

**TECHNICAL EFFICIENCY OF TOMATO FARMERS IN THE
ASHANTI REGION OF GHANA**

BY

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**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN
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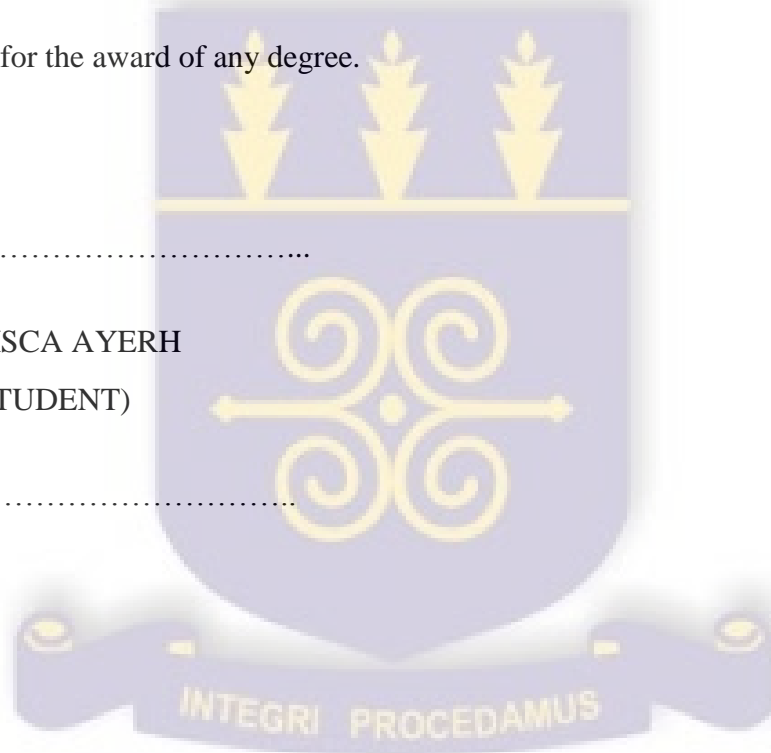
DECLARATION

I, FRANCISCA AYERH, do hereby declare that the work presented in this thesis, **“TECHNICAL EFFICIENCY OF TOMATO FARMERS IN THE ASHANTI REGION OF GHANA”** was done by me under supervision from the Department of Agricultural Economics and Agribusiness from August 2014 to July 2015. This is the record of my research work and apart from my references to other works which are duly acknowledged, this work has never been published or submitted either in part or in whole anywhere for the award of any degree.

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DEDICATION

I sincerely dedicate this piece of work firstly to the Almighty God for how far He has brought me in life. Secondly, to my parents Mr. Francis Edward Ayerh and Mrs Lawrencia Ayerh for their prayers and unflinching support through my entire period of study. Finally to my lovely nephew of blessed memory, Markendy Ayerh.



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ABSTRACT

The purpose of this study was to assess the technical efficiency of tomato farmers in the Ashanti region of Ghana using the stochastic frontier methodology. The study looked at the productivity levels of tomato farmers, examined the determinants of technical inefficiency of tomato farmers and analysed the constraints generally facing tomato production in the region. A total of 150 tomato farmers in three districts namely Offinso South, Offinso North and Asante Akim North in the Ashanti region were randomly selected for the study using a cross sectional data. The results of the study showed that improved seeds use, fertilizers, pesticides, labour and other costs have a positive relationship with output, hence an increase in any of them will increase output. An increasing returns to scale of 1.35 was also realized from the data analyzed from the region. A mean technical efficiency of 86% was achieved with the least being 35% and a maximum of 97% indicating room for improvement in their technical efficiency. Also, in the determination of technical inefficiency, household size, extension visits, years of experience in tomato farming and credit use were found to positively influence technical efficiency. Inaccessibility of credit facilities was found to be the major constraint faced by tomato farmers and the least was land acquisition and land tenure problems. The study concluded that on average, tomato farmers are 14% below the frontier of production and can attain the maximum output when best farm practices are employed. Hence, these study led to the recommendation that farmers should be encouraged to adopt best agronomic practices especially with pesticide and fertilizer applications through extension advisory services as a way of improving their technical efficiency. Finally, Government should also show keen interest in enhancing agricultural credit schemes to make it more accessible to rural farmers in Ashanti Region of Ghana.

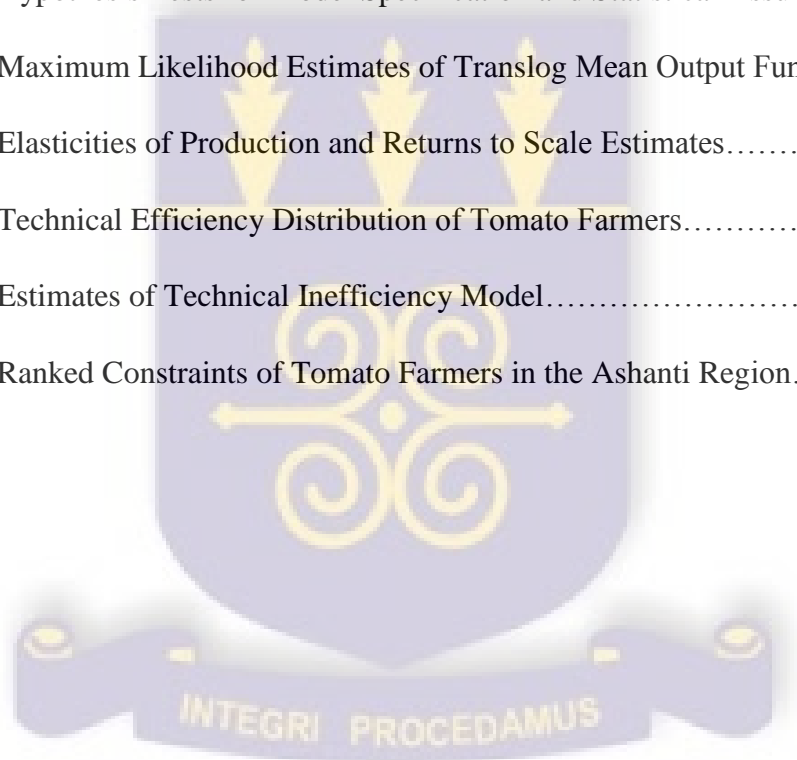
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LIST OF ACRONYMS

DEA	Data Envelopment Analysis
EU	European Union
FAO	Food and Agriculture Organization
FBO	Farmer Based Organization
GDP	Gross Domestic Product
GIHOC	Ghana Industrial Holding Company
GLSS	Ghana Living Standards Survey
GSS	Ghana Statistical Service
IFPRI	International Food Policy Research Institute
MoFA	Ministry of Food and Agriculture
MT	Metric Tonnes
OLS	Ordinary Least Square
SFA	Stochastic Frontier Analysis
SFP	Stochastic Frontier Production
SRID	Statistics Research and Information Directorate
TOMACAN	Tomato Cannery



CHAPTER ONE

INTRODUCTION

1.1 Background

Agriculture continues to be the predominant sector of the economy of Ghana that engages 55 percent of the nation's labour force (Breisinger *et al.*, 2008). This workforce has taken advantage of the large natural resources to engage in agriculture as a source of livelihood and also for income generation. Attributes such as large and fertile lands, well-irrigated plains, conducive weather suitable for production, as well as different ecological zones to support diversification also encourages people to engage in agriculture.

