacy of it may have serious repercussion on output. A deficiency in soil moisture for 1 – 2 days during the tasseling stage of maize can reduce output up to 28% and 6 – 8 days wilting stage can also decrease output by 50%, which later rains cannot compensate for (Tweneboa, 2000). These may result in inefficiencies in maize production. This makes irrigation necessary even in high rainfall areas as it can serve as an additional water supply especially during the dry season.

Statement of the Problem

In the Ejura-Sekyedumase District, the agricultural sector serves as the main source of employment and income generation for the people. Maize is the major type of food crop grown. The Ejura-Sekyedumase District was selected because it is the principal producer of maize in the Ashanti Region. Facts from the Statistics, Research and Information Directorate of the district shows that estimated cropped area (HA) of maize has been increasing since 2006 but the estimated output in metric tonnes has been declining. The estimated cropped area in hectares increased from 11,951 in 2006 to 13,486 in 2007 and to 17,500 in 2008. In contrast, output in metric tonnes declined from 30,833 in 2006 to 28,861 in 2007 and to 24,419 in 2008 (MoFA, 2013). One would presume that as area under crop cultivation of maize increases so would output but this is not the case. This phenomenon may arise as a result of inefficiencies leading to variations in output. Differences in yields can arise between and amongst farmers who have the same farming locations, same seed varieties, soil type and equal amount of fertiliser. The cause of variation in output is as a result of the differences in management practices followed by the farmers. The potential returns that can be derived from highly sophisticated technologies cannot totally be compensated for by the presence of higher technical inefficiency levels (Ahmad, 2001; Kalirajan, Obwona and Zahao, 1996). Inefficiencies in production in one way or the other is affected by the decisions taken by farmers with respect to inputs combination and time of application. Decision making is critical in agricultural production and the outcome also determines the impact on crop yield. Factors such as education, experience, age among others influences such decisions.

The presence of gaps in efficiency means that output could be increased without requiring additional conventional inputs and without the need for new technology. If this is the case, then empirical measure of technical efficiency in maize production is necessary in order to determine the extent of the gains that could be obtained by improving performance in agricultural production with a given technology.

A lot of work has been carried out in maize production. Mostly these researches are related on how to improve maize yields by looking at pest and disease resistant variety, nutritional quality variety and access to financial institution among others (Morris, Tripp and Dankyi, 1999; Bio, 2010 and Kpotor, 2012). However, much work has not been done when it comes to investigating technical efficiency of maize production in Ejura-Sekyedumase where a lot of maize production is undertaken. It is on these premises that this study identifies technical efficiency in maize production and derives policy implications.

Objectives of the Study

Generally, the goal of this study is to assess technical efficiency and its determinants in maize production in the Ejura-Sekyedumase District.

The specific objectives of the study include:

1. Estimate the level of technical efficiency of maize production.
2. Estimate the productivity level of maize production.
3. Examine the determinants of technical efficiency of maize farmers.
4. Identify and rank the constraints limiting maize production.

Research Questions

1. What is the level of technical efficiency in maize production?
2. What are the determinants of technical efficiency in maize production?
3. What is the level of productivity in maize production?
4. What are the constraints faced by farmers in maize production?

Statement of Hypotheses

The following hypotheses were tested:

1. H_0 : Farmers are not technically efficient in maize production in the Ejura Sekyedumase District.

   H_1 : Farmers are technically efficient in maize production in the District

2. H_0: Socioeconomic variables such as age, sex and off-farm work does not significantly influence technical inefficiency.

   H_1: Socioeconomic variables such as age, sex and off-farm work significantly influence technical inefficiency.

3. H_0 : The stochastic production frontier estimation does not adequately fits the data better than the average production function.

   H_1 : The stochastic production frontier estimation adequately fits the data.

4. H_0: The Cobb-Douglas production function does not adequately fit the model specification better than the translog production function.

   H_1: The Cobb-Douglas production function adequately fit the model specification better than the translog production function.

5. H_0: There is no significance difference in the ranking of perceived constraints in maize production among farmers in the District.

H_1 : There is a significance difference in the ranking of perceived constraints in maize production among farmers in the District.

The third and fourth hypotheses were tested using the generalised likelihood ratio test (LR). It is specified as:

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

Where $L\left(H_0\right)$ and $L\left(H_0\right)$ 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.

Significance of the Study

Maize is the main staple food in Ghana and therefore high yield and efficiency in its production are critical to food security and income generation. Food security particularly in maize influences the well-being and the health of the population as it contains vital nutrients. Additionally, efficiency in maize production has a direct benefit to poverty reduction in the rural areas and this goes a long way to aid slow down rural urban migration. Therefore, determining technical efficiency in maize production is very important for policy purposes. Thus, a comprehension of the relationship between efficiencies and farmer specific factors will give policy makers the necessary information to design policies to improve the technical efficiency in maize production to enhance the productivity of maize farmers. No country has ever achieved mass poverty reduction without a prior substantial boost in agricultural productivity (Timmer, 2005). The African Union Commission summit on food security in Africa has recognised maize among other crops as a strategic commodity when it comes to attaining food security and ensuring poverty reduction (African Union Commission, AUC, 2006). The measurement of efficiency is therefore vital because it serves as a factor of productivity growth.

In addition, agricultural resources including land, labour, capital and management are limited in nature and the opportunities for the development of new technologies are not much, hence, efficiency is very important in maize production. This will enable producers of maize achieve maximum yield with the available resources and technology.

This study will also add to empirical literature in Ghana.

Delimitations of the Study

1. Even though the Ejura Sekyedumase District on its own may not be representative of the whole of Ghana, findings from this study will throw light on the technical efficiency levels of maize farmers.
2. The accuracy of responses from farmers depended on their ability to recall past information on inputs used and output obtained.

Limitations of the Study

1. It is assumed that all production inputs and farm/farmer specific characteristics were included in the specification of the stochastic frontier model.
2. The second assumption is that the production function faced by farmers who participated in this study is similar.

Organisation of the Rest of the Study

The study is organised into five main chapters. The first chapter highlights the background of the study, statement of the problem, objectives, significance of the study as well as the organisation of the study. Chapter two covers the literature review which discusses the importance of maize, production levels of maize and the theory of technical efficiency. It also looks at the factors that influence technical efficiency, the constraints faced by maize farmers in production and related studies utilising the model of the study. Chapter three outlines the research design, population of the study, the sample and sampling procedures, instrumentation and data collection procedures. The presentation and discussion of the results are captured in chapter four whilst conclusions of the major findings and recommendations are discussed in chapter five.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Overview

This chapter reviews the importance of maize, the production levels of maize, the theory underlying production and technical efficiency. It also emphasizes on the various approaches that are used in estimating the production frontier. The determinants of technical efficiency, constraints to maize production and related studies concerning technical efficiency are also discussed.

The Economy of Maize in Ghana

Maize (*Zea mays L.*) is a plant belonging to the family of grasses, *poaceae*. It is known to have been originated from the Mesoamerican region, now Mexico and Central America. Maize is grown globally and its ability to adapt to different environmental conditions cannot be compared to any other crop. It is grown in areas with 250mm to more than 5000mm of rainfall per year. It has a growing cycle ranging from 3 months to 13 months. The pattern of growth and development for all maize varieties are typically the same. The growth pattern is as follows: the sprouting stage, the grand growth stage, the tasseling stage, the silking, the milky stage and the maturity stage (Manglesdorf, 1974; Dhillon and Prasanna, 2001).

Maize was introduced in Africa in the sixteenth century by Portuguese traders on the Eastern and Western Africa coast including Ghana (Miracle, 1996). The economic importance of maize was not that recognised in the early part of its introduction into Ghana as much credit was given to traditional crops like cocoa and oil palm. However, due to the decline in the profitability in these plantation crops as a result of falling world prices and diseases, attention was then drawn to the commercialization of food crops like maize. Since then at least half of the national output of maize is believed to enter the market (Alderman, 1991).

According to CIMMYT and IITA (2010), the estimated demand for maize in developing countries would be doubled by 2050 and it would also become the crop with the largest production globally. In Africa, maize accounts for only 7% of worldwide production. In 2006, the average yield of maize in Africa was 1.7 tons/ha whilst that of global production was 5 tons/ha. Statistics shows that North America contributes about 38.8% of the global output. This is followed by Asia (28.5%), South America (11.2%), Europe (11.1%), Africa (6.9%), Central America (3.4%), and Oceania (0.007%). This indicates that Africa is one of the least producers of maize worldwide. For the past two decades outputs have increased slightly and this has been attributed to expansion in area cropped other than increases in yields. The largest producer of maize in Africa is South Africa, followed by Nigeria, Ethiopia, Tanzania and Kenya. Generally, Africa is a net importer of maize and as at 2007 net imports of maize stood at 10.64m tons at a value of US$2.25 billion. In Africa, West Africa is the second largest producer of maize and as at 2006 it produced about 11,109 (‘000 tons) of maize (Food and Organisation, 2008).

In Ghana, the average yield of maize recorded by the Ministry of Food and Agriculture in 2010 was 1.9 Mt/ha as against an estimated achievable yield of about 2.5 to 4 Mt/ha (MoFA, 2010). Maize producers in Ghana are therefore producing below the optimum level of production. This implies that Ghana is losing some amount of maize output which she could have obtained without employing additional agricultural resources.

The Importance of Maize

The economic importance of maize in Ghana can be seen in it contribution to food security and poverty reduction especially in the rural areas. With the ever increasing rate of the Ghanaian population, maize has been identified as an important crop in combating food insecurity. Also, maize generates incomes to agents involved in the production, marketing and distribution of the product. This bridges the poverty gap thereby improving livelihoods. Evidence by Boateng, Ewusi, Kanbur and Mackay (1990) shows that poor households earn about 16.8% of revenue from the selling of maize.

In developing countries, maize forms a large percentage of human consumption. According to African Revolution Council (2003), the cob of fresh maize can be eaten by roasting or boiling and therefore plays a crucial role in filling the hunger gap during the dry season. The nutritional value of maize cannot be overlooked as it improves human diet. Maize is a good source of carbohydrate, iron, vitamin B, protein and minerals. Also, the leaves either fresh or dry can be used to feed animals and also it can be added to the soil as a form of mulch to improve soil fertility. The table below shows the composition of edible portion of maize as reported by Gopalan, Sastri and Balsubramanian (2007).

Table 1: Composition per 100g of Edible Portion of Maize (dry)

Nutrients	Per 100g	Nutrients	Per 100g
Moisture	14.9g	Minerals	1.5g
Protein	11.1g	Carbohydrates	66.2g
Fat	3.6g	Calcium	10mg
Fibre	2.7g	Iron	2.3mg
Calories	342mg	Potassium	286mg
Phosphorus	348mg	Thiamine	0.42mg
Sodium	15.9mg	Carotene	90mg
Sulphur	114mg	Vitamin C	0.12mg
Riboflavin	0.10	Magnesium	139mg
Amino acids	1.78mg	Copper	0.14mg

Source: Gopalan et al., 2007

Again, fuel (ethanol) and starch are by products of maize. Starch is used in the manufacturing of products such as dextrin, sorbitol, ice cream, syrup, glue, ink, batteries, beer, shoe polish, aspirin, paint and mustard cosmetics (Directorate Agricultural Information Services, 2003).

Theory of Farm Production

Production is the process of transforming inputs into output by firms or producers. In the course of production choices are made with respect to the firm's objective. The main aim of every firm is to maximise output with a given amount of resources or minimise the level of inputs used to obtain an output and or both. Therefore the allocation of resources is very important in agricultural production. The process whereby firms combine inputs to produce a given level of output can be explained using the production function. The production function depicts a technical relationship between input and output. Mathematically, it is expressed as:

$$q = f(x_1, x_2, ..., x_N) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where q represents output, x_1 to x_N represents a vector of inputs such as land, labour, capital and fertiliser.

Productivity and Technical Efficiency

The concepts productivity and efficiency are often used interchangeably although they are not the same. Productivity of a firm is the ratio of its output produced to the inputs used. The measure of productivity is simple when it requires a single input and a single output. However, in agriculture, most production is undertaken by using several inputs. In this case an appropriate method would be needed to combine the various inputs into a single index input so as to obtain a ratio measure of productivity. On the other hand, technical efficiency refers to the ability of a producer to combine minimum inputs to achieve a maximum output with the available resources. It can also be expressed as the ratio of the observed output to the frontier output (Fried, Lovell and Schmidt, 2008).

The Concept of Technical Efficiency in Production

Technical efficiency is a component of economic efficiency. According to Khanna (2006), a farmer who produces a higher output than his counterpart with the same level of inputs is said to be more technically efficient. Again, technical efficiency measures the ability of a farmer to attain a maximum output with given levels of input and technology. The determination of technical efficiency does not include the prices of input and output quantities. Technical efficiency of a firm refers to the difference between its observed and optimal values of its outputs and inputs and this can be achieved from either the output side or the input side. Thus, technical efficiency can be looked at from the angle where optimal inputs are combined to achieve a given level of output and where optimal output are obtained given a set of inputs (Sentumbwe, 2007). The optimum is defined by production possibilities in both scenarios.