The three different sectors, namely, the service, industry and agriculture contribute a total of 49.5%, 28.6% and 22% respectively to the economy in terms of GDP. This depicts that currently, the agricultural sector contributes the least to GDP (GSS, 2014). Agriculture, however supplies 90% of the food needs of the country's fast growing population of 24.6 million together with raw materials for the agro-based industries (FAO, 2010). Ghana has a total of 24 million hectares of land, out of which 14 million hectares are classified as agricultural land area. This forms 58.8% of total land area.

Also, 7.8 million hectares (55.9%) are considered to be under cultivation whereas about 30,000 (0.4 %) hectares are under irrigation. This leaves a total of 6 million hectares (44.1%) not cultivated at all (MoFA, 2013). This implies that the country still has huge

agricultural lands yet to be exploited to enhance productivity. Also, despite these vast agricultural lands, the nation still battles with issues of low productivity and food insecurity in vegetable production particularly in tomatoes. Tomato (*Solanum lycopersicon*) production is one of the most widely grown vegetables in the world and also an important farming activity assumed to reduce food and cash insecurity (Donkoh *et al.*, 2013).

There has been different views as to the origin of tomatoes. Currently, there seem to be two competing hypotheses to the origin of domestication of this vegetable, one siding with the origin from Peru and the other from Mexico (Peralta and Spooner, 2007). Tomato is grown in practically every country of the world, in outdoor fields, greenhouses and net houses (Abdulmalik *et al.*, 2014). It can be used in preparing a wide variety of dishes such as gravies, soup, and can also be eaten in its raw state when used for vegetable salads or garnishing. It is estimated that tomato is one of the most widely used vegetable in terms of quantities, hence signifying its importance (Ellis *et al.*, 1998). Adenuga *et al.* (2013) stated that tomatoes are packed with nutrients such as fiber, potassium, vitamins A and C.

It is also a source of lycopene, a very powerful antioxidant, which helps prevent the development and growth of many forms of cancer. Different varieties of tomato are cultivated all year round in Ghana. Predominant varieties cultivated include the Power Rano, Pectomech, Ada Lorry Tyre, Burkina, Meenagiant, Nimagent, Techiman and Wosowoso. The Power Rano is precisely cultivated in the Brong Ahafo and Ashanti regions of Ghana under rain fed conditions. The Pectomech is an improved variety which

is also grown and is most appropriate for processing. The Upper East region as well as some parts of Burkina Faso cultivates this type. This variety is known to have superior yield qualities than other varieties whereas Nimagent F1 is known to be the most expensive variety hence its production is lower in Ghana (Adu-Dapaah and Oppong-Konadu, 2002).

Tomato production requires a cool, dry climate for higher yields with premium quality, preferably a proper water holding capacity well loamy and sandy loam soils, but can typically grow in almost all soil types except heavy clay and saline soils. They are, however adapted to a wide range of climatic conditions from temperate to hot and humid tropical climates (Srinivasan, 2010). Just like most crops cultivated everywhere, inputs are of high essence. Inputs such as seeds, land, labour, capital and agrochemicals are considered as the most common in crop production. These resources constitute the driving force in the tomato production process as well.

Resources or inputs are said to be efficiently utilized when they are put to best use possible and at minimum allowable cost. It is the aim of every farmer to make maximum outputs from the inputs he combines during any production process. Productivity of crops is associated with the intensive use of appropriate inputs. Yield on, the other hand can be increased through better land management and farming practices, such as weed and pest controlling. Agriculture is considered highly risky and also for this part of our world, highly dependent on rainfall hence maximum outputs are usually not achieved. The concept of efficiency is basically about obtaining maximum output from a set of inputs available.

Efficiency of a production unit as defined by Ellis (1993), is how variable resources are used effectively for profit maximization purposes under a given technology. The concept of efficiency broadly comprise of technical and allocative efficiencies. Technical efficiency is defined as the ability to attain maximum output from a given set of production inputs, under a range of alternative technologies (Cobbina, 2014). Technical efficiency measurements is highly important for developing nations especially, where resources are scarce and the ability to develop new and better technologies are low (Ali and Chaudhly, 1990). Allocative efficiency on the other hand applies only to the adjustment of inputs to reflect prices, having chosen the production technology (Ellis, 1993).

1.2 Problem Statement

Tomato is a major horticultural crop cultivated in Ghana. Generally, Ghana recorded significant increase in tomato production in the 1970s/80s and 1990s, although the early years of the 1970s and 1980s recorded a sharp decrease in production from about 100,000 tons per year to about 50,000 tonnes per year. Production increased back to around 100,000 tons in the late 1980s (Robinson and Kolavalli, 2010). Finally, in the 1990s, production increased again, averaging around 200,000 tons per year by the end of the decade. However, studies related to production trend of tomatoes indicate a gradual fall in the 2000s (Robinson and Kolavalli, 2010) and this is shown in Appendix 1 on page 104.

Although FAOSTAT (2013) data show a gradual rise in production from 2008 to 2013 as shown in Appendix 3, average yields and achievable yields still remain low. The average

yield of tomato in Ghana is 7.2 metric tonnes, which is far below the achievable yield of 15.0 metric tonnes per hectare hence leaving farmers with a yield gap of about 7.8 metric tonnes per hectare (MoFA, 2013). This gap implies that the supply of fresh tomatoes most often than not is unable to meet demand of consumers all year round unless processing into other forms are done. Production figures are also quite low as compared to other neighbouring African countries such as Nigeria and Egypt who record 1.5 million metric tonnes and 8.6 million metric tonnes yearly (FAOSTAT, 2012).

The inability of domestic production of fresh tomatoes to meet its demand nationwide has resulted in the high importation of processed tomato which serves as a perfect substitute for fresh tomatoes in most Ghanaian dishes (Robinson and Kolavalli, 2013). This phenomenon is not only peculiar to tomatoes but recently, the agricultural sector of the nation appears to be losing out to imported processed food products, due to low productivity (Robinson and Kolavalli, 2013). Importation of tomato and tomato products have greatly increased with these shortfalls in production.

Importation of tomato paste stagnated during the 1990's when domestic production was high. It increased from 3 300 tons in 1998 to 24 740 tonnes in 2003, an increase of 650 percent (FAO, 2006). Most of these imports are from countries such as Italy, China, USA, Spain, and Turkey. A contributing factor to high importation of processed tomato in the country has to do with the closure of factories established for domestic processing (Robinson and Kolavalli, 2010). The GIHOC cannery located in Nsawam, GIHOC Tomato

Cannery –TOMACAN located in Wenchi (Brong Ahafo region) and Pwalugu Tomato Factory also in Pwalugu (Upper East region) were closed down in the late 1980's. Other factors such as lack of spare parts, frequent breakdown and obsolete machinery hastened their closure (Robinson and Kolavalli, 2010).