Cooper, Seiford and Tone (2004) have also pointed out that a producer is fully efficient based on available evidence if and only if the performance of other producers does not indicate that the improvement in some inputs or output do not worsen some of its other inputs or output. This is what they term as relative technical efficiency. A firm's technical efficiency is relative to the groups of firms from which the function is estimated. The introduction of additional firms into the analysis may reduce but not increase the technical efficiency of a given firm. At times one may wonder whether the inputs of a given firm are really the same as those shown by the corresponding points on the efficient isoquant. This phenomenon does not pose much of a problem if there are a small number of homogenous inputs each of which is measurable in physical units. Also, simple differences in factors of production will not be of much importance so long as it is evenly distributed over the firms. It will only be a problem when the average quality of factors is different between firms. In this case technical efficiency will exhibit the quality of the firms' inputs in addition to the efficiency of its management. A firm's technical efficiency must reflect the quality of its factors of production to some extent and the measurement of management efficiency cannot be carried out independently from this factor (Farrell, 1957).

Forms of Efficiency

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

- Technological efficiency: the ability to produce an output by using the best technology available.
- 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.
- Scale efficiency: the ability of the firm to produce at a suitable level by exploiting scale economies. Thus, management are 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.
- Dynamic efficiency: operating at the optimum level by incorporating innovations in products and processes.

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

Measurements of Technical Efficiency

According to Berger and Humphery (1997), technical efficiency measurements have to do with the comparison of actual performance to optimal performance. They observed however that since the true frontier is not known an empirical approximation normally referred to as "best-practice" frontier is required. This can be done by using the parametric or the non-parametric technique.

The estimation of technical efficiency comprises two main methods, namely, the parametric approach and the non-parametric approach. A well-known example of the non-parametric approach is the Data Envelopment Analysis (DEA). The DEA is a mathematical programming model applied to observational data which provides a new way of obtaining empirical estimate of efficient production possibility. Thus, linear programming methods are used to construct a non-parametric piece-wise surface (or frontier) over the data. There are two basic DEA models and these are CCR and BCC. The CCR (constant returns to scale) was developed by (Charnes, Cooper and Rhodes, 1978). This model uses constant returns to scale concept to assess relative productive efficiencies of decision making units (DMUs) with multiple inputs and outputs. The second model, BCC (variable returns to scale) introduced by (Banker, Charnes and Cooper, 1984) also uses the concept of variable returns to scale to measure relative productive efficiencies of DMUs with multiple inputs and outputs. Efficiency measures are then estimated relative to this surface.

Data envelopment analysis does not assume any a priori functional relationship between inputs and output and does not make any assumptions about the error term. Also, it easily handles multiple inputs and outputs (Charnes et al., 1978). However, a major weakness of the DEA is that it is a deterministic method and hence assumes that all deviations from the frontier are due to inefficiencies. This makes it susceptible to measurement errors since random errors and statistical noise are not taken into consideration (Battese and Coelli, 2005).

An example of the parametric approach is the stochastic frontier approach. The stochastic frontier function, an improved model of estimating technical efficiency was developed independently by Aigner, Lovell and Schmidt (1997) and Meeusen and van de Broeck (1977). The model incorporates an error term which is a component of statistical noise and technical inefficiencies. The disintegration of the error term makes this technique more preferable to others. The random errors are assumed to be independently and identically distributed. It also assumes a stochastic relationship between inputs and the output produced. Thus, it allows the assumption that deviations from the frontier are due to inefficiencies and noise in the data. However, the assumption of a-priori distributional forms for the inefficiency component and the imposition of an explicit functional form for the underlying technology is a major flaw for the stochastic frontier analysis. Literature highly recommends the use of stochastic frontier analysis in agricultural production as a result of its inherent nature of uncertainty (Ezeh, 2004).

Requirements for Functional Form Specification

In other to analyse a production function, it is always necessary to specify a particular functional form that will depict the production technology. Many at times, 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. A criteria has been formulated by Lau (1978 and 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 other to predict relations, functional forms should

be well matched with upheld hypotheses outside the range of observations.

3. Flexibility: A functional form is said 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 to other recognized empirical facts.

Lau (1978) also noted that one should not expect a particular algebraic functional form to meet all the requirements of his 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 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 and 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. The function portrays the

weak and strict essentiality assumption always. 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 quantity 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 econometric problems. Thus, there would be more parameters to be estimated and this can lead to multicollinearity.

The effect of functional forms on efficiency analysis as asserted by Kopp and Smith (1980) is limited.

Factors Influencing Technical Efficiency

Technical efficiency, the ratio of the observed output to the frontier output is important in any policy formulation geared towards productivity improvement. The ability of the farmer to combine inputs in an efficient manner to produce a maximum output is influenced by the decisions they take during the production process. These decisions which are influenced by farmer specific characteristics are examined to ascertain its impact on technical efficiency. The farmer specific characteristic include age, education, farming experience, sex, access to credit, household size etc.

Age

In literature, the influence of age on technical efficiency tends to have conflicting views. It has been argued that a positive relationship exist between older farmers and technical inefficiency. Older farmers have a tendency to stick to their old methods of production and are unusually unwilling to accept change. However, the younger generation 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 and Yousif (2012). Coelli and Battese (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 and Ruttan, 1985). Lin (1991) has also 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) has identified two different ways through which education can affect agricultural productivity. The first is the “worker effect” and this 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 obtain and decipher information about costs and productive characteristics of other inputs. It also 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 negative relationship with technical inefficiency.

Farming Experience

The age of a farmer is used as a proxy for measuring farming experience. Thus, experience gained by farmers' increases as they advance in age. The number of years spent in farming has an impact on technical efficiency. Its impact is like a two sided coin so it 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 and 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 a source for family labour especially in most developing countries. The availability of labour especially during the peak periods of farming activities influences the technical efficiency of farmers. Households with large family sizes normally depend on its 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 therefore expected that households with small family sizes would be technically inefficient in production.

Sex

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 at the household level. Therefore, decision making of most women are based on what their male counterpart thinks 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 and 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 rate charged by them makes it difficult for farmers to obtain credit from them. Further, more uncertainties in agricultural production can affect the productivity of farmers negatively. This situation can render farmers incapable of paying back the loans given to them (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 Work

Off-farm work is an additional work engaged in by farmers apart from farming to augment household income. Studies show that farmers who engage in other non-agricultural activities are likely to be less efficient as they may fail to pay much attention to the production of maize (Ali and 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 and Akoa, 2004). These may affect the type of information given to the farmers and their rate of adoption. Farmers who have extension contacts are expected to improve their efficiency levels.

Farmer Based Organisations (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 gain from the education on good agricultural practices. Membership to farmers association is known to reduce the inefficiency level of farmers (Idris, Siwar and 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 to FBO's and technical inefficiency is expected.

Farm Size

One of the factors postulated to be a determinant of efficiency is farm size. Ekborm (1998) has established a negative but statistically significant relationship between agricultural productivity and farm size. This suggests that smaller farms are more productive than larger farms. Ekborm (1998) attributed this to the fact that farmers with smaller farms tend to use more labour per unit of land than the larger farms.

Related Studies Utilising the Stochastic Frontier Approach

In the Eastern Region of Ghana, Kuwornu, Amoah and Seini (2013) conducted a study analysing 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 farmers based organisation. This outcome was associated to 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 markets outlets. It was shown that farmers who had access to credit in cash or kind performs better in terms of production than their counterparts who had none. The availability of credit enable 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. This implies that the difference between the actual and potential output is 0.49. The output elasticity for maize production was estimated to be 0.47 indicating decreasing returns to scale.

An empirical work was carried out in Eastern Ghana to investigate the productivity and technical efficiency of cocoa production. The study employed the multi-stage sampling method to select 190 respondents from three districts. The analytical technique used was the stochastic frontier analysis and the single-stage maximum likelihood was used to concurrently estimate the technical efficiency levels of cocoa production and the causes of the determinants of inefficiency. The findings of the study showed that about 77% of the deviations from the output frontier were mostly related to farmers' inefficiencies whereas the remaining 23% was attributed to statistical noise such as unfavourable weather conditions. Given the available resources and technology, the average technical efficiency in the region was estimated at 85%. Cocoa farmers in this region exhibited decreasing returns to scale as the calculated returns to scale was 0.93 (Onumah, Al-hassan and Onumah, 2013). Major sources of inefficiency comprised farming experience, gender, access to credit and extension contacts. Male farmers were more efficient than their female counterparts. Apart from the work they do on the farm female farmers are also burdened with household chores and therefore have little or no time in attending meetings set by extension agents. In cases where they are able to attend such meetings their opinions and worries may not be properly addressed. Also years of experience in farming and access to credit influenced technical efficiency positively. More years of farming experience equips the farmer with knowledge on best input combination and good management practices. The findings also showed that farmers who received more extension visits were less inefficient as compared to those who received less extension visits (Onumah, Al-hassan and Onumah, 2013).

Goyal and Suhag (2003) employed panel data analysis to estimate technical efficiency on wheat farms in Northern India. The analytical tool used was the stochastic frontier analysis and the Cobb-Douglas production function was specified. The ordinary least square and maximum likelihood methods were used to estimate its parameters. According to the findings of their research ordinary least square method was not the appropriate method for this study because the observed output varied substantially from the best practice frontier. The variations observed in the study were caused by factors that were within the farmers' control. Again, the value of the estimated returns to scale was 1.01 suggested constant returns to scale.

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 detrimental 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.

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. Additionally, the calculated gamma value was 0.77 suggesting that 77% of deviations from the production frontier were as a result of inefficiencies in production and the remaining 23% was due to factors that were beyond the farmers' control. He also observed 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.

Oyewo (2011) used the stochastic frontier model to estimate technical efficiency of maize production in Nigeria precisely Oyo State. 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 so would output. 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 triggered the negative relationship with technical efficiency. Similarly, the mean technical efficiency was estimates at 0.961 and 12% of the variations in maize output was due to inefficiencies. Following Oyewo's results, it was concluded that about 82% of the differences in maize output was due to stochastic noise which is beyond the farmer's control.

Lachaal, Chebil and Dhehibi (2004) used a panel data to measure technical efficiency and its determinants in the Tunisian agro-food industry. Results of the maximum likelihood estimates showed that on average smaller firms were technically efficient as compared to the larger ones. The coefficient of skilled labour was negative suggesting that the employment of more skilled labour would reduce the efficiency of the industry. The mean technical efficiency was estimated at 67%. They recommended that the agro-food industry could close the gap between their observed output and frontier output by improving the efficiency level by 33%.

Hasan (2008) conducted a survey on economic efficiency and constraints of maize production in the northern region of Bangladesh. The aim of the study was to characterise the production system, estimate the profitability and input use efficiency and identify the constraints encountered by maize farmers. The systematic random sampling technique was used to select 100 maize farmers for the study. It was revealed that the use of inputs such as seed, fertiliser, irrigation and human labour had a positive influence on yield, indicating that an increase in any of the inputs would lead to an increase in output, all things being equal. The elasticity of output which measures the productivity level was found to be 0.72 in Dinajpur District and 0.68 in Panchagarh District respectively. So a 100 percent increase in all inputs caused output to increase by 72% and 68% in the Districts respectively. Also, variations existed in the output levels of farmers. The technical efficiency level of those at Dinajpur had a range from 0.64 to 0.93 whilst those at Panchagarh had a range from 0.52 to 0.94. The major constraints identified by farmers in maize production included high price of seeds, low price of grains, unavailability of fertilisers, lack of technical knowledge and inefficient marketing system.

Ike and Inoni (2006) conducted a study to look at the determinants of yam production and economic efficiency among smallholder farmers 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%, 29% and 66% 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.

Rahman and Umar (2009) measured technical efficiency and its determinants in crop production in Nigeria. They used a two stage random sampling procedure to select 100 farmers for the study. Using the stochastic production frontier model, they concluded that 77.8% of the deviations from the maximum crops output levels was caused by inefficiencies in production. Additionally, it was discovered that farmer's age, marital status, land ownership and gender had positive and significant relationship with technical efficiency. Furthermore, household size and other occupation had a significant effect on technical efficiency but the relationship between them was negative. Other factors such as major occupation, credit obtained, educational level, number of crops grown and farming experience had no significant relationship to technical efficiency.

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% suggesting that farmers could improve their output level by 17% 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.

The Cobb-Douglas production function was employed by Adeyemo, Oke and Akinola (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% 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 1 of production as the returns to scale was found to be 2.62.

Dadson, Bakang and Cofie (2013) conducted a study to estimate the farm level technical efficiency of small-scale cowpea production. Two hundred (200) farmers were randomly selected from the Ejura Sekyedumase Municipality. The stochastic frontier model as well as the Cobb-Douglas production function was employed to estimate the technical efficiency level of the farmers. Results indicated majority of the cowpea farmers were males. Also, the average age of farmers was 45 and that of farming experience was 16 years. The agricultural inputs farm size, seed, pesticides and labour positively influenced output significantly. The socio-economic factors that contributed to a reduction in technical efficiency included education, farm experience, extension contact and membership to farmers based Organisation. A gamma value of 0.70 was reported and a mean technical efficiency of 0.66 was also achieved. The computed returns to scale was 1.26 indicating increasing returns to scale.

In Bangladesh, a survey was carried out to investigate the technical efficiency of rice farmers under large scale, medium scale and small scale farms. The stratified random sampling technique was used to select 1360 farmers. The results from the maximum likelihood estimates of the Cobb-Douglas production function showed that output had a positive and significant relationship with fertiliser, manure, irrigation cost and land. Under large scale farms, inefficiencies in production were caused by family size whilst that of small scale farms was caused by age, education and family size. The mean technical efficiency for large scale, medium scale and small scale farms was 0.88, 0.92 and 0.75 respectively (Rahman, Mia and Bhuiyan, 2012).