One contributing factor to lower productivity is the inability of tomato farmers to fully exploit the available technologies of production. As a result of this, farmers do not fully benefit from the available technology either from technological change or best farm practice. Also, because tomato production in Ghana is done mostly on relatively smaller farms with the main motive of domestic consumption and not for export often, farmers find it difficult adopting certain technologies which come at an extra cost (Binswanger and Pingali, 1988). The inability to precisely combine improved inputs such as seed use and also appropriate technologies related to the recommended rate of agrochemicals such as fertilizer, pesticides and herbicides application by most farmers in Ghana lead to inefficiency (Kalinga, 2014).

For instance, the indiscriminate use of chemical pesticides has been reported severally and this poses a potential health risk to farmers, consumers, and other stakeholders as well as the environment at large (Osei *et al.*, 2008). Hence this indiscriminate chemical use coupled with farmers inefficiencies contribute to the inability of farmers attaining maximum levels of output. Technical inefficiency is attributed to many factors which can be said to be under the control or influence of the farmer or not. Socio-economic

characteristics such as education, experience as well as other exogenous variables such as ones participation in Farmer Based Organizations, access to credit are considered to be under the control of the farmer and they tend to either increase or decrease efficiency of production. Those not under their control are factors such as inconsistencies in the weather and other risk elements. When inefficiencies on the part of farmers are reduced output will inevitably increase.

Challenges pertaining to production seasonality, high perishability, high cost of production, coupled with the inability to finance farm operations, poor market access and lack of ready market, limits the scale and efficiency of production. This therefore led to the need of assessing the levels of technical efficiency and determinants of inefficiency amongst tomato farmers within the Ashanti Region. Specifically tomatoes because it's one of the crops produced in large quantities in some districts of the Ashanti region. Also, though much studies has been done on technical efficiency pertaining to other crops, not much has been done to establish the productivity levels of tomato production and determinants of inefficiencies in this region. These therefore led to the formulation of the following research questions:

1. What is the productivity of tomato farms in the Ashanti region with respect to input factors?
2. What are the levels of technical efficiency of tomato farmers in the Ashanti region?
3. What are the determinants of technical inefficiencies of tomato farmers in the Ashanti region?
4. What are the constraints tomato farmers encounter in the production of tomatoes?

1.3 Objectives of the Study

The primary objective of the study is to assess the technical efficiency of tomato farmers in the Ashanti region of Ghana. The following specific objectives are employed to accomplish this study:

1. To estimate the productivity of tomato farms in the region with respect to input factors
2. To estimate the technical efficiency levels of tomato farmers
3. To identify the determinants of technical inefficiency of tomato farmers
4. To identify and rank the constraints faced by farmers in tomato production

1.4 Justification

Taking into consideration the critical role tomato plays in the economy and diet of people worldwide, issues relating to production efficiency should be keenly addressed to ensure higher yields. One major way in which a country can experience growth in its economy is by improving on the various inputs of production. For instance, there is the need to ensure that high quality seeds, coupled with required agrochemicals application are employed. The tomato industry encounter diverse challenges with regards to the inadequate use of input and technology to give the desired output.

When adequate inputs and improved technologies are employed output will likely increase, hence conducting efficiency studies will give policy makers the knowledge on how to attain high output which will cause an increase in production. Also, for tomato farmers to increase

output and meet the demands of consumers, it is imperative that they focus on the essential ways in which they can increase their efficiencies. This study is important because knowing the factors that contribute to high efficiency of production will lead to significant growth in production. Also, with an extensive work on technical efficiency and the factors that determine inefficiency, it will not only add up to literature but will also inform farmers as well as stakeholders on the best farm practices that should be encouraged and also gain knowledge on farmer specific characteristics that should be increased in order to enhance efficiency respectively.

A careful study and understanding of the level of technical efficiency and its determinants is also relevant so as to know the existing gap of tomato output from the frontier output at a given technology. Productivity has been of immense concern to most countries whose economies are largely dependent on agriculture. Researching into such areas will provide them with requisite knowledge required to enhance output and productivity.

This study will also help formulate effective policy recommendations based on empirical results made, to improve the level of technical efficiency of tomato farmers in the Ashanti region of Ghana. Finally, knowledge on the constraints faced by tomato farmers in the region will help policy makers formulate policies toward them in order to improve their production in the Ashanti region.

1.5 Organization of the Thesis

This thesis is organized into five chapters. Following chapter one, chapter two entails the literature review on empirical models used in technical efficiency analysis. It also reviewed works on technical efficiency as well as studies on constraint methodologies and finally reviewed constraints generally faced by tomato farmers in the Ashanti region. Chapter three commences by describing the study area and also took a look at the conceptual and theoretical frameworks of the study. It also presents the empirical models used in analysing each specific objective. Finally, the type of data and sampling procedures employed in the study was also elaborated on. Chapter four outlines and discusses the results of data analysis. Chapter five covers the summary and major findings, conclusions and policy recommendations of the thesis.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews models for estimating technical efficiency of production. It also reviews technical efficiency studies and determinants of technical inefficiencies in tomato production. Finally, chapter two also highlights on the constraints faced by tomato farmers in the region.

2.2 Performance Measure of Production

Performance measure of firms or any production unit is done by the use of fundamental analysis such as the use of profitability and efficiency analysis (Loukoianova, 2008). These two performance measures have different approach to measurement. Profitability analysis indicates the ability of a firm or company to earn substantial profit and return on investment and usually measured as ratios. These ratios indicate a good financial status and how the company in managing its assets effectively (Lesáková, 2007). Other profitability ratios include return on assets and return on equity.

On the other hand, efficiency measures show how a company uses its available resources to generate maximum output. This study will focus on efficiency, hence all discussions will centre on efficiency measures other than profitability. Efficiency studies in literature begun with a seminal paper written by Farrell (1957). There are two main approaches in

measuring productive efficiency of firms. They are the Parametric and Non-Parametric. Economic efficiency measurement has been intimately linked to the use of frontier functions (Murillo-Zamorano, 2004). Farrell (1957) revealed that a productive unit can be said to be inefficient when it obtains less than the maximum output available from a number of inputs (technically inefficient) or by not purchasing the best package of inputs given their prices and marginal productivities (allocatively inefficient).