An empirical study was undertaken in Nigeria to examine farm size and technical efficiencies of rice farmers. A sample size of 160 rice farmers was randomly selected. Findings from the Cobb-Douglas production function showed that planting materials, labour, farm size and expenditure on agro-chemicals significantly influenced output positively. The sigma squared value of 0.651 and 0.59 for large and small scale famers indicated a good fit and correctness of the distribution of the assumption. The computed returns to scale under large and small scale farms were 2.25 and 2.01 respectively. Thus, both farms sizes exhibited increasing returns to scale. In addition, the gamma values were 0.32 and 0.35 for large and small scale farms. The average technical efficiencies were estimated at 0.65 and 0.68 for large and small scale farms. Farmer specific factors that influenced technical efficiency positively included capital, extension contact, access to credit and extension contact (Enwerem and Ohajianya, 2013).

Baten, Kamil and Haque (2009) used panel data to model technical inefficiency effects in a stochastic frontier production function. They assumed that the random variable 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 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 size was found to be more efficient than the larger ones.

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 the function 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, an 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 statically 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.

García , Espino and Toribio (2004) conducted a study using Stochastic Frontier Analysis (SFA) and Deterministic Frontier Analysis (DFA) to determine technical efficiency of fisheries in Spain. They came out with the findings that parameter estimates and technical efficiency values differ when different models are used for the estimation. The estimates for the technical inefficiency level using DFA was lower as compared to that of SFA. They attributed this to the fact that DFA does not account for stochastic effects in its estimation. It was also noted that the efficiency indicator for Battese and Coelli (BC) had more spreading than that of Jondrow, Lovell, Materov and Schmidt (JLMS). Again, the mean efficiency for BC was higher.

Hassan and Ahmad (2005) investigated 112 wheat farmers in Pakistan on their level of technical efficiency. The maximum likelihood method was used to estimate the parameters of the stochastic production function. The result of the study showed that the Cobb-Douglas production function adequately represented the data as opposed to the translog production function that was specified. Also, the coefficient for fertiliser use was positive and statistically significant. This showed that an increase in fertiliser use, “all other things being equal” would increase the production of wheat. The parameter of seed was found to be statically significant with a value of -0.39. Thus, a one percent increase in seed use decreased the yield of wheat by 0.39%. The average technical efficiency of wheat farmers was 0.936 with a maximum value of 0.985 and a minimum value of 0.58.

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 percent of the differences in output were attributed to inefficiencies among the farms and 14% 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.

Empirical Review on Constraints to Maize Production

It is the desire of every farmer to attain a maximum output from the resources they combine in production. However, most farmers are not able to achieve this goal due to the scarcity nature of resources. Not only do farmers face inputs constraints but they are also faced with production and marketing constraints.

Chavas, Petrie and Roth (2005) have identified credit and institutional constraint as challenges that maize farmers face in their production. Farmers face institutional constraints in the form of late delivery of fertilisers. This leads to late planting and causes the farmer to produce below the maximum output. Another study by Kumbhakar (1994) reveals that government support affects efficiency in one way or the other. Many farmers were found to be under users of inputs such as fertilisers and seeds and the under use of these resources were linked to market distortions from government regulations.

A stochastic frontier approach was used to measure resource-use efficiency and technical efficiency of turmeric production in Tamil Nadu. One of the goals of this study was to identify the constraints in turmeric production. The Garrett's ranking technique was used to rank and analyse the various constraints. The major constraints identified were non-availability of farm labourers, incidence of pest and diseases, high wage rates, high cost of fertilisers and the scarcity of water (Karthick, Alagumani, and Amarnath, 2013).

It has been reported by International Institute of Tropical Agriculture (2007) that the average yield of maize could reduce by 15% each year as a result of limited use of fertiliser, drought caused by irregular rainfall distribution patterns, declining soil fertility as well as pest and diseases which cause great harm to crops. Also, medium scale farmers who were into the production of soybean in Nigeria produced below the optimum level so the supply of soybean could not meet the demand by consumers. The inability of farmers to be technically efficient in the production of soy bean was explained by the challenges they faced in production. The most worrying problems encountered by the farmers were lack of access to mechanical services followed by inadequate processing facilities, fluctuating prices, high cost of production, poor extension services and lack of finance (Otitoju and Arene, 2010).

In examining the trends, challenges and opportunities of maize farming in Asian countries, it was identified that drought, poor soil fertility, waterlogging and pests and diseases were the major constraints limiting the production of maize. Zaidi, Manislevan, Srivastava, Yadav and Singh (2010) have reported that as a result of flooding and waterlogging problems in South and Southeast Asia, maize production loss incurred per annum is 25% to 30%. Also, the incidence of insects and pests contributes significantly to pre and post-harvest losses. The mean annual yield loss attributed to stem borers, grain weevils and ear rots are 18%, 80% and 49.5% simultaneously (CIMMYT, 2013).

Mahagayu, Kamwaga, Ndiema, Kamundia and Gamba (2007) conducted a study on wheat productivity and the constraints associated in the eastern parts of Kenya. The study revealed that the high cost of seed contributed to the low level of production of wheat. The high cost of seed made most of the farmers to recycle seed from the previous crops harvested which with time causes yield to decrease. The major marketing problems identified were instability of prices and inadequate facilities. Also, the cost of machinery services such hiring of tractors was expensive for small scale farmers as compared to the large scale farmers.

Mudasser, Hussain and Aslam (2001) used a comparative analysis to investigate the constraints to wheat productivity in India and Pakistan. They found out that two climatic factors, rainfall and temperature were major constraints to wheat production. Wheat production was found to be greatly affected by high temperatures during the flowering and the early grain filling stage. In addition, weed control also was also identified as a constraint to the production of wheat. Rawson and Macpherson (2000) have reported that wheat crop competes with weeds for light, nutrients, water as well as root space. Another effect of weeds on wheat crops was wheat could be harmed as a result of poisonous substances produced by weeds.

The potentials of the maize value chain in Ethiopia were examined by International Food Policy Research Institute (2010) by looking at the constraints and opportunities for enhancing the system. Maize is the largest staple crop grown in Ethiopia and it continues to play an important role in ensuring food security. Findings from the study points to the fact inadequate use of modern inputs such as chemical fertiliser and hybrid seeds results in a reduction in maize yield. From a survey conducted by IFPRI (2008), it was made known that all cereal producers in the country used about 17% of fertiliser and 12% also used improved seeds. Another, challenge faced by the farmers was high post-harvest losses. Time of harvesting, shelling methods and the type of storage facilities used were the main causes of post-harvest losses.

An investigation was carried out by Nyangito, Ikiara and Ronge (2002) to ascertain the reasons why the domestic production of wheat in Kenya was uncompetitive. Results showed that land shortage was a major constraint to wheat productivity. This challenge caused many farmers to shift the growing of wheat from areas with fertile soil and adequate areas to low potential areas. Other constraints identified were pest infestation, low producer prices, lack of access to credit and poor supply of inputs.

Conceptual Framework of the Study

Farrell (1957) has defined a simple measure of firm efficiency that could account for multiple inputs and this measure was based upon the work of Debreu (1951) and Koopmans (1951). He proposed that a firm's efficiency comprises two components. First is technical efficiency (TE) and this shows the ability of the firm to obtain maximum input from a given set of inputs. The second component allocative efficiency also reflects the ability of a firm to use minimal inputs, given their respective prices and available technology to obtain maximum output. The product of these two measures gives total economic efficiency.

Technically efficiency measure is usually illustrated in input/input space and this is known as input-orientated measures. This answers the question "By how much can input quantities be proportionally reduced without changing the output quantities?" This is depicted by Figure 1. From Figure 1, a firm combines two inputs ($x_1$and x_2) to produce a single output (q), under the assumption of constant returns to scale. The unit isoquant SS' represents the minimum combination of inputs needed to produce a unit of output. Any inputs combination along the isoquant is considered to be technically efficient while any point above it such as point P, defines a technically inefficient firm since it uses a more than enough inputs combination to produce a unit of output. Hence, the distance QP along the ray 0P measures the technical inefficiency of the firm located at point P. This distance represents the amount by which all inputs could be proportionally reduced without a reduction in output. The technical inefficiency level of a firm is expressed by the ratio QP/0P. Therefore, the technical efficiency of a firm is measured by the ratio 0Q/0P and it is also equal to one minus QP/0P. It takes a value between zero and one, hence, a value of one shows that the firm is fully technically efficient (Farrell, 1957).

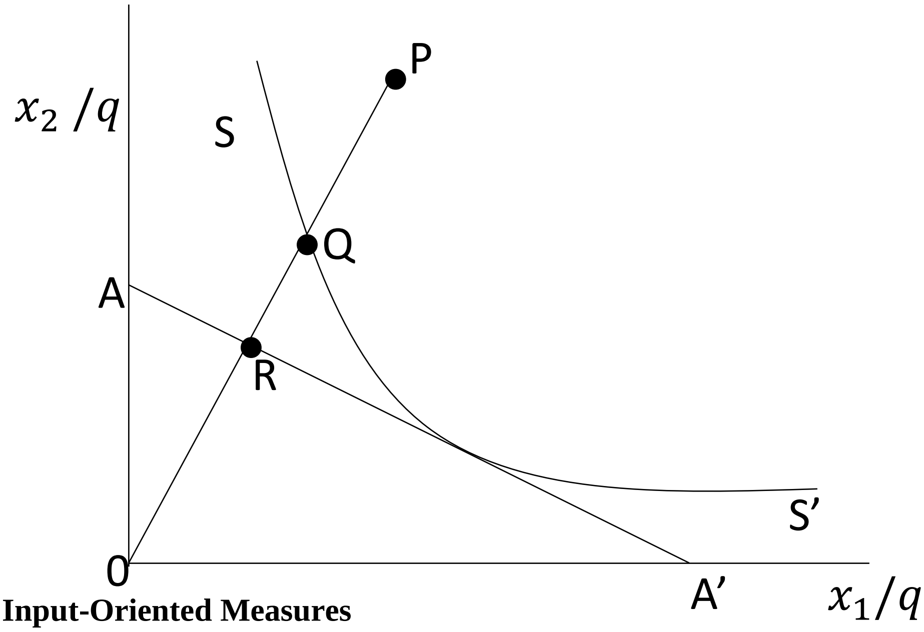

Figure 1: Input-Oriented Measures

Source: Coelli, Rao, O'Donnell and Battese, 2005

CHAPTER THREE

METHODOLOGY

Introduction

This chapter focuses on the description of the study area, research design, sampling techniques, data collection and analytical techniques employed in the study. It also describes the variables that were used to estimate the technical efficiency level of maize farmers in the study area.

Research Design

This study employs the cross sectional survey design to examine technical efficiency in maize production. In this type of research study, data is collected from the entire population or a subset of it to help answer questions that are of interest. It is called cross-sectional because information regarding the dependent and the independent variables to be measured represented what was going on at a single point in time. This research design is appropriate as it makes inference about the effect of one or more explanatory variable on the dependent variable by recording observations and measurements on a number of variables at the same point in time (Gay, 1992).

In efficiency analysis, this technique is more useful as it allows for the collection of data on attitudes and behaviours exhibited by respondents in this case maize farmers. It also allows the researcher to collect information from large number of respondents and therefore can include many variables in the analysis. Again, this research design is appropriate when dealing with respondents that are scattered in different districts or regions.

However, the use of cross-sectional data in efficiency analysis comes with its own problems. One is that it cannot measure changes that occur especially technological changes which are key determinants of efficiency. This technique is also time bound and more expensive as data collection covers more respondents and areas.

Study Population

The population of the study included all maize farmers in the Ejura Sekyedumase District which is located in the Ashanti Region of Ghana. The District was formerly part of the Sekyere and Offinso Districts but was carved out on 29th November, 1988. It shares boundaries with four other Districts, namely: Nkoranza and Atetebu North Districts (both are found in the Brong Ahafo region) located on the northern part, Offinso District located on the western part, Sekyere Central located on the eastern part and Sekyere West and Mampong located on the southern part. Economically, agriculture is the main activity and largest employer in the area accounting for about 60% of the total employment. The District lies within longitudes 1°5 and 1°39' West and latitudes 7°9' and 7°36' North. It is reported that about 65% of the population are Muslims, 30% are Christians and 5% are traditionalists. The topography of the northern part of the District is fairly flat. The district experiences a bimodal rainfall distribution as it lies in the semi-deciduous rainforest and the savanna zone. The major season starts in April and ends in August whilst the minor season begins in August and ends in November. The dry season which occurs between November and April is accompanied with the North-East trade winds (harmattan) which blows dry and dusty wind across the District. The annual rainfall distribution ranges from 1,200mm to 1,500mm. Generally, the rainfall pattern in the District is not reliable and high humidity is experienced during the rainy seasons. The district is the most arid in the Ashanti region and in June it has a relative humidity of 90% and 55% in February. The mean monthly temperature ranges from 21°C to 30°C. The semi-deciduous forest vegetation covers the south-eastern part and the Guinea savanna vegetation covers the northern of the District. Some form of mechanized farming is practiced by those who are into maize and rice production. The soil in the study area has a moderate supply of organic matter and plant nutrient which is deep, light in colour, well aerated and easy to work with. This makes it suitable for the growing of maize, millet, groundnuts, cowpea, yams, cassava, garden eggs, tomatoes among others (MoFA district report, 2013).