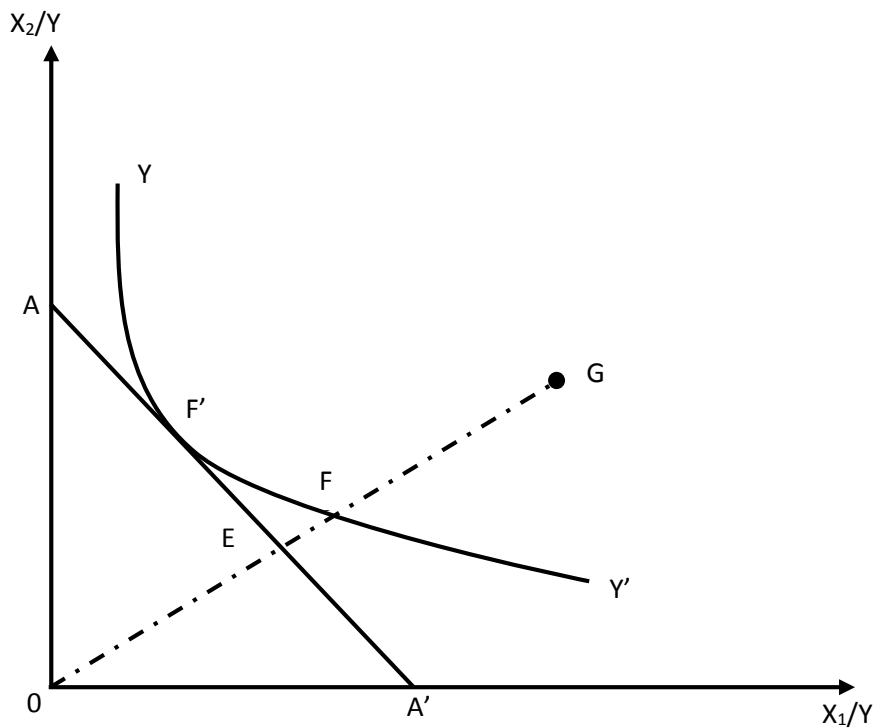
2.3 Efficiency Measures

Farrell (1957) came out with tremendous findings on the measurement of efficiency several years ago. The outcome of his findings have ever since been used for the estimation of efficiency. Other economists including Aigner, Lovell, Schmidt (1977) and Meeusen and van den Broeck (1977) over the years have also worked on such areas and added up to his information. Farrell (1957) greatly influenced by Koopmans (1951) formal definition and Debreu (1951) measure of technical efficiency decompose the overall efficiency into its technical and allocative components.

Technical efficiency is defined as the ability to produce maximum output from a given set of inputs or a situation whereby output is produced from a minimal set of inputs. Allocative efficiency otherwise known as price efficiency refers to the optimal selection of inputs, given their prices. In other words, a combination of inputs are chosen to produce a set quantity of output at a minimum cost. This concept is explained in Diagram 2.1 below. Farrell (1957) assumes a constant returns to scale (CRS) and the unit isoquant YY' fully

describes the technological set that captures the minimum combination of inputs required to produce a unit of output. Hence, every combination of inputs along the unit isoquant is considered as technically efficient whilst any point above and to the right of the isoquant, such as point G, indicates a technically inefficient producer. This is because, more than enough of the input combination is being used to produce a unit of output.

Figure 2.1 A Diagram Showing Allocative, Technical and Economic Efficiencies



Source: Murillo-Zamorano (2004)

Hence, the technical inefficiency of the producer at G is measured along the distance FG. The technical inefficiency of the producer at G can be expressed as FG/OG , hence, its corresponding technical efficiency (TE) is given as $(1-FG/OG)$ or further simplified as

OF/OG. When information on market prices are known, allocative inefficiency can also be derived from the isoquant in the graph given above. Therefore, for the estimation of allocative inefficiency, the relevant distance is indicated by the line segment EF, which would be given as the ratio EF/OF.

The allocative efficiency (AE) that defines the producer at point G is given by the ratio OE/OF. Efficient frontier measurement is categorized into either parametric approach or non-parametric approach. The Economic Efficiency which Farrell (1957) describes as an overall efficiency, encompasses the multiplication of the technical and allocative efficiency and is given in the ratio,

$$EE=TE * AE= OF/OG * OE/OF= OE/OG$$

The parametric method deals with estimations using the Stochastic Frontier model whereas the non-parametric approach employs the use of a linear mathematical programming known as the Data Envelop Analysis (DEA) method.

Greene (1993), Curtiss (2000), Tewodros (2001) presented empirical studies on different approaches of estimating production functions: parametric against the non-parametric, deterministic against the stochastic and also linear programming methods against statistical methods. These different models have different ways by which they are estimated. From all these approaches, the highly used and essential ones are those based on the notion of best practice frontier and are purely based on economic theories (Sena, 2003).

2.3.1 Non Parametric Frontier Approach

The Data Envelopment Analysis (DEA), is a nonparametric approach to efficiency analysis which originated from a seminal paper written by Farrell in 1957. This gives another approach to estimating efficiency of production. His findings were later added on and formulated to its specification by other economists such as Charnes *et al.* (1978). The DEA developed tends to extend the usual efficiency analysis from an index number- based approach to a more analytical framework (Hokkanen, 2014). This approach to frontier is done by constructing a mathematical programming algorithm, which usually has non specific functional form. It just assumes a general production function.

This framework seeks to take a set of individual decision making units (DMUs) and constructs an efficient production frontier against which each DMU can be compared to obtain the efficiency of the unit in question. These units can be a number of firms for instance. The model then approximates the general production nonparametrically, by way of enveloping hyperplanes (Charnes *et al.*, 2013).

Charnes *et al.* (1978), developed the first DEA model and was expressed mathematically

$$\text{as:} \quad \max_{\theta, \lambda} \theta \quad (2.1)$$

$$\text{Subject to} \quad X\lambda \leq x_0 \quad (2.2)$$

$$\theta y_0 \leq Y\lambda \quad (2.3)$$

$$\lambda \geq 0 \quad (2.4)$$

From the equations above, x denotes inputs and y denotes output for the matrices used in analysis. A producers ability to expand his output is used in the evaluation of his

performance under the DEA, subject to the constraint being imposed by the best practicing firm. A firm's expansion level is determined by comparing its θ estimates to 1. When $\theta \geq 1$, then a radial expansion is said to be possible but when $\theta = 1$, then expansion is said to be optimal. The DEA approach formulated by Charnes *et al.* (1978) imposes a constant returns to scale on the technology in use.

Another approach to DEA was again proposed by Banker *et al.* (1984), which has a similar mathematical format as the first equations except that the last equation was substituted by adding all the λ 's and constrained to zero (Sena, 2003). This second model usually referred to as BCC, makes a distinction between technical and scale inefficiencies. It does this by making estimations for pure technical efficiency at the given scale of operation. And also identifies whether the three assumptions on returns to scale possibilities are present (Charnes *et al.* 2013).

2.3.2 Parametric Approach

The parametric programming approach (Aigner and Chu, 1968; Ali and Chaudhry, 1990) encompasses the deterministic and the stochastic frontier approach which uses either cross sectional or panel data. The deterministic frontier is estimated either by mathematical programming or econometric approach whilst the stochastic uses the econometric technique only.

2.3.2.1 Deterministic Frontier Approach

The deterministic frontier model is defined in a cross section perspective as;

$$Y_i = f(X; \beta) \exp(u_i) \quad (2.5)$$

Where $i = 1, 2, 3, \dots, N$

Y_i denotes the possible production level for the i -th sample farm bounded by a deterministic component $f(X; \beta)$ shown above. The deterministic component, $f(X; \beta)$ is a suitable function of the vector, X_i , of inputs for the i -th farm. The vector, β refers to the unknown parameters to be estimated. u_i is said to be a non-negative random variable specifying the inefficiency in the production process. The technical efficiency of individual farm is defined as the ratio of observed output Y_i to the corresponding potential frontier output Y_i^*

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(x_i; \beta) \cdot \exp(-u_i)}{f(x_i; \beta)} = \exp(-u_i) \quad (2.6)$$

In the case of the deterministic frontier technique all deviations in output are attributed to technical inefficiency effects regardless of the fact that the deviations in output might be contributed by random errors including weather effects and errors of measurement which are beyond the control of the producer.

2.3.2.2 The Stochastic Production Frontiers

The Stochastic Frontier Production model originated from works done by economists such as Meeusen and van den Broeck (1977), Aigner *et al.* (1977) and Battese and Corra (1977).

This model has the error component which is decomposed into the random noise and inefficiency effect. Hence, this approach to technical efficiency analysis seeks to explain that deviations from the production frontier may not necessarily be entirely under the control of the production unit. Other factors which contribute to variations may be external shocks outside the control of the producer (Kebede, 2001). These random or external shocks include effects of weather as well as diseases on the value of output obtained by the producer. These effect can be separated from the contribution of variation in technical efficiency using this model.

The stochastic frontier function is given by;

$$Y_i = f(X; \beta) \exp(v - u) \quad (2.7)$$

where Y_i denotes the output, X are input variables and β is a vector of technology parameters. This model was later extended by works done by Jondow *et al.* (1982) and obtained producer-specific estimates of efficiency. Other works by Greene (1980) proposed the different ways of the error term distributions whilst the half normal distribution specification gradually gained popularity in the empirical works. The second part of the frontier model gives the error term, (ε_i) . This can be further decomposed into $(v_i - u_i)$. The random noise component v_i is assumed to be identically distributed, symmetric and distributed independently of u_i . But the error term in itself is not symmetric, since $u_i > 0$. When it is assumed that, the random noise and inefficiency given as v_i and u_i respectively are distributed independently of x_1 , then the Ordinary Least Square (OLS) estimates by the Stochastic Frontier model provides consistent results of all

parameters except β_0 . In order to achieve estimates of β which gives the production technology parameters in the stochastic frontier model, the producer-specific inefficiency u_i is the ultimate objective of the estimation. Individual estimate for both the statistical noise, v_i and technical inefficiency, u_i can be extracted from the error term, ε_i for each producer.

Jondrow (1982) in his studies revealed that, the mean of the conditional distribution of u_i given ε_i of the technical efficiency of any production is defined by:

$$E(u_i / \varepsilon_i) = \sigma^{*2} \left[\frac{f^*(\varepsilon_i \lambda / \sigma)}{1 - F^*(\varepsilon_i \lambda / \sigma)} - \frac{\varepsilon_i}{\sigma} \right] \quad (2.8)$$

Where $\lambda = \sigma_u / \sigma_v$, $\sigma^2 = \sigma_u^2 + \sigma_v^2$ while f^* depicts the standard normal density function and F^* refers to the distribution function respectively evaluated at $\varepsilon_i \lambda / \sigma$. The sigma squared and gamma estimates are also given by the frontier production model and these are given in the equations, $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\gamma = \sigma_u^2 / \sigma_u^2 + \sigma_v^2$. The frontier model gives the technical efficiency estimates as well as estimates of technical inefficiency in one approach (Battese and Coelli, 1995). From the point of view of model specification, the estimate for gamma γ is of much importance since it gives the measure of total variation that is attributed to technical inefficiency in the model. It usually within the range of zero (0) and one (1). Unlike lambda which should be significantly greater than zero. The sigma squared estimate on the other hand shows that the stochastic production frontier is a good specification when $\sigma^2 \neq 0$. The technical efficiency to be estimated for a specific year is

defined in terms of observed output y_i to the corresponding potential output y_i^* using the available technology (Battese *et al.*, 1996), derived from the result of equation 3 as;

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(x_i; \beta) \cdot \exp(-u_i)}{f(x_i; \beta)} = \exp(-u_i) \quad (2.9)$$

From the equations above, Y_i denotes the observed output of the i-th farm and Y_i^* is the frontier output in the i-th farm as well. The technical efficiency model given in equation 2.9 can be simplified into e^{-u_i} so as to give estimates within 0 and 1 ($0 \leq \frac{y_i}{y_i^*} \leq 1$).

2.4 Stochastic Frontier Distribution Assumptions

This seeks to look at the various assumptions that form the basis of estimation for the use of the stochastic frontier in statistical analysis. These are given in the distributional assumptions of v_i and u_i . The v_i 's are assumed to be independent of the u_i 's with both terms uncorrelated with the explanatory variables. Ensuring consistency with the conventional classical assumption, the v_i and u_i are given as:

$E(v_i) = 0$	(Zero mean)
$E(v_i^2) = \sigma_v^2$	(Homoskedastic)
$E(v_i v_k) = 0$ for all $i \neq k$	(Uncorrelated)
$E(u_i^2) = \text{Constant}$	(Homoskedastic)
$E(u_i u_j) = 0$	(Uncorrelated)

Based on the assumptions of v_i 's and the u_i 's, then estimates from the Ordinary Least Square can be used for the model. But with this, the coefficient of the intercept term which is biased downwards can be corrected by applying the least square estimator. The use of

the maximum likelihood method of estimation gives a better solution under certain distributional assumptions of the two error terms using iterative optimization routines.

Assuming the random component v_i 's are said to be independently and identically distributed with a zero mean and constant variance and the u_i 's are distributed as any of the following independent pure noise:

$$U_i \approx iidN^+(0, \sigma_u^2) \quad (\text{Half Normal})$$

$$U_i \approx iidN^+(\mu, \sigma_u^2) \quad (\text{Truncated Normal})$$

$$U_i \approx iidG(\lambda, 0) \quad (\text{Exponential})$$

$$U_i \approx iidG(\lambda, m) \quad (\text{Gamma})$$

The distributional specification with respect to the u_i 's is sometime a matter of computational convenience. The half-normal and truncated-normal models can be estimated using the Frontier 4.1 software which has an inbuilt statistical package. The half-normal and exponential distribution assumes that most inefficiency effects are in the range of zero, which is associated with technical efficiency approaching 0. The truncated normal and gamma models allow for a wider range of distributional shapes, but, there is rather a cost of computational complexity, so far as there are more parameters to estimate and the probability distributional functions for v_i 's and u_i 's may have similar shapes which can make it difficult to distinguish inefficiency effects from random noise.

Looking at the assumptions of the random errors given, a log likelihood function for the

observed farm output is given in terms of $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\lambda = \frac{\sigma_u^2}{\sigma_v^2}$ Aigner *et al.* (1977).