Sample and Sampling Procedure

The Ejura Sekyedumase District has been divided into nineteen (19) agricultural operational areas. Each of these operational areas has a number of communities under it. For this study, five agricultural operational areas were selected randomly by using the lottery method. The chosen operational areas were Ejura, Drobong, Aframso, Sekyedumase and Dromankuma. A sampling frame of the number of maize farmers from the selected operational areas was obtained from the Ministry of Food and Agriculture in Ejura. From the five operational areas, the estimated figure of the sampling frame was 1,305. Following Yamane (1967), the sample size was calculated to be 306. In all, a total of three hundred and six (306) maize farmers were selected for the study. Then, a proportionate stratified sampling technique was used to select the required number of maize farmers from the five agricultural operational areas. The study used an equal sample size because the operational areas had similar strengths in terms of population and maize production. The simple random sampling was then used to select 61.2 maize farmers from each agricultural operational area.

Calculation of the sample size

$$n = \frac{N}{1 + N\left(e\right)^2}$$

$$n = \frac{1305}{1 + 1305(0.05)^2}$$

$$n = \frac{1305}{4.2625} = 306.158$$

Where

n = the sample size

N = the population size

e = the sampling error

Accuracy is important in research work and one of the things that determine accuracy is the sample size. In choosing the size of a sample, one needs to take into consideration two concepts. That is, precision and confidence level. Precision explains the amount of error that the researcher is willing to tolerate and the level of confidence is the degree of certainty that the true value of the variable being studied is captured within the standard error. It is also believed that the larger the sample size, the more accurate the estimates.

Instrumentation

Primary data was used for the study and this was obtained through interview schedule (self-administered questionnaires). Structured interview schedule which included open and closed ended questions were used to gather information relating to technical efficiency in maize production from farmers involved in maize production. The structured interview schedule was used because most of the farmers could not read or write the English language. The questionnaire was structured in a way that the section A covered the farm and farmer specific characteristics such as the age of the farmer, gender, household size, educational level, marital status, off-farm work among others. Section B of the questionnaire dealt with the production activities of the farmer. Also, section C of the questionnaire provided information on the inputs used and the output obtained by the farmer. These included information on land, labour, material used for planting, fertiliser, equipment, chemical use and output obtained. The last section D, covered the constraints that farmers face in their production. This included input, production, and marketing constraints.

Pre-testing of Instruments

Sarantakos (1997) defines a pre-test to be small tests of single elements of the research instrument which are predominantly used to check eventual 'mechanical' problems of the instruments. This is done when a researcher is unsure about the appropriateness of one small part of the instrument. The pre-test was undertaken in January 2014 with 18 respondents who cultivated maize in the Abura-Aseibu-Kwamankese 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 when found necessary. Inaccuracies identified during the pre-testing were corrected before the actual data collection took place. The Cronbach's alpha was then used to measure internal consistency. The estimated reliability coefficient was 0.74. This was above 0.7 so the scales used were reliable.

Data Collection Procedure

The actual data collection was carried out from 16th February 2014 to 12th March, 2014 by the researcher with the help of five Agricultural Extension Agents (AEAs). The AEAs were recruited from the Ministry of Food and Agriculture under the Ejura Sekyedumase District. The field assistants were selected based on their educational level, past research experience and the knowledge of the local language (Twi and Dagbani). These assistants were trained to understand the purpose of the study and how to ask clear questions so that the respondents would give appropriate answers. For the respondents who had no or low education, their responses were recorded by the interviewers in English.

Issues from the Field

A few challenges were encountered during the data collection. Majority of the respondents thought that the interviewers were delegated by the government or some Non-Governmental Organisation (NGOs) to listen to their problems and offer immediate help especially with the provision of inputs needed to undertake their production activities. Therefore, some respondents were not willing to participate in the interviews. They also claimed that each year people come to solicit information from them with regard to their farming activities but they had not received any direct benefit from such interviews.

Description of Output and Input Variables for the Study

Output: The total quantity of maize harvested during the 2013 cropping season and it is measured in kilogram.

Land: It is the area of the farm allocated to the production of maize and this variable is measured in acres. All maize farmers interviewed practiced mono cropping. The amount of land used is expected to have a positive influence on output.

Labour: This includes both family and hired labour and it is measured as person-days spent on the farm from land preparation to harvesting. Person-days were measured according to the rule that one adult male, one adult female and one child (less than 18 years) equals 1 man-day, 0.75 man-days and 0.50 man-days respectively. A day's work on the farm equals 8 hours. These proportions have also been applied by Coelli and Battese (1996). It was expected that labour would have a positive influence on output.

Equipment: The cost of items that are directly involved in the production process. It is measured in Ghana cedi (GHS). The use of equipment was anticipated to increase output.

Seed: The quantity of maize seeds cultivated and it is measured in kilograms (kg). The plant population of maize is influenced by the quantity of seeds cultivated per acre of land which will in turn influence output. It could have a direct or indirect relationship with output.

Agrochemicals: The quantity of agrochemicals (weedicide, pesticide, fungicide and insecticide) used per acre of land and it is measured in litres. Its influence on output could be positive or negative.

Fertiliser: the amount of fertiliser applied on maize plot in kg per acre during the 2013 cropping season. It is of the expectation that fertiliser would have a positive effect on yield.

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 with regard to input combination and use of existing resources. Hence, it is anticipated that education would influence technical efficiency positively.

Age: It is a categorical variable that measures the age of maize farmers. It is measured in years. Chukwuji, Inoni & 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 is measured as a dummy variable, 1 if the farmer is a male and 0 if the farmer is a female. Male farmers are expected to be more technically efficient.

Extension services: It shows whether the farmer had access to extension services during the cropping season. It is measured as a dummy variable, 1 if farmer had access to extension service and 0 if otherwise. Extension services provided to farmers enable them to learn better farm management practices and efficient use of resources.

Occupational status: It indicates whether the farmer engaged in other economic activities aside from maize farming during the 2013 cropping season. It has been argued by Rahman (2002) that those who engage in different economic activities at the same time do not have full time for any of them thereby leading to technical inefficiency. It is measured as a dummy variable and has a value of 0, if the farmer engages in other off farm work whilst a value of 1 indicates that maize production is regarded as a full time occupation.

Access to credit: It is measured as a dummy variable, 1 if farmer had access to credit, 0 if otherwise. Access to credit helps to ease the financial constraint faced by farmers. Farmers who have access to credit tend to have higher technical efficiency than those who have not (Binam et al., 2004).

Household size: It includes the number of people who were living with the farmer as at the 2013 cropping season. It is 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 maize 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 is expected that farming experience would have a significant relationship with maize output.

Data Analysis

Descriptive statistics and econometric methods were used for the study. Descriptive statistics including frequencies and pie chart were used to describe farm and farmer specific characteristics. The stochastic frontier analysis, econometric approach of measuring technical efficiency was also employed for the study. The statistical packages used for the data analysis were the SPSS and the R programming software.

Analytical Model for Estimating Technical Efficiency

In order to estimate the technical efficiency level of maize farmers, the technical efficiency score was computed. The outcome of the technical efficiency score determines whether maize farmers in the study area are technically efficient or not. In this study, the stochastic frontier model was used to parametrically estimate the production frontiers and the level of technical efficiency in maize production. Due to the nature of agricultural production, the stochastic frontier model which was independently put forward by Aigner et al. (1977) and Meeusen et al. (1977) was used for the estimation of technical efficiency. This allows stochastic noise and producer's inefficiency to be accounted for at the same time. For cross-sectional data, the stochastic frontier function is given as:

$$Y_i = f(X_i;\beta)\exp(\varepsilon_i) = f(X_i;\beta)\exp(V_i - U_i),\ i = 1, 2, ..., N \ \ldots\ldots\ldots \qquad (2)$$

Where Y_i denotes the level of output for the i^{th} farmer; X_i denotes a vector of inputs; β denotes a vector of unknown parameters to be estimated; ε_i denotes the composed error term consisting of two independent elements V_i and U_i such that $\varepsilon_i = (V_i - U_i)$. V_i denotes the stochastic noise and other factors beyond the farmers control; U_i denotes the inefficiency error term which is non-negative. This makes it possible for all observations to lie on or below the stochastic production frontier (Coelli, Rao, O'Donnell and Battese, 2005). Further, it is assumed that the two-sided error V_i is identically and independently distributed (iid) with a mean of zero and a variance of σ_v^2. Also, V_i and U_i are distributed independent of each other and of the independent variables. Following from equation (2), technical efficiency can then be specified as:

$$, TE_i = \frac{f(X_i;\beta).\exp\{v_i - u_i\}}{f(X_i;\beta).\exp\{v_i\}} = \exp\{-u_i\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Equation 3 defines technical efficiency as the ratio of the observed output to the frontier output. Technical efficiency takes a value between zero and one. Thus, $0 \leq TE_i \leq 1$. If $u_i = 0$, then the production firm is 100% efficient and if $u_i > 0$, then there is some inefficiency.

Below is the marginal density function for the composed error term specified by Kumbhakar & Lovell (2000) assuming that the inefficiency error term is half-normally distributed:

$$f(\varepsilon_i) = \left(2/\sigma\right).\phi\left(\varepsilon_i/\sigma\right).\phi\left(-\varepsilon_i\lambda/\sigma\right), \text{ for} -\infty < \varepsilon_i < \infty, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where $\sigma = \sigma_u^2 + \sigma_v^2$ and $\lambda = \sigma_u/\sigma_v$ are the parameterised variance parameters

The model was estimated using the maximum likelihood (ML) method which 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 and Battese, 2005). It makes some distributional assumptions about the two error terms. Thus, it helps us to model the impact that external factors may have on the distribution of the inefficiencies. The ML estimator is preferred to other estimators such as the ordinary least squares (OLS) and the corrected ordinary least squares (OLS) because it is asymptotic. Thus, it has many desirable large sample properties. With the maximum likelihood estimation, a value is chosen for the 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. The gamma estimate is specified as:

$\gamma = \frac{\sigma_u^2}{\sigma^2}$. Gamma ($\gamma$) takes a value between zero and one. Variations in the observed output is attributed to inefficiency factors if the value is closer to one and deviations from the frontier output is attributed to random factors if the value is closer to zero (Battese and Corra, 1977). 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.

Specification of the Empirical Model

In this study, the Cobb-Douglas production function was used to estimate the stochastic frontier production function. This functional form was chosen because it is flexible, self-dual and its returns to scale are easily interpreted (Bravo-Ureta and Evenson, 1994). Also, empirically, the Cobb-Douglas production function has been widely used in technical efficiency estimation (Hasssan et al., 2005; Essilfie et al., 2011). The model is specified as:

$$\log \mathrm{Y}_i = \beta_0 + \sum_{i=1}^{6} \beta_i \log X_i + e_i$$

$$\log Y_i = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 + e_i \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

$$e_i = v_i - u_i$$

Where Y_i is the output of maize (kilograms) produced in 2013 season by the i^{th} farmer; X is a set of six input categories namely: land size (acres), labour (man-days), seed (kilograms), agrochemicals (litres), Equipment (GHS), fertiliser (kilograms); β denotes the unknown parameters to be estimated; v_i denotes random shocks; u_i is the one-sided non-negative error representing inefficiency in production.

Estimation of Factors Influencing Technical Efficiency

The determinants of technical efficiency was obtained by identifying the factors that influence technical inefficiency levels through the establishment of the relationship between farm and farmer specific characteristics and the technical efficiency scores. Two main approaches are used in the estimation of factors that influence technical inefficiency, thus, the two-stage and the one-stage approach. With the two-stage approach, the stochastic production function is firstly estimated to obtain the efficiency scores and in the second stage, the efficiency scores obtained were regressed on the explanatory variables using the ordinary least square method. The one-stage approach as in Battese et al. (1995), involves a concurrent estimation where the inefficiency effects are expressed as an explicit function of a vector of explanatory variables. This study adopted the single stage approach because the choice of inputs by farmers is shaped by their level of technical inefficiency. The inefficiency model of the stochastic frontier function is given by:

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

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 \quad \text{………...} \quad (6)$$

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 (1 = male, 0 = female)

Z_4 denotes agricultural extension services (if yes = 1, no = 0)

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

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

Z_7 denotes household size (number)

Z_8 denotes experience (number of years in maize production)

Z_9 denotes farmer based organisation (if yes =1, no =0)

Estimating the Level of Productivity

Productivity level of maize production was determined by estimating the output elasticities of the factors of production. From the Cobb-Douglas production function, the elasticities of the inputs are equal to the corresponding coefficients. Based on the firms' output elasticities, it would be known whether the firm shows constant returns to scale, decreasing returns to scale or increasing returns to scale and its implication to the firm. A production function exhibits constant returns to scale if a proportionate increase in all inputs leads to the same proportionate increase in output. A production function exhibits decreasing returns to scale if a proportionate increase in all inputs results in a less than proportionate increase in output. A production function exhibits increasing returns to scale if a proportionate increase in all inputs results in a more than proportionate increase in output. The summation of all the output elasticities gives the returns to scale (RTS). Mathematically, it is specified as:

$$RTS = \sum_{i=1}^{6} \varepsilon y_i \qquad \text{…………………………} \qquad (7)$$

Identifying Constraints to Maize Production

The Kendall's coefficient of concordance was used to rank the constraints faced by farmers in maize production. Kendall and Smith (1939) have provided 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 assesses 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. The most important constraints to maize production were identified and assessed for severity on a scale of 1 - 4 (1 = very high constraint; 2 = high constraint; 3 = low constraint, 4 = very low constraint). The rankings were then subjected to the Kendell's coefficient of concordance measure so as to know the degree of agreement of rankings by different maize famers. 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:

$$W = \frac{12\left[\sum T^2 - \frac{\left(\sum T\right)^2}{n}\right]}{nm^2(n^2-1)} \qquad \text{.............................} \quad (8)$$

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 maize farmers; n represents the number of constraints being ranked. The F distribution was used to test for the significance of the Kendell's coefficient of concordance (Tetteh, Adjetey, and Abiriwie, 2011). Mathematically, the F-ration is given as:

$$F = \left[(m-1)W / (1-W)\right]$$

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

$$(n-1) - \left(2/m\right)$$

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

$$m-1\left[(n-1)-2/m\right]$$

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:

$$S = \frac{12\sum_{j=1}^{m} R_j^2}{m^2 n\left(n^2-1\right)} - 3\frac{n+1}{n-1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

Equations 8 and 9 are equivalent. 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

Introduction

This chapter presents the analysis and discussions of the findings of the study. It comprises five sections. The first section looks at the farm and farmer specific characteristics. The second section presents the technical efficiency level of the farmers. The third section looks at the determinants that influence technical efficiency. The last two section looks at respondents' productivity levels and the problems they face in maize production respectively.