However, this parameterization is limited because the variance σ_u^2 refers to the variance of the truncated random variable instead of the truncated half normal model.

The estimates for the frontier model are given by the maximization of the appropriate log likelihood function. These estimates are useful in validating the appropriateness of the inefficiency model. Considering the assumption of inefficiency being half-normally distributed that is $U_i \approx iidN^+(0, \sigma_u^2)$. Information on the U_i 's is conditioned on the composed error term. This was used to derive the predictor of U_i 's and $1 - E(U_i | V_i - U_i)$ was further used to predict the technical efficiency of the i-th farm. The U_i 's were also estimated in the case of exponential distribution of the one-sided error term.

However, the technical efficiency of the i-th farm given as $TE = \exp(-u_i)$ is best predicted by using the conditional expectation of $\exp(-u_i)$, given the value of the random variable, $E_i = V_i - U_i$, because it is consistent with the definition of the technical efficiency. Battese and Coelli (1995) came out with their findings on the truncated distribution with mean, u_i dependent on the exogenous variables and the input variables as opposed to the half-normal distribution. Also to overcome the shortfall associated with the half-normal and exponential cases, the two parameter gamma distribution were proposed by Greene (1980).

2.5 Review on Functional Forms

Under the frontier approach of estimating technical efficiency, there are different functional forms usually employed in establishing relationships between inputs and outputs in data analysis. These forms are translog, quadratic, transcendental and Cobb- Douglas production functions (Greene, 1980a). This study reviewed the Cobb-Douglas and Translog production functions because they are commonly employed in technical efficiency analysis. These models used in analysis become linear in parameters when there is logarithmic transformation hence can be estimated using the least square methods.

2.5.1 Cobb-Douglas Production Function

This production function can be explained in the equation below,

$$\ln Y_i = \beta_0 + \sum_{k=1}^N \beta_k \ln X_k + \varepsilon_i \quad (2.10)$$

This model was proposed by Knut Wicksell (1851 - 1926) and was further tested by Charles Cobb and Paul Douglas against statistical evidence in 1900-1928 as cited in Shen *et al.* (2012). Since then, it has been used for many production analysis. This model like most other production models is appropriate for analyses and usually involves the estimation of fewer parameters. The Cobb-Douglas has inherent advantages which makes it preferred for analysis. Some of its advantages include, the ability to handle various econometric estimation problems such as serial correlation, multicollinearity and heteroscedasticity in a much simpler and adequate manner (Ogujiuba *et al.*, 2014). Another ability this model has is how it facilitates computations and has the properties of explicit representability,

uniformity and flexibility. Finally, elasticities of individual inputs estimated by this model can be easily obtained, read and interpreted (Ilembo and Kuzilwa, 2014) and said to be less data demanding. But on the other hand, one disadvantage with this is that, it assumes all firms have the same production elasticities and that substitution elasticities are equal to one.

2.5.2 Translog Production Function

The translog production function is commonly used in production analysis and is said to be the generalized form of the Cobb-Douglas functional form. This can be expressed in the equation below,

$$\ln Y_i = \beta_0 + \sum_{k=1}^N \beta_k \ln X_k + \frac{1}{2} \sum_{k=1}^N \sum_{j=1}^N \beta_{kj} \ln X_k \ln X_j + \varepsilon_i \quad (2.11)$$

The translog is usually referred as a flexible functional form. Just as the Cobb-Douglas functional form, the translog also has inherent advantages. These include, the fact that the flexible nature of the translog functional form provide lesser restrictions on production elasticities and substitution elasticities. It as well provides a second-order approximation to any underlying function. However, one setback is the fact that, this flexible functional form estimation requires a larger sample size, which is always not possible. Moreover, there can be instances of multicollinearity with regards to translog model among the regressors which is likely to result to imprecise estimates of model parameters (Daghbashyan, 2011). Though the translog is considered as more difficult to interpret, it requires the incorporation of many parameters than the Cobb-Douglas production function.

2.6 Incorporation of Exogenous Variables in the Technical Inefficiency Model

The incorporation of exogenous variables bring about differences in technical efficiency levels and an understanding of this will enable policy makers formulate policy directives toward the achievement of the frontier output at a given technology and input level (Coelli and Battese, 1996). Some of the exogenous variables may include the following: age of farmer, level of education of the farmer, access to credit by the farmer, extension services, experience, farm distance etc.

The exogenous variables have been explained by several researchers to specify the performance of producers with variation in their respective output and can affect the production frontier relative to which the efficiencies of farmers are estimated. They are incorporated in the equation,

$$\ln Y_i = \ln f(x_i, z_i; \beta) + v_i - u_i \quad (2.12)$$

Where, $v_i \sim iidN(0, \sigma_v^2)$ and $u_i \sim iidN^+(0, \sigma_u^2)$. One disadvantage to this approach is its failure to explain the technical inefficiency effects in an appropriate production model since it assumes it to be uncorrelated to the inefficiency effects. On the other hand, this approach represents the production possibilities better (Kumbhakar and Lovell, 2000). There is a different approach to this estimation which assumes a correlation between the inefficiency effects and the exogenous variables incorporated into the model. This approach involves two steps.

The initial step estimates a stochastic frontier model with the predicted technical inefficiencies given in equation (2.13) below, then the second step goes further to use the Ordinary Least Square (OLS) to regress the exogenous variables on the inefficiency effects also given in equation (2.14) below. However, the exclusion of the exogenous variables in the initial step makes this formulation and the estimated technology parameters bias. Also, the second step regression results to econometric problems as well since it breaks the assumption of uncorrelation of the technical inefficiency effects with the socioeconomic variables (Kumbhakar and Lovell, 2000).

$$\ln Y_i = \ln f(x_i; \beta) + v_i - u_i \quad (2.13)$$

$$E(U_i | v_i - u_i) = g(z_i; \gamma) + \varepsilon_i \quad (2.14)$$

A better approach is the incorporation of exogenous variables in the production process given in equation (2.15) under a deterministic perspective.

$$\ln Y_i = \ln f(x_i; \beta) - \exp(\gamma z_i) + \varepsilon_i \quad (2.15)$$

This provides accurate results and provide explanations for the inefficiency effects which is highly important. This approach also solves the problem of independence. One disadvantage is its inability to allow for the effects of random noise given in equation (2.14). This approach has been worked on by several economists and a more current one which carefully takes into account the random noise effect and also provide solutions to the problem of variable omission and interdependence problem was formulated. It does this in a single step estimation procedure using the maximum likelihood estimation method under varying distributional assumptions of the inefficiency effects.