Description of Farmer and Farm Specific Characteristics

This section gives descriptive statistics of farm and farmer specific characteristics. These include, sex, age, marital status, educational level, farming experience, household size, land ownership, method of land preparation, variety of maize grown among others.

Sex Distribution

From the results in Table 2, 76.1% of the respondents were males and 23.9% were females. The sex of respondents was highly skewed towards the males. This shows that the cultivation of maize in this District is dominated by males. It has been found that both men and women have similar abilities in farm management when equal opportunities are given to them (Sharma and Leug, 2000).

Table 2: Sex Composition of Respondents

Sex	Frequency	Percentage
Female	73	23.9
Male	233	7 6.1
Total	306	100

Source: Field data, 2014

Age Distribution

Findings from the study show that majority of the respondents representing 31.4% fell between the ages of 50 and 59. This was followed by farmers with ages between 40 and 49. Farmers with the least age were those between the ages of 60 and 69. So, maize cultivation is mostly undertaken by farmers who are forty years and above. This reinforces the findings by Andoh (2007) that farming in the rural areas has been left for the older generations. Age is known to affect a person’s personality make-up in the way they think, behave and make decisions (Bembridge, 1987). These may affect the rate at which both the young and the old adopt certain agricultural technologies and how they react to risks and uncertainties.

Table 3: Frequency Distribution of the Age of Respondents

Age of Respondents	Frequency	Percentage
20-29	52	17.0
30-39	61	19.9
40-49	73	23.9
50-59	96	31.4
60-69	17	5.6
70-79	7	2.3
Total	306	100

Source: Field data, 2014

Marital Status

Results in Table 4 shows that 77.5% of maize farmers interviewed were married, 14.1% were single, 5.6% were divorced and 2.9% were widowed. Respondents who are married have the opportunity to use family labour to carry out some of their farming operations. However, they may have extra responsibilities to fulfil aside from their farming activities. This may affect their efficient use of resources.

Table 4: Distribution of Famers' Marital Status

Marital status	Frequency	Percentage
Single	43	14.1
Married	237	77.5
Divorced	17	5.6
Widowed	9	2.9
Total	306	100

Source: Field data, 2014

Educational level of Farmers

From Table 5, the educational level of the respondents show that 36.3% of farmers had no formal education, 22.9% had primary education, 25.2% got to the junior high school level (JHS), 15% also experienced schooling up to the senior high school level (SHS) and only 0.7% had tertiary education. Formal education has been identified as a stepping stone for which farmers can become better managers of agricultural resources. It is known to have an influence on the kind of information accessed and on the kind of planning that takes place at the household level (Moyo and Chambati, 2009).

Table 5: Frequency Distribution of Respondents' Educational Level

Educational Level	Frequency	Percentage
No education	111	36.3
Primary	70	22.9
Middle/JHS	77	25.2
O'level/SHS	46	15.0
Tertiary	2	0.7
Total	306	100

Source: Field data, 2014

Farmers' Occupational Status

As indicated in Figure 1, most of the respondents representing 53.59% are engaged in off-farm work activities. Data collected showed that majority of those who engage in other work aside farming are into trading. This is not surprising because two main market centres are located in the District: one at Ejura and the other at Sekyedumase. These markets attract buyers and sellers from near and afar so the farmers also used that opportunity to sell some of the produce from their farms. Thus, trading has become another activity from which they can generate extra income. Due to this activity, farmers may devote less time to their farm work which may impact on technical efficiency negatively (Abdulai and Eberlin, 2001).

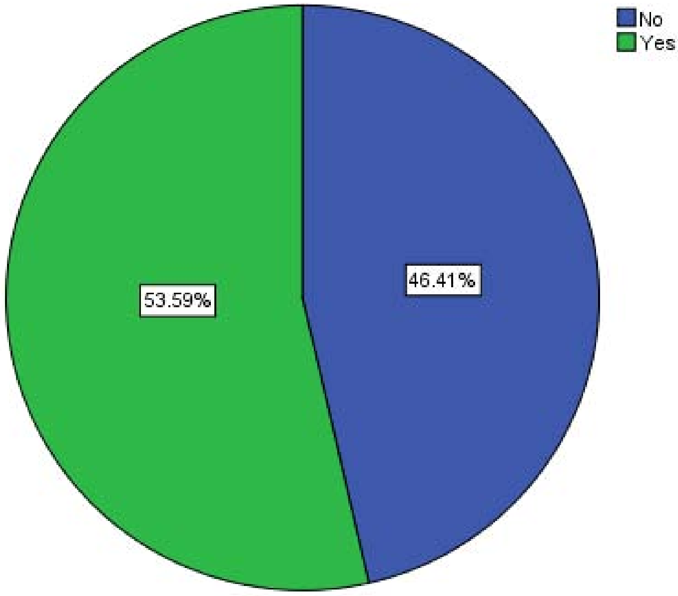

Figure 3: Farmers' Occupational Status

Source: Field data, 2014

Farmers Access to Technical Training

Findings show that 91.2% of maize farmers did not receive technical training in terms of field demonstrations. Technical training through field demonstrations plays a vital role in the distribution of information about modern agricultural practices. Some gains from the demonstrations includes planting methods and correct spacing of seeds, correct timing of fertiliser application, weed control as well as pest and disease control. Learning by doing is an effective way of practicing accurately what has been thought.

Table 6: Access to Technical Training

Received technical training	Frequency	Percentage
No	279	91.2
Yes	27	8.8
Total	306	100

Source: Field data, 2014

Sources of Finance to the Farmer

It is shown in Table 7 that majority of the respondents constituting 91.5% depend on their own savings to undertake agricultural production activities. Other sources of access to credit by farmers include the family, friends and Non-Governmental Organisations (NGO's). Also out of the 306 farmers interviewed, none of them accessed a loan from the financial institutions such as such as banks and micro finance companies. Farmers are likely to engage in other activities that will help them to earn extra income as they depend on their own personal savings for production. Peacock, Jowsett, Dorward, Poulton and Urey (2004) established that because farmers' livelihoods are characterised by risks and uncertainties, micro finance institutions have failed to provide them with financial assistance.

Table7: Sources of Finance Available to Farmers

Source	Frequency	Percentage
Own	280	91.5
Family	13	4.2
Friends	9	2.9
NGOs	4	1.3
Total	306	100

Source: Field Data, 2014

Means of Land Ownership

From Table 8, it is clear that about 67% of the farmers have no land on their own and therefore have to rely on renting. The implication of this situation is that the farmers may not feel the need to invest in land development as they may not have any emotional attachment to the land they cultivate. This may prevent them from adopting best cultural practices and cropping system. This is vital when it comes to enhancing agricultural output. Also, land tenure is known to influence the ability of farmers to invest in fixed inputs such as machinery (Hayes, Roth and Zapenda, 1993).

Table 8: Pattern of Land Ownership

Land ownership	Frequency	Percentage
Own land	13	4.2
Family land	89	29.1
Rent	204	66.7
Total	306	100

Source: Field data, 2014

Results from Table 9 shows that 65.4% of farmers are engaged in the production of aburowhoma, 46.7% of farmers produce obatanpa and 11.1% produces mamaba. Obatanpa, a quality protein maize (QPM) is known to be the most popular maize variety in Ghana as well as many other African countries. It also has the ability to withstand pest and diseases. Mamaba is a hybrid variety and it is characterized by high yield, drought resistance and it ability to resist the maize streak virus is moderate. Aburowhoma is a local or traditional variety and it is the most common maize seed grown by the farmers in the District. They believe that under the conditions of limited resources such as water and soil nutrients, the local variety is the best. Its ability to withstand drought is high as compared to the improved varieties. Local maize seeds according to Smale, Heisey and Leathers (1995) are normally preferred by most smallholder farmers as it vulnerability to pest is low and it can also be recycled. Most respondents interviewed used farmer-saved seeds for production. As a result of multiple responses the number of maize farmers are more than 306.

Table 9: Type of Maize Cultivated

Variety	Frequency	Percentage
Obatanpa	143	46.7
Aburowhoma	200	65.4
Mamaba	34	11.1

Source: Field data, 2014

Method of Land Preparation

In production, land clearing is carried out to aid soil preparation and planting. Maize farmers in the District combine one or more method of land preparation. About 70% of the farmers make use of machines like tractors to till the land. This is made possible because of the undulated nature of the topography of the land in that area. About 97% of farmers' employ the use of herbicides to control newly developed weeds after plowing. It can therefore be concluded that use of herbicides has been embraced by farmers in the District.

Table 10: Method of Land Preparation

Method	Frequency	Percentages
Slash and burn	97	31.7
Slash no burn	13	4.2
Herbicides	296	96.7
Machines and implements	214	69.9

Source: Field data, 2014

Findings from Table 11 indicate that on average a yield of 7396.37kg was obtained. This output was obtained by combining on the average 170.65 person-days of labour, 16.06 acres of land, 15.82 litres of agrochemicals, 140.98 kilogram of fertiliser, 5.03 kilogram of seeds and GHS15.68 of equipment. The least and highest yield obtained shows there is a large variation in maize output among farmers in the District. The wide variation in output could be attributed to differences in technical efficiency.

Further, the average age and the years of schooling of maize farmers were 44 years and 5 years respectively. It can therefore be asserted that the older people are the ones engaging in agricultural production especially in maize cultivation. In addition, averagely, the highest level of education attained by a farmer is the primary school and the average number of persons in a household was seven. Respondents with large household size tend to depend more on family labour and those with small household size also depend more on hired labour. Household size also has an effect on family expenditure. The result also shows that the number of years engaged in maize production by farmers ranged from 2 years to 52 years. Respondents have much experience in maize farming as the mean experience is about 18 years. Farmers had an extension contact approximately once during the cropping season.

Table 11: Summary Statistics of Variables in the Frontier and Inefficiency Models

Variable	Unit	Minimum	Maximum	Mean	Std. Dev
Output	Kg	480.00	52200.00	7396.3660	6919.3094
Labour	P-D	28.00	469.00	170.6471	75.9079
Land	Acres	2.00	60.00	16.0556	10.6040
Equipment	GHS	2.40	72.00	15.6811	14.0402
Agrochemicals	Lit.	3.00	63.00	15.8235	10.6514
Fertiliser	Kg	25.00	300.00	140.9804	43.3289
Seed	Kg	3.00	9.00	5.0310	1.1212
Age	Years	20.00	75.00	43.5915	12.6338
Education	Years	.00	18.00	5.1307	4.5111
Household size	No.	.00	25.00	6.6536	4.3837
Experience	Years	2.00	52.00	17.8268	10.8292
Extension visits	No.	.00	5.00	0.6111	1.0631

Source: Field data, 2014

Technical Efficiency Level of Maize Farmers

As shown in Table 12, the positive coefficients of labour, land, equipment and fertiliser implies that as each of these variables is increased, output of maize also increases. Arable land available for production continues to reduce as a result of pressure from population increase. This makes it difficult for farmers to practice agricultural techniques such as crop rotation and shifting cultivation which would have helped replenish soil nutrients. Therefore, it has become necessary that farmers embrace the use of fertiliser to enhance output. There is also a significant but negative relationship between the use of agrochemicals (weedicides, pesticides, fungicide and insecticide) and maize yield. This suggests that the output level of maize would decline as the use of agrochemicals is increased. One plausible explanation for this relationship may be due to the wrong application of the input resulting in excessive use. The coefficient of seed is insignificant but has a negative relationship with output. An explanation for this result is that the quantity of maize seed used by farmers may be higher than the recommended seed rate. The data collected showed that most of the farmers used aburowhoma which is a local variety. Local varieties are known for its low germination rate and yielding capabilities, therefore, farmers are tempted to use as many as 3 to 6 seeds in a hole. This may lead to overcrowding which makes seedlings compete for nutrients, space and air. This result is consistent with the studies by Battese and Hassan (1999).

It is also evident that the sigma square value is significantly different from zero, showing a good fit and correctness of the specified distribution assumption. Again, it is clear that the maximum likelihood estimate of the gamma value is 0.6324 and this is coherent with the theory that the parameter gamma lies between zero and one (Battese et al., 1995). The parameter, gamma, shows the total variation of observed output from frontier output. The value (0.6324) is significantly different from one. This means that variations in output are not only caused by inefficiencies in production but it can also be attributed to stochastic noise such as bad weather. This confirms the argument that agricultural production is characterised by uncertainties (Abedullah and Mushtaq, 2007).

Drawing from Henningsen (2013), the variance of the inefficiency term *u*, is not equal to σ_u^2 rather it is equal to $Var(u) = \sigma_u^2 \left[1-(2\phi(0))^2\right]$. Therefore, the proportion of the total variance as a result of inefficiency cannot be explained as the estimated parameter γ. So, further analysis shows that the proportion of the total variance due to inefficiency is 0.38 or 38%.

Table 12: Maximum Likelihood Estimates of the Stochastic Frontier Model

Variable	Parameters	Coefficient	Std. error	z-value
Intercept	β_0	5.4713***	0.3478	15.7324
log (Lab)	β_1	0.0768	0.0646	1.1893
log (Land)	β_2	1.2862***	0.0637	20.2077
log (Equip)	β_3	0.0667**	0.0255	2.6059
log (Agrochem)	β_4	-0.1646*	0.0681	-2.4161
log (Fert)	β_5	0.0498	0.0551	0.9037
log (Seed)	β_6	-0.0931	0.0813	-1.1443
Variance parameters				
Sigmasq	σ^2	0.0935***	0.0183	5.1033
Gamma	γ	0.6324**	0.2071	3.0529
Log likelihood		-49.4088		

Source: Field data, 2014

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 10 ‘ ’ 1

As indicated in Table 13, the technical efficiency of the farmers is below 100% or 1, showing that all the sampled maize farmers in the District produce below the frontier. The efficiency distribution show that about 61% of the farmers had a technical efficiency of 70 percent while 39% had an efficiency level of above 70 percent. The mean technical efficiency level is about 67% and this is lower than that of Wakili (2012) who found the average technical efficiency of maize production to be 84%. A wide range of variation exists in the technical efficiency scores of the maize farmers with 28% as the least score and 93% as the highest score. This disparity could be explained by the fact that farmers' combination of inputs yielded different output levels, all other being equal. The average technical efficiency level of 67% shows that maize farmers could bridge the gap between their observed output and the frontier output by 33%. The implication of this is that with the same level of available resources, farmers could increase yield by 33% without employing any additional resources. This can be achieved by improving farmer specific factors such as education, off-farm work activities, access to credit and experience.

Table 13: Frequency Distribution of Technical Efficiency Scores

TE: Range (100%)	Frequency	Percentage
1-50	20	6.5
51-60	72	23.5
61-70	95	31.0
71-80	75	24.5
81-90	43	14.1
91-100	1	.3
Total	306	100
Mean TE		66.99
Minimum		28.33
Maximum		93.09

Source: Field data, 2014

The frequency distribution of technical efficiency scores is displayed by Figure 4. Majority of the farmers representing 31 percent had a technical efficiency scores between 61 and 70. Also, twenty farmers had a TE score between 1 and 50 and only one farmer had a TE score from 91-100. This shows that a wide variation in output exists among producers of maize.

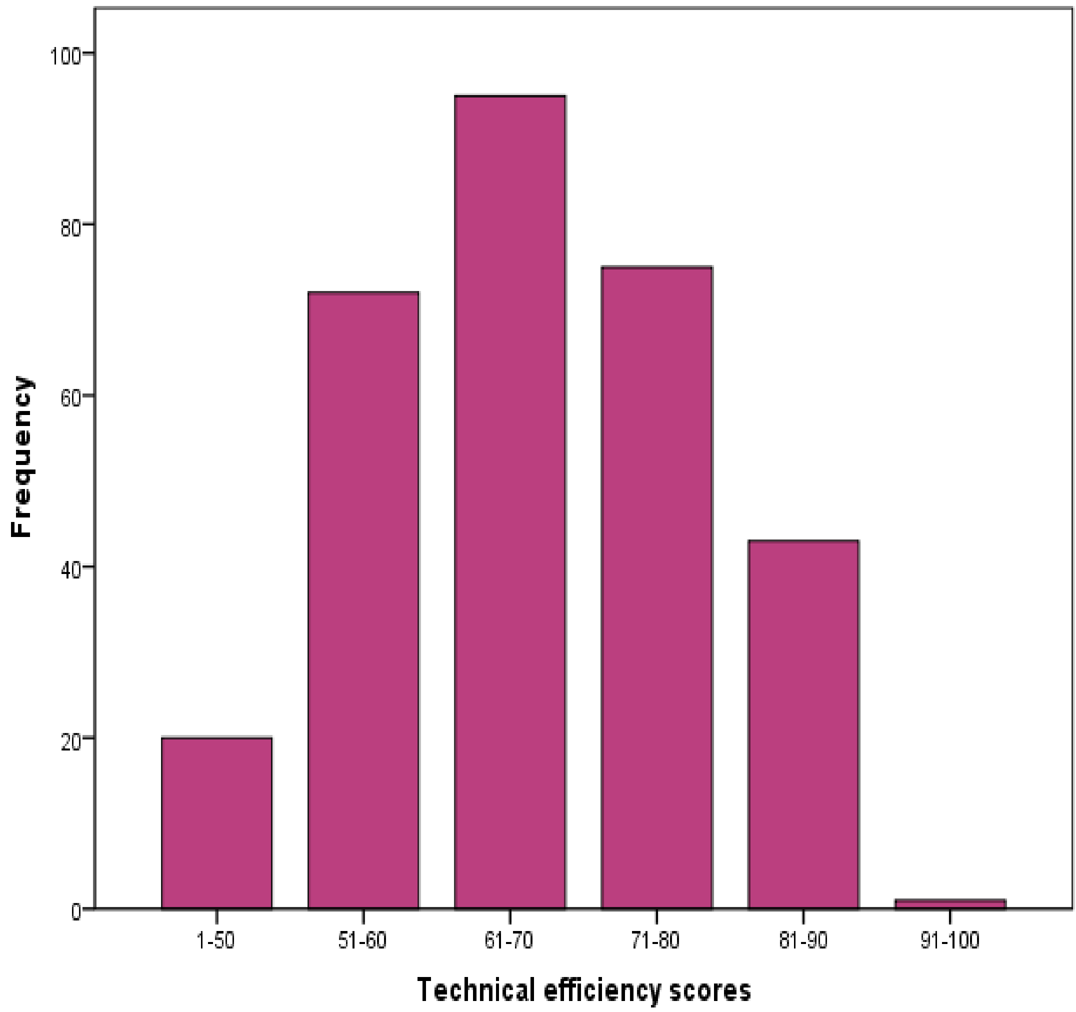

Figure 4: Frequency Distribution of Technical Efficiency Scores

Source: Field data, 2014

Determinants of Technical Efficiency

Estimates of the technical inefficiency model are presented in Table 14. The factors that influence technical efficiency are explained based on their coefficient signs. A positive sign indicates a decrease in technical efficiency or an increase in technical inefficiency and a negative sign shows an increase in technical efficiency or a reduction in technical inefficiency.

The coefficient of age in the inefficiency model is negative at 10% significant level. This suggests that older farmers are less technically inefficient than the younger farmers. Younger farmers are normally faced with limitations when it comes to the ownership of agricultural resources (land, labour and capital). For instance, land ownership according to the survey was mainly by rent. Therefore, the ability of the farmer to acquire land for production depends on their capital base of which the older farmer may have an advantage because they may have accumulated wealth over the years. Again, even where family land exists for cultivation, it is normally distributed based on age. This result is in line with that of Etwire et al. (2013) and Essilfie et al (2011). However, this finding is contrary to the studies by Maganga (2012) who reported a positive relationship between age and technical inefficiency, indicating that younger farmers were more technically efficient than older farmers. This relationship may arise due to the fact that older farmers are less eager to adopt new ideas of doing things.

Another vital determinant of inefficiency is the variable sex. But the result is contrary to the a priori expectation because a positive and significant relationship was found between the variable sex and technical inefficiency. It was revealed that female farmers were technically efficient as compared to their male counterparts. This is much of a surprise because the social status of women in many developing countries do not allow them to have access and own resources unlike men who are not limited in their ability to own and to have access resources. Females are less likely to have easy access to credit. Also, it has been found that women as compared to men have lower access to extension service (Njuki, Kihiyo, O'ktingati and Place, 2004).

The availability of credit, whether in cash or kind reduces the constraint faced by farmers financially. This allows them to get the necessary inputs they need and implement certain management decisions on time. Waqar, Zakir, Hazoor and Ijaz (2008) have also shown that credit in the form of cash, fertiliser and seed foster the growth of the agricultural sector. Also, because the production of maize is labour intensive, a greater part of the credit is used to hire labour especially during land preparation and weeding. However, credit, in the form of cash may sometimes be diverted into other activities especially in situations where farmers are not able to access it on time. This result confirms the study by Essilfie et al. (2011) who found out that credit had no effect on efficiency.

The estimated coefficient of off-farm work was positive and significant at 5%. Off-farm work activities reduce the technical efficiency in maize production. Thus, farmers who engage in non-farm employment are more technically inefficient than those who do not. Farmers become less technically efficient when they engage in occupational activities that gives them extra or higher income. They may therefore pay little attention to the production activities on the farm. The finding obtained corroborates the studies by Coelli, Rahman and Thirtle (2002).

Surprisingly, farmers experience in maize farming had a negative influence on technical efficiency although it did not have a significant influence on technical efficiency. The positive sign of experience in the inefficiency model indicates that farmers with higher experience are less technically efficient in maize production. The reason for this finding may be attributed to the fact that farmers who have spent long years in farming may be less willing to adopt modern techniques of agricultural practices and new technologies. This result is similar to the study by Otitoju et al. (2010).

The benefits that we get from education and its effects on efficiency have greatly been discussed by many researchers. In principle, it is expected that education will enhance agricultural productivity. In this study, the variable education surprisingly had a positive influence on technical inefficiency but was not a significant determinant of technical efficiency. Farmers who are more educated are more technically inefficient than those who are not. If farmers are better educated, then they have opportunities to pursue other income earning activities aside from their farm business. This decreases their level of technical efficiency (Wadud, 2003). Coelli et al (2002), Wadud and White (2000) in their studies also failed to obtain a significant relationship between education and production efficiency. They attributed this to the fact that the Bangladesh educational system was not agricultural oriented. However, most studies have found education to be significant and negatively related to technical inefficiency. Thus, the more schooling one has, the less technically inefficient they become. Educated farmers become better managers of resources, prefer to take risks, adopt the use of modern agricultural inputs and technological innovations (Weir and Knight, 2004).

The existence and operation of extension services affects efficiency of farmers in one way or the other. Extension services as pointed out by Evenson and Gwabu (1998) enrich the managerial abilities of farmers. These services help shape individual attributes which are not observable. Agricultural extension is a tool through which information on new technologies and better farming practices are transmitted to farmers. Consistent with the studies of Al-hassan (2012) and Maganga (2012), findings of this study shows that a negative and an insignificant relationship exist between extension contact and technical inefficiency. The negative relationship means that extension contact reduces technical inefficiency. The reason is that farmers are able to apply the training they receive and also appreciate good management practices like timely planting and weed control, correct application of fertiliser, pest and disease control as well as the right amount of seed rate. This leads to the efficient use of scarce resources. A contradictory result has also been reported by Kuwornu et al. (2013) that extensions contacts negatively and significantly influence technical efficiency. They attributed this to the fact either the content of the message delivered by the extension agents were unproductive or the farmers failed to apply the training given to them.

Further, results show that there is no significant difference in technical inefficiency between farmers who join farmer based organisations (FBO's) and those who do not. However, the positive coefficient shows that those who belong to FBO's are technically inefficient than those whose do not. This finding is similar to that of Kuwornu et al. (2013) who also found that membership of farmer groups positively influence technical inefficiency among maize farmers in the Eastern Region of Ghana.

Table 14: Maximum Likelihood Estimates of the Inefficiency Model

Variable	Parameters	Coefficient	Std. error	z-value
Intercept	δ_0	0.4664*	0.2195	2.1246
Age	δ_1	-0.0054.	0.0033	-1.6588
Sex	δ_2	0.1093.	0.0592	1.8456
Education	δ_3	0.0005	0.0056	0.0938
Household	δ_4	-0.0023	0.0070	-0.3358
Experience	δ_5	0.0018	0.0033	0.5384
Off-farm work	δ_6	0.1199*	0.0557	2.1516
Credit	δ_7	-0.1121	0.0788	-0.1423
Extension	δ_8	-0.0185	0.0523	-0.3542
FBOs	δ_9	0.0187	0.0550	0.3409

Source: Field data, 2014

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 10 ' ' 1

Estimating the Productivity Level

Table 15 reports the productivity level of the maize farmers by looking at the production elasticities and returns to scale. It can be seen that the elasticity of all input are inelastic except land which is elastic. Input elasticities are inelastic if a one percent increase in input results in a less than one percent increase in output and vice versa. An elastic input elasticity means that a percentage change in input use will cause output to change by more than one percent.

Following from the result, the input with the highest elasticity is land and its relationship with output is positive. Thus, as farmers increase their land size under cultivation, it will result in significant increase in output, all other things being equal. Land continues to be the most fundamental input in agricultural production. The major role played by land in production has also been reported by Rahman, Wiboonpongse, Sriboonchitta and Chaovanapoonphol (2009) in their findings. The elasticity of labour is positive and non-significant in maize production. This implies that more of labour will be needed if output is expected to increase. During the survey, it was found that apart from family labour, hired labour was much involved in every step of the production process: land preparation, planting, weed control, application of chemicals and harvesting. Aside from land, agrochemical is the second most used input. A one percentage increase in the use of agrochemicals reduces output by 0.16 percent. The cause of reduction in output may reflect in the incorrect application of the input. The use of agrochemicals protects crops from pests and fungal pathogens.