This approach was proposed by Reifschneider and Stevenson (1991). Finally, a non-neutral stochastic frontier model was also proposed by Huang and Liu (1994) which allows the exogenous variables to interact with the conventional input variables in the production model. Hence, the non-neutral technical inefficiency model is given as;

$$\ln Y_i = \ln f(x_i; \beta) + v_i - g(z_i, x_i; \gamma) + \varepsilon_i \quad (2.16)$$

2.7 Review of Studies on Technical Efficiency

The significant role agriculture plays on economic development has been recognized over the years. Economic development can also be accelerated when the adoption of new technologies designed to enhance farm output and income are critically looked at (Bravo-Ureta and Pinheiro, 1993). The inefficiencies on the part of farmers has also contributed to the many studies of technical efficiency on diverse crops. The potential importance of efficiency as a means of enhancing production has yielded a substantial number of studies in this field.

A study conducted by Asante *et al.* (2013) who used Cobb-Douglas production function model for the analysis found land, labour, fertilizer and pesticides to be significant in his study. Labour, fertilizer and pesticides had a negative relationship with output. He also recorded a mean technical efficiency of 78%, which implies that farmers in the area are below the potential output by 22%. Hence, in the short run there is a 22% possibility of increasing the output of tomato in the region by adopting the practices being employed by best farms. The maximum and minimum efficiencies estimated were 95% and 40%.

Tomato as well play a significant role in the economies of other countries as well. Technical efficiency studies by Ogunniyi and Oladejo (2011) in the Oyo State of Nigeria used a cross sectional data obtained from a total of 150 tomato farmers. Their study categorized farmers under constant returns to scale and variable returns to scale. A total of 26 farmers exhibited constant returns to scale, 94 showed increasing returns to scale whereas 30 showed a decreasing returns to scale. The mean technical efficiency recorded under the constant returns to scale and the variable returns to scale were 42% and 55% respectively. These results indicate that technical efficiencies can be increased by at least 45% through the use of best available resources, given the current state of technology.

Other works on technical efficiency pertaining to different sectors of agriculture have also been documented. A study conducted by Onumah and Acquah (2011), on “A Stochastic Production Investigation of Fish Farms in Ghana” also recorded a mean technical efficiency of 78% showing that output realized could be increased by about 22% without any additional resources. These estimates were within the range of 34.3% and 98.4%. The elasticities with respect to all the input variables were significant and positively related to output. The inputs incorporated in the study were feed, seed, land, family size, hired labour and othercost with elasticities of 0.13, 0.17, 0.42, 0.07, 0.09 and 0.24 respectively. A returns to scale of 1.12 which was statistically different from 1, hence an increasing returns to scale was computed.

A study conducted by Bakhsh and Ahmed (2006) on Technical Efficiency and its Determinants in Potato Production in Pakistan recorded a mean efficiency of 84% hence averagely, potato farmers are below the potential frontier by 26%. He employed the Cobb-Douglas production function model. Parameters such as tractor hours, quantity of seeds and labour positively influenced output and were statistically significant a 1%. On the other hand, fertilizer usage and irrigation hours were also found to be negative and insignificant. This implies that fertilizer and irrigation do not affect the yield of potato significantly.

Al-Hassan (2008) also conducted a study on technical efficiency where he categorized rice farmers as irrigators and non-irrigators. He sampled 250 irrigators and 482 non-irrigators. A mean technical efficiency of irrigators was 51% whereas that of non-irrigators were 53%. Hence, the mean technical efficiency estimate for the pooled sample farmers was 53%, indicating that rice farmers (both irrigators and non-irrigators) produce below the frontier level of 47%. Hence, he concluded that there is no significant difference in technical efficiency between irrigated and non- irrigated rice farmers in the study area. Rice farmers on a whole in the study are technically inefficient in the study area.

2.8 Review on the Determinants of Technical Inefficiencies in Tomato Production

Several works have been done on technical efficiency in diverse fields specifically in the agriculture sector. These studies, come out with findings pertaining to factors or determinants that contribute to inefficiency in production. Rahman *et al.* (2009), identified in his empirical studies that factors such as socioeconomic and farm characteristics,

environmental, physical and non-physical factors are some important determinants of technical inefficiency in agriculture for both the developed and developing nations.

Different variables incorporated in the model gives different implications. These variables may include certain socio-economic characteristics such as age and sex, others also show information status and managerial skills, such as education, technical knowledge and extension contacts, as well as other effects exogenous to the farm, such as credit, input markets or tenancy (Ali and Byerlee, 1991). The following empirical studies give an insight into the determinants of technical inefficiency in tomato production and how they influence technical efficiency.

A study conducted by Asante *et al.* (2013), indicated education, gender and experience to have a negative relationship with technical inefficiency. Hence, they tend to increase efficiency and decrease inefficiency. The education aspect implies that, the higher or more education acquired by farmer results to achieving higher technical efficiency in tomato production. With regards to gender, due to the laborious nature of tomato production, it is quite understandable why males dominate. Investigations show that, females usually provide support to their male counterparts in most tomato production activities.

Another study conducted by Donkoh *et al.* (2013) on the topic “Estimating Technical Efficiency of Tomato Production in Northern Ghana” showed that farmers’ level of formal education and years of farming experience was significant and also had a negative

relationship with inefficiency (hence a positive relationship with efficiency). They therefore concluded that educated farmers are equipped with requisite knowledge in the discretionary use of modern technology, farm organization, and optimal utilization of farm inputs which increases their efficiency. Also in the case of experience, he concluded that with more experiential knowledge, farmers effectively mobilize and appropriately use inputs and technology available to enhance efficiency.

Adenuga *et al.* (2013), conducted a study on the economics and technical efficiency of dry season tomato production in selected areas in Kwara state, Nigeria and also identified age, education and access to credit as the three exogenous variables that significantly raise efficiency in tomato production in that state. Last but not least, Ogunniyi & Oladejo (2011) conducted a study on the technical efficiency of tomato production in Oyo state, Nigeria. In their studies, gender and diversification were found to be significant and contributed positively to technical efficiency. On the other hand, experience had a negative relation with technical efficiency, which implies that efficiency decreases with increase in farming experience in that study. They found education, household size and marital status not to be significant in their study.

2.9 Review on Constraint Methodologies

Several methodologies have been proposed by economists in constraints analysis. The two main approaches usually employed in identifying and analyzing constraints faced by farmers are the Kendalls Coefficient of Concordance and Garrett Ranking Technique.

The Kendall's approach is easy and involves identifying constraints and presenting to farmers to rank from the most pressing to the least pressing constraints. Its estimation is done such that the most pressing constraint ends up with the least mean score estimate whereas the least pressing constraints records the maximum mean score. The Kendall's Coefficient of Concordance (W) shows the measure of agreement among several judges or respondents who are assessing a given set of objects (number) (Legendre, 2005).

The index, (W) also measures the ratio of the observed variance of the sum of ranks to the maximum possible variance of the ranks. The purpose for achieving this index is to find the total sum of the ranks for each constraint been ranked. If the ranking are in perfect agreement, the variability among this sum will be maximum (Mattson, 1986). W is said to exist within the range of 0 to 1 and must always be a non-negative (≥ 0) estimate. It assumes an estimate of 1 when ranks given by every judge is same that is a perfect agreement on constraints among judges or rankers. It takes 0 for maximum disagreement among judges or rankers.