Returns to scale which is the summation of the output elasticities was found to be 1.22. The production function of the maize farmers exhibited increasing returns to scale. Thus, a proportionate increase in all inputs more than doubles output. This result is similar to that of Wu, Devadoss and Lu (2003). Farmers, are therefore operating at the irrational stage of production (stage I). They could increase their scale of production efficiently by employing more inputs especially labour, land, equipment and fertiliser to expand output.

Table 15: Elasticity of Production and Returns to Scale (RTS)

Variable	Elasticity	RTS
Labour	0.0768	1.22
Land	1.2862	
Equipment	0.0667	
Agrochemicals	-0.1646	
Fertiliser	0.0498	
Seed	-0.0931	

Source: Field data, 2014

*** represents 1% significance level

Constraints to Maize Production

Maize farmers were asked to identify and rank the challenges they face in the production of maize. The constraints are ranked in a descending order starting with the most pressing ones. The mean rank shows the averages as computed by the Kendall's coefficient of concordance. The elicited information on the constraints is summarized in Table 17.

The purchasing price of maize and price fluctuations are ranked the first and third constraints limiting farmers in maize production. The immediate cash need by farmers sometimes force them to sell their produce at a price determined by the sellers. They have no choice than to sell at the prevailing price so as to settle the debts they owe friends and families. Also, Ejura and

Sekyedumase have major periodic markets where traders from other regions come to buy maize. However, farmers from the other operational areas feel reluctant to transport their produce to these markets. They claim that getting trucks and big lorries to transport their produce to the major markets is difficult and in the case where they get access to one, the transportation cost deters them. So they normally rely on private traders who go around with their trucks from one village to another to buy maize. Farmers are therefore forced to accept the prices dictated by these traders and these prices are normally low. Thus, maize farmers in this District are price takers. This affects their productivity for the next season as they may not be able to buy the required inputs needed for production. The excess of maize during the harvesting period and the scarcity of it near the end of the season puts pressure on the price. Farmers become frustrated especially during the period of glut. Prices offered them are so low that it cannot even cover their production cost. The result of this study is consistent with the studies of Nganga, Kinyae, Walingo and Wakahiu (2003) and Kaguongo Gildemacher, Demo, Wagoire and Thiele (2008).

The second major constraint limiting the production of maize is lack of capital. Lack of capital has been viewed as one of the reasons for low productivity. Most smallholder farmers encounter financial hardship during the production process. Most of them cannot afford to acquire the necessary inputs needed for production on time. The availability of capital increases the purchasing power of famers to buy needed agricultural inputs for production.

The availability of labour is considered as a constraint by producers of maize. Labour is one of the primary agricultural resources used in production.

Most households provide labour that is needed in the course of production. However, during the period of land preparation and weeding during the growing season, farming households normally tend to depend on hired labour. This is as a result of the time constraint most farmers face during these periods. Labour may be short in supply during the peak production periods. Karthick et al. (2013) in their study found non-availability of farm labourers to be a challenge facing farmers in turmeric production.

Rainfall is the fifth constraint faced by farmers in maize production. Agricultural production in the District largely depends on rainfall. Rainfall variability as a result of climate change has become a worry for many farmers. Farmers who expressed their concerns about the irregular rainfall pattern mentioned that this challenge has affected their ability to plan their farming activities. According to them, planting is normally delayed especially during the minor season as a result of late rains. Also drought at any phase of crop development affects productivity particularly during the tasselling stage. Drought that occurs at the tasselling stage can only be lessened through irrigation. So some farmers attempt to avoid this risk by planting near river banks. However, this practice also has its own flaws. Flooding occurs in these farming areas during a period of excess rainfall. They highly regarded the availability of water and the timing of availability to affect productivity negatively. Badu-Apraku, Fakorede, Ouedrago, Carsky and Menkir (2003) have also reported that drought stress as a result of irregular rainfall pattern has been mentioned by many farmers as a major constraint limiting high maize productivity.

Lack of government support is the next constraint that limits farmers in maize production. The inability of the government to subsidize agricultural inputs such as fertilizers and cutlasses has become a concern for many farmers. Again, farmers expressed their concern about the operations of the Ejura farms, a government owned institution. It used to serve as a buying company where farmers could sell their maize at a satisfactory price but it no longer performs that function.

The acquisition of land is considered by farmers as a major constraints to maize production. During the survey, it was found that most of the farmers in the District do not own their farm lands. They therefore rent land for production. Majority of the farmers migrated from other parts of the country to settle in the District. Although, the District has become a place where many were born, lived and reproduced, they still do not have easy access to land which they can call their own. They rent the land every season and the cost of the land depends on how far or near it is to the community. This phenomenon makes it difficult for them to make long term investment on the land. This finding is similar to the one obtained by Agyare, Asare, Sogbedji and Clottey (2014).

The next constraint limiting farmers in the production of maize is the unavailability of storage facilities. Farmers complained that the unavailability of storage facilities is one of the main reasons why they sell their produce right after harvesting and it is of a general assumption that farmers who sell their produce soon after harvest receive low prices and those who store and sell at a later period gets higher prices. During the period of storage farmers encounter difficulties such diseases, insect attack and theft. A proper storage procedure adds time utility to maize which helps to evenly distribute the supply of the commodity from one production season to the other. The incidence of post-harvest losses serves as a disincentive to most famers. Similar result was obtained by Otitoju et al. (2010).

Land preparation is the next challenge faced by maize producers. Most of the farmers use machines like tractors to plow their land. However, during the period of land preparation the demand for the services of tractors exceeds their supply. This sometimes causes delay in the preparation of land. Moreover, majority of the farmers who get access to tractors by hiring considers it as costly. The amount charged is GHS50.00 per acre. Jehangir and Ali (1997) have cited in their report that inadequate access to modern equipment and machinery results in poor land preparation.

Fertiliser acquisition is the next constraint limiting maize production. High cost of inputs such as fertiliser greatly influences the production of maize. This causes the underutilization of the input. The high inputs cost in agricultural production has been attributed by Nganga, et al. (2003) to poor producer prices. A study conducted by Kaguongo et al. (2008) also shows that the inadequate use of fertiliser reduces agricultural productivity.

Minor constraints limiting the production of maize are weed control, formation of marketing associations, pest and disease control, pesticide acquisition, ready market, planting of seeds and acquisition of seeds. Farmers consider weed, pest and disease control as a minor constraints because the price of both inputs are affordable and it is easily acquired. Acquisition of seeds is considered by farmers as a minor constraint to production because most seeds planted by farmers are farmer-saved. Access to high quality seed is essential to productivity increase. The availability of seeds is not much of a concern as most farmers continue to use seeds saved from previous harvest. Those who also buy seeds easily obtain one from the office of MoFA and agro-input shops.

Table 16: Rankings of Constraints by Farmers

Constraint	Mean Rank
Purchasing price of maize	3.18
Access to capital	3.19
Price fluctuations	5.27
Availability of labour	5.65
Rainfall	6.76
Government support	7.49
Land acquisition	8.45
Availability of storage facilities	8.46
Land preparation	11.12
Acquisition of fertiliser	11.38
Weed control	11.51
Chemical application	11.98
Formation of marketing associations	12.04
Pest and disease control	12.33
Pesticide acquisition	12.53
Ready market for maize	12.57
Planting of seeds	13.53
Acquisition of seeds	13.54

Source: Field data, 2014

Hypotheses Testing

From Table 13, the mean technical efficiency (67%), the minimum technical efficiency (28%) and the maximum technical efficiency (93%)

indicates that maize farmers are not technically efficient in the production of maize. This means that the null hypothesis which states that farmers are technically inefficient is accepted in favour of the alternative hypothesis. The ratio of the observed output to the frontier output in this case is not the same. Thus, maize farmers are producing below the production frontier. The implication is that farmers have the opportunity to increase maize productivity by 33% with the available resources and technology.

Results from the maximum likelihood estimates of the inefficiency model shows that age, sex and off-farm work were significant determinants of technical inefficiency. Age had a negative relationship with technical inefficiency, implying that older farmers were more technically efficient than the younger farmers. Again, female farmers were technically efficient as compared to the male farmers. This is as a result of the positive relationship that was established between sex and technical inefficiency. Farmers who engaged in other farm work activities were less technically inefficient in the production of maize. Therefore, the null hypothesis which stated that socioeconomic variables such as age, sex and off-farm work does not significantly influence technical inefficiency is rejected in favour of the alternative hypothesis.

The third hypothesis is tested using the likelihood ratio test. The likelihood ratio test is used to determine whether the stochastic frontier model adequately fits the data as compared to average production function estimated by the Ordinary Least Square (OLS). The OLS attributes deviations from the frontier to only random errors, it does not take into account inefficiencies in production. However, the stochastic frontier model attributes deviations to both inefficiencies and random errors. It is confirmed by the likelihood ratio test that the stochastic frontier model fits the data better than an average production function estimated by the OLS at a 10% significance level (with a small p-value). Hence, the null hypothesis is rejected and the alternative hypothesis which states that the stochastic production function fits the data best is accepted.

Table 17: Likelihood Ratio Test of Ordinary Least Squares and Stochastic Production Model

Model 1		OLS (no inefficiency)			
Model 2		Efficiency Effects Frontier (EEF)			
	Df	LogLik	Df	Chisq	Pr (>Chisq)
1	8	-58.043			
2	19	-49.409	11	17.269	0.07051.

Source: Field data, 2014

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 10 ‘ ’ 1

Results from Table 19 shows that the Cobb-Douglas production function adequately fit the model better than the Translog production function at 5 percent significant level. This leads to the rejection of the null hypothesis and the acceptance of the alternative hypothesis that the Cobb-Douglas production function best fits the data.

Table 18: Likelihood Ratio Test of Translog Production Function and Cobb-Douglas Production Function

Model 1		Translog production function			
Model 2		Cobb-Douglas production function			
	Df	LogLik	Df	Chisq	Pr (>Chisq)
1	40	-34.833			
2	19	-49.409	14	29.151	0.1104*

Source: Field data, 2014

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 10 ' ' 1

The result from the Kendall's W test statistics shows that an agreement exists among farmers on the ranking of constraints to maize production at 1% significant level (Table 16). This implies that maize farmers in the District agree on the rankings of the constraints that limit them in production. Therefore, the null hypothesis that there is no significance difference in the ranking of perceived constraints in maize production is rejected at 1 percent significant level in favour of the alternative hypothesis which states there is significance difference in the ranking of perceived constraints in maize production. Hence, it can be established that there is an agreement among maize farmers on the constraints they face in their production.

Table 19: Kendall's W Test Statistics

N	274
Kendall's W	0.534
Chi-square	2777.164
Df	17
Asymp. Sig.	0.000***

Source: Filed data, 2014

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

This chapter reflects on the study as a whole. It comprises the summary of the main findings of the study, the conclusions and recommendations to improve the technical efficiency of maize farmers in the District.

Summary

The purpose of the study was to assess the technical efficiency level of maize farmers and its determinants in the Ejura Sekyedumase District. Specifically, it sought to: first estimate the level of technical efficiency of maize farmers, next identify the factors that influence technical efficiency, then estimate the level of productivity in maize farming and finally identifying and ranking the constraints that limits maize production.

Cross sectional survey design was used for the study and a total of 306 maize farmers were randomly chosen as the sample size. Maize farmers who participated in the study were randomly selected from the District. Primary data was used for the study. Both descriptive statistics and econometric models were employed to achieve the objectives of the study. A pre-test of the research instrument was done in the Abura-Aseibu-Kwamankese District. All analyses were carried out in SPSS and R statistical software.

Findings

The findings of the study are presented in accordance with the objectives of the study.

1. Description of Farmer and Farm Specific Characteristics

Maize farming is an important economic activity in the Ejura Sekyedumase District with males (76.1%) dominating its production. Majority of the respondents (77.5%) were married with a mean age of 44 and an average household size of 7. Also, 36.3% of the farmers had no formal education and the average years of schooling was 5 years. Most of the farmers (53.6%) engaged in off-farm work activities which generate additional income. Similarly, 91.5% of the farmers were their own financiers in production. Few farmers (8.8%) received technical training on the production of maize. The most popular maize variety grown by the respondents was Aburowhoma. On, average, 170.65 person-days of labour, 16.06 acres of land, 15.82 litres of agrochemicals, 140.98kg of fertiliser, 5.05kg of seeds and GHS15.68 of equipment were combined to obtain a maize yield of 7396.37kg.

2. Technical Efficiency Level of Maize Farmers

Results show that maize farmers were producing below the production frontier. The variations in the observed output and that of the frontier output were attributed to production inefficiencies and stochastic noise such as poor weather conditions. The technical efficiency levels of farmers varied widely among farmers with a minimum of 28% and a maximum of 93%. Thirty three (33) percent of maize output was not realised as the estimated average technical efficiency score was 67%.

3. The Productivity Level of Farmers

It was established from the results that all inputs used in the production of maize were inelastic except land which was elastic. Also, inputs that were found to increase maize output were land, labour, equipment and fertiliser and those that led to a reduction in output were agrochemicals and seed. Maize farmers were found to be producing at an increasing returns to scale.

4. Determinants of Technical Efficiency

The empirical results show that age, sex and off-farm work activities were the significant factors that influenced technical efficiency in maize production. A negative relationship was found between age and technical inefficiency whilst sex and off-farm work activities influenced technical inefficiency positively.

5. Constraints to Maize Production

Results indicates that purchasing price of maize, access to capital, price fluctuations, availability and cost of labour, rainfall, government support and availability of storage facilities were the main challenges limiting farmers in maize production.

Conclusions

The following conclusions are made based on the study objectives and in relation to the various findings:

1. Maize farming in the District is male dominated. The production of maize is undertaken by the less educated farmers and the middle-aged adults. Farmers earn extra income by engaging in other business

activities aside from farming. Most of the farmers do not have access to technical training and the variety of maize grown by most farmers is the local variety 'Aburowhoma'.

2. Maize farmers in the District produce below the production frontier and are therefore technically inefficient. There is an opportunity for maize farmers to increase their yield by 33% with the same level of inputs and available technology.
3. Agricultural production inputs such as land, labour, equipment and fertiliser have a positive effect on output whilst agrochemicals and seed have a negative relationship on output. Farmers were operating at an increasing returns to scale.
4. Farmer specific characteristics such as sex, age and off-farm work activities were the important determinants of technical inefficiencies in production.
5. Major problems that limited farmers in production are purchasing price of maize, access to credit, price fluctuations, availability and cost of labour, rainfall, government support and inadequate storage facilities.

Recommendations

Based on the study findings, the following recommendations are made.

1. The government through the District Assembly should encourage the youth, females and the well educated to actively take part in maize production. Also, the Ministry of Food and Agriculture should prioritise technical training as a service to farmers and expand its activities to many farmers. 'Learning by doing' is a fast way that can

help farmers to adopt modern agricultural practices which will boost yield.

2. The Ministry of Food and Agriculture should organise educational programmes for farmers on the need to improve upon their production activities through the efficient combination of inputs given that the farmers were producing below the frontier.
3. The Ministry of Food and Agriculture should train and encourage farmers to use more of labour, equipment and fertiliser in production as these inputs tend to increase the productivity of maize. Likewise, farmers should be educated to use the recommended seed rate and right quantities of agrochemicals given that these inputs affected productivity negatively.
4. The Ministry of Food and Agriculture should educate farmers on the factors reducing technical inefficiency such as credit, age, extension contact, household size and provide incentives that will improve their production.
5. The government and the Ministry of Food and Agriculture should put in place policies that would lessen the constraints that limit the production of maize. Policies such as setting up minimum price controls to save farmers from being exploited by the local market forces, creating enabling environment for farmers to be able to access credit from banks and other microfinance institutions will help to improve the production of maize.

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APPENDICES

Appendix A: Questionnaire for Farmers

UNIVERSITY OF CAPE COAST

SCHOOL OF AGRICULTURE

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

TOPIC: TECHNICAL EFFICIENCY IN MAIZE PRODUCTION: A CASE OF THE EJURA SEKYEDUMASE DISTRICT

INTRODUCTION: This interview schedule is designed with the sole aim of collecting information on technical efficiency and the factors that influence it. Information obtained from this study shall be handled privately and with discretion. Thank you for your time

BASIC INFORMATION

Enumerator Code …………………………………………………....

Name of community: ………………………………………………

Date of interview: ……………………………………

Farmers phone number (if any): ………………………………………

SECTION A: FARMER AND FARM SPECIFIC CHARACTERISTICS

1. Name of farmer: ……………………………………………
2. Age of farmer at last birthday: ………… years
3. Sex of farmer: (a) Male (b) Female
4. Marital status of farmer:

   (a) Single (b) Married (c) Divorced (d) Widowed

5. Educational background of farmer: (a) No formal education (b) Primary (c) Middle/JHS [ ] (d) O'level/SHS (e) Tertiary
6. Years of formal education ……………………..
7. Household size: ……………. (number)
8. Number of years engaged in maize farming: …………… years
9. Do you engage in other occupations apart from maize farming? (a) Yes (b) No
10. If yes, what other occupation are you engaged in? ………………..............

SECTION B: PRODUCTION ACTIVITIES

11. Do you receive extension services: (a) Yes (b) No
12. If yes, how many times? ……………………………
13. Do you get financial support from any quarters for maize production? (a) Yes (b) No if Yes from where ………………………………
14. At what interest do you repay the amount borrowed? ……………….(%)
15. Do you belong to any farmer organisation? (a) Yes (b) No
16. If yes, which organisation do you belong to? ………………………
17. Which maize varieties do you grow on your farm?

    1)………………………………..

    2)…………………………………

    3)……………………………….

18. Methods of land preparation: (a) Slash and burn (b) Slash no burn (c) Use of weedicide (d) Machines and implements

19. Methods of weed control: (a) Weedicides (b) Uses cutlass (c) Uses hoe (d) Hand picking of weeds (e) Other (specify)……………

20. Have you received any technical training in maize production within the past five years? (a)Yes (b) No

21. If yes, who provided the training? (a) Fellow farmer (b) AEAs (c) Media (d) Others (specify) ……………....................

22. If yes, what did you gain from it? ……………………………………...

23. Do you irrigate your farm? (a) Yes (b) No, if no Why ………………………………………………………………………

24. Do you cultivate maize in both major and minor seasons? (a) Yes

    (b) No, if no why? …………………………………………………

25. Do you grow only maize on a farm plot (mono cropping)? (a) Yes (b) No

26. If no, what crops do you grow apart from maize? ……………………

SECTION C: INPUT AND OUTPUT INFORMATION

<u>FIXED INPUTS</u>

LAND

27. Kind of land ownership: (a) Own land (purchased or gift)

(b) Family land (c) Rent (d) Leased (f) Sharecropping

(g) Other (specify) ……………………

28.

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

29. EQUIPMENTS

Tools	Number	Unit cost (GHS)	How many years old?
i. Cutlass			
ii. sprayer			
iii. Hoe			
iv.Watering can			
v. Plough			
vi.			
vii.			

<u>VARIABLE INPUTS</u>

30. PLANTING MATERIAL

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

31. Source of maize seeds for production: (a) Farmer-saved (b) Seed stores (c) Friends/Family (d) Government (e) Other (specify) ……………………….

32. LABOUR INPUTS IN MAIZE PRODUCTION

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

Type		Number of persons	Hours used per person per day	Days worked per crop season	Wage per person per day (GHS)
Family	Male				
	Female				
	child (under18)				
Hired					

33. FERTILIZER

Type of fertilizer	Quantity (kg)/acre	Unit cost (GHS)
i.NPK		
ii.Ammonia		
iii.Urea		
Others specify		

34. How many times do you apply fertilizer in a season? …………………

35. PESTICIDE USE

Type of pesticide	Quantity used (litres) per acre	Unit cost (GHS)	Total cost (GHS)
i. Fungicide			
ii.Insecticide			
iii.Weedicide			
Iv			
v.			

MAIZE OUTPUT

36. Do you sell maize produced on your farm? (a) Yes (b) No

37. If Yes, please fill the table below

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

SECTION D: CONSTRAINTS TO MAIZE PRODUCTION

38. **INPUT, PRODUCTION AND MARKETING CONSTRAINTS**

Input constraints	Response	Production constraints	Response	Marketing constraints	Response
Cost of labour		Land preparation		Purchasing price of maize	
Land acquisition		Pest and disease control		Price fluctuation	
Acquisition of fertilizer		Weed control		Availability of storage facilities	
Pesticide acquisition		Chemical application		Government support	
Access to		Rainfall		Formation	

capital				of marketing association	
Acquisition of seeds		Planting of seeds		Ready market for maize	
Others (specify)		Others (specify)		Others (specify)	

Scale: 1 = very high constraint; 2 = high constraint; 3 = low constraint; 4 = very low constraint

Appendix B: Focus Group Discussion Interview Guide

This is used to solicit information from maize farmers in groups.

1. What processes are involved in maize production?

   ……………………………………………………………………..

2. Do you hire machines and implements to undertake production? If yes which ones and at what cost? ……………………………………….

3. How will you relate the acquisition of land to soil fertility management?

   ……………………………………………………………….

4. In what state do you normally sell your produce?

   …………………………………………………………………

5. What challenges limits the production of maize?

   …………………………………………………………………

6. What reasons accounts for these challenges?

   ………………………………………………………………

7. What steps do you take to solve these problem?

   ………………………………………………………………

8. Where and how do you store your maize?

   ………………………………………………………………

9. What are the difficulties in storing maize?

   ………………………………………………………………

10. Do you experience high storage losses?

……………………………………………………………………

11. How would you grade the price you received for last season's output?

…………………………………………………………

Appendix C: Technical Efficiency Scores of Maize Farmers in the District

Farmer No.	TE	Farmer No.	TE	Farmer No.	TE
1	79.15	23	55.61	45	71.74
2	53.2	24	82.11	46	77.17
3	61.63	25	75.36	47	66.16
4	69.91	26	75.25	48	55.82
5	78.49	27	71.28	49	69.8
6	72.54	28	54.88	50	62.53
7	59.3	29	56.14	51	80.58
8	45.37	30	54.32	52	89.22
9	52.32	31	49.81	53	74.44
10	62.08	32	49.07	54	82.19
11	70.94	33	53.02	55	59.71
12	49.43	34	75.55	56	72.74
13	78.81	35	69.23	57	70.25
14	70.48	36	73.82	58	73.1
15	68.24	37	80.56	59	75.62
16	79.15	38	83.98	60	50.86
17	78.96	39	59.45	61	47.36
18	49.25	40	56.14	62	57.71
19	64.95	41	7.013	63	69.74
20	84.08	42	61.27	64	78.09
21	53.68	43	81.31	65	83.95
22	62.35	44	88.48	66	73.56

Farmer No.	TE	Farmer No.	TE	Farmer No.	TE
67	77.18	90	75.3	113	70.37
68	63.91	91	55.4	114	83.57
69	70.1	92	57.83	115	55.57
70	79.47	93	52.77	116	68.06
71	68.34	94	72.32	117	66.15
72	60.35	95	83.28	118	72.12
73	71.57	96	69.68	119	71.14
74	84.54	97	83.17	120	72.37
75	66.01	98	72.9	121	67.49
76	61.37	99	73.45	122	75.43
77	67.26	100	70.48	123	54.34
78	70.11	101	71.44	124	82.68
79	67.76	102	60.58	125	79.58
80	88.39	103	74.32	126	55.36
81	73.11	104	77.35	127	74.61
82	72.31	105	84.29	128	52.06
83	63.22	106	78.02	129	49.16
84	93.92	107	63.31	130	66.09
85	65.25	108	64.73	131	69.26
86	66.31	109	82.78	132	62.09
87	65.3	110	60.12	133	70.05
88	58.98	111	70.66	134	58.52
89	61.03	112	72.37	135	68.19

Farmer No.	TE	Farmer No.	TE	Farmer No.	TE
136	54.95	159	65.98	182	76.64
137	69.82	160	64.16	183	62.14
138	57.2	161	58.63	184	70.26
139	60.87	162	75.16	185	55.74
140	58.17	163	59.46	186	73.06
141	80.91	164	55.2	187	89.32
142	74.47	165	62.89	188	81.86
143	77.71	166	72.14	189	55.83
144	83.99	167	56.55	190	50.43
145	58.23	168	63.78	191	61.64
146	84.23	169	53.28	192	57.99
147	84.9	170	56.61	193	43.9
148	83.66	171	61.44	194	55.6
149	62.01	172	80.15	195	80.12
150	60.6	173	61.39	196	65.7
151	70.7	174	67.77	197	44.39
152	82.52	175	68.63	198	53.67
153	88.58	176	51.01	199	58.68
154	93.1	177	82.91	200	44.17
155	53.03	178	72.92	201	45.96
156	69.15	179	76.96	202	38.17
157	70.49	180	65.67	203	56.43
158	68.46	181	54.35	204	59.85

Farmer No.	TE	Farmer No.	TE	Farmer No.	TE
205	83.14	228	67.62	251	71.69
206	75.23	229	63.43	252	62.44
207	76.24	230	50.14	253	73.19
208	64.27	231	41.91	254	43.73
209	51.24	232	53.73	255	87.37
210	75.79	233	62.31	256	87.44
211	51.49	234	73.29	257	87.16
212	71.81	235	54.41	258	87.4
213	73.39	236	50.29	259	60.21
214	77.62	237	54.45	260	69.62
215	53.36	238	81.68	261	48.74
216	55.59	239	50.72	262	63.89
217	61.07	240	53.54	263	63.65
218	69.48	241	77.07	264	59.38
219	80.29	242	69.79	265	54.45
220	61.92	243	79.94	266	74.6
221	52.87	244	64.63	267	86.95
222	54.29	245	68.52	268	62.9
223	83.65	246	66.56	269	62.3
224	61.97	247	66.41	270	74.25
225	66.77	248	61.4	271	61.2
226	69.81	249	28.33	272	67.04
227	64.07	250	86.66	273	65.67

Farmer No.	TE	Farmer No.	TE	Farmer No.	TE
274	72.18	285	61.32	296	69.23
275	56.35	286	55.63	297	79.72
276	53.84	287	47.52	298	85.9
277	79.6	288	73.14	299	80.7
278	81.34	289	64.91	300	82.53
279	51.35	290	59.18	301	59.35
280	70.94	291	59.72	302	57.63
281	56.64	292	75.01	303	53.56
282	68.44	293	64.91	304	57.34
283	75.91	294	85.26	305	54.54
284	68.78	295	60.79	306	78.37