The estimation of the Coefficient of Concordance (W) is given by the formula:

$$W = \frac{12 \left[\sum T^2 - (\sum T)^2 / n \right]}{nm^2(n^2 - 1)} \quad (2.17)$$

where;

T = sum of ranks for each constraint.

m = number of rankers (farmers)

n = the number of constraints ranked.

Afterwards the index estimated is tested for significance using the Chi-Square distribution or F-Statistic distribution. Based on this, the hypothesis formulated will be either rejected or not rejected. This form of hypothesis is stated as;

H_0 : There is no agreement among the rankings of the constraints by the farmers.

H_A : There is an agreement among the rankings of the constraints by the farmers.

where H_0 and H_A denote null and alternate hypotheses respectively.

Another approach is the use of the Garrett Ranking Technique (Sedaghat, 2011), which is quite simple to use in ranking the constraints faced by respondents. Judges or rankers are given common constraints to rank according to order of importance. The ranks are then converted into percent positions. The percent position of each rank is given as:

$$\frac{100(R_{ij} - 0.5)}{N_j} \quad (2.18)$$

Where:

R_{ij} = rank given for the i th constraint by the j th respondent

N_j = number of factors ranked by the j th respondent

The percent position of each rank is then converted into scores using the Garret and Woodworth (1969) table. Then for each constraint, the scores of the individual rankers are added together and divided by the total number of rankers for whom scores were added.

These mean scores for all the individual constraints are then arranged in a descending order and the most influencing factor identified through the ranks computed. Unlike the Kendall's approach, the higher the magnitude of constraint, the more important is the constraint.

2.10 Review on Constraints Faced in Tomato Production

Agriculture still remains a dominant sector of the economy (GSS, 2014) due to this, it serves as the principal source of food and livelihood in the region, making it a critical component in government programs that seek to reduce poverty and attain food security. Agriculture production in recent times have been faced with diverse challenges that inhibit the achievement of high productivity. A number of studies have been done on constraints tomato farmers encounter in Ghana. A study conducted by Adu-Dapaah and Oppong-Konadu (2002), on selected major tomato producing areas of the Ashanti and Brong Ahafo regions of Ghana came out with certain challenges facing tomato farmers. Another study by Aidoo *et al.* (2014) on the determinants of postharvest losses in tomato production in the Offinso North district of Ghana also outline constraints facing tomato farmers as well.

A list of constraints reviewed from literature included high cost of production, lack of market, limited access to credit, diseases, pest and problems with weed control, land tenure and land acquisition problems, irrigation facilities for dry season tomatoes as well as the accessibility of improved seeds for cultivation.

High cost of production: This has been one of the major challenges to most tomato farmers in Ghana. With the recent depreciation in the Ghanaian currency even worsens the situation since the prices of items are skyrocketing. This constraints are due to the high prices of factors of production such as fertilizer, pesticide, seed, tractor services, and irrigation facilities if application. Cost of hired labour also forms a part of this constraint.

Lack of market: Farmers due to hard work coupled with favourable weather conditions at certain times of the year achieve bumper harvests during peak seasons of production. The constraint they mostly face has to do with the poor prices offered by market queens for their produce. Most often due to the perishable nature of fresh tomatoes, farmers have no other option than to sell at lower prices to avoid their produce going waste. This constraint of nonexistence of guaranteed market and pricing system for their produce is a major disincentive to production.

Limited access to credit: Most farmers in Ghana are classified as resource poor and a large number of them would find it difficult to finance their own farm operations coupled with the high cost nature of inputs. Hence, concerns of financing farm operations is a major constraint to tomato production in Ghana. Farmers are generally unable to access credit/loans from financial institutions mainly because of lack of the requisite collateral security to support credit application. Most financial institutions do not give out loans to farmers due to the risky nature of farming in general.

Diseases, Pest and Problems with Weed control: These are challenges that contribute to severe losses in both quality and quantity of produce. When diseases, pests and weeds are properly controlled, losses can be reduced and farmers can as well get real value for their money. The white fly which is a vector for transmitting the tomato yellow leaf curl virus is one major disease in tomato production which has the potential of causing up to 100% economic losses in tomato production in many tropical and subtropical regions if not controlled (Pico *et al.* 1996). Bacterial wilt (Hayward, 1991) also causes severe damages to tomato production coupled with the devastating effects of rodents.

Land tenure or land acquisition problems: Land acquisition can be a source of constraint depending on the nature of crop and location in question. Migrant farmers who farm on different pieces of land yearly or seasonally face this constraint. Farmers will usually prefer lands nearer to a perennial source of water, this could be a stream or river, to enable them use their irrigation pumps, if the need arises or to embark on manual watering by using buckets or watering cans during the dry season production.

Irrigation facilities for dry season tomatoes: Dry season tomato cultivation becomes a very challenging season for tomato cultivation since farmers encounter challenges with the access water. Irrigation facilities on the other hand becomes very expensive for the average farmer to access seasonally.

Accessibility of improved seeds for production: Hybrid seeds and improved seeds have been proven to produce much and quality tomato yields (Opena *et al.*, 2001). Farmers are then encouraged to purchase these for planting. Farmers complain of the lack of availability at certain locations and also high cost of these seeds. Hence, farmers tend to extracted seeds from previous harvest which they then replant for the new season.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter discusses the methodology employed for the study. The first section describes the study area as a whole and the subsequent sections look at the profile of each district sampled. The conceptual and theoretical frameworks of the study are discussed in sections 3.4 and 3.5 respectively. Section 3.9 looks at the various hypotheses to be tested for the study. The fourth objective which analyses the constraints faced by tomato farmers, sources of data and sampling size and sampling technique are presented in the last three sections respectively.

3.2 Study Area

This study was undertaken in the Ashanti region of Ghana specifically in the Offinso Municipal, Offinso North and the Asante Akim North districts of the region. The region currently has a population size of 4,780,380 making it the highest populated region in Ghana. Out of which 2,316,052 and 2,464,328 represent males and females respectively (GSS, 2010). The Ashanti Region has Kumasi as its capital town and lies centrally within the middle belt of the country. The region falls between longitudes 0.15W and 2.25W, and latitudes 5.50N and 7.46N (Gyasi-Agyei, 2014). In terms of landmass, the region covers a total of 24,389 square kilometres, which represents 10.2 per cent of the total land area of Ghana (Ghanadistricts, 2014). The Ashanti region of Ghana is bounded on the north by the Brong-Ahafo region and on the east by the Eastern region. The Central region is located

on its southern part, whereas the Western region is located on its southwestern part. Studies have shown that, the economically active population in the Ashanti region is engaged mainly in Agriculture. The second highest proportion of the economically active population is employed in Wholesale and Retail Trade (18.4%), followed by Manufacturing (12.2%) and Community, Social and Personal Services (9.9%) (Ghanadistricts, 2014). The region has 30 political districts with Offinso Municipal, Offinso North and Asante Akim North forming three of these districts.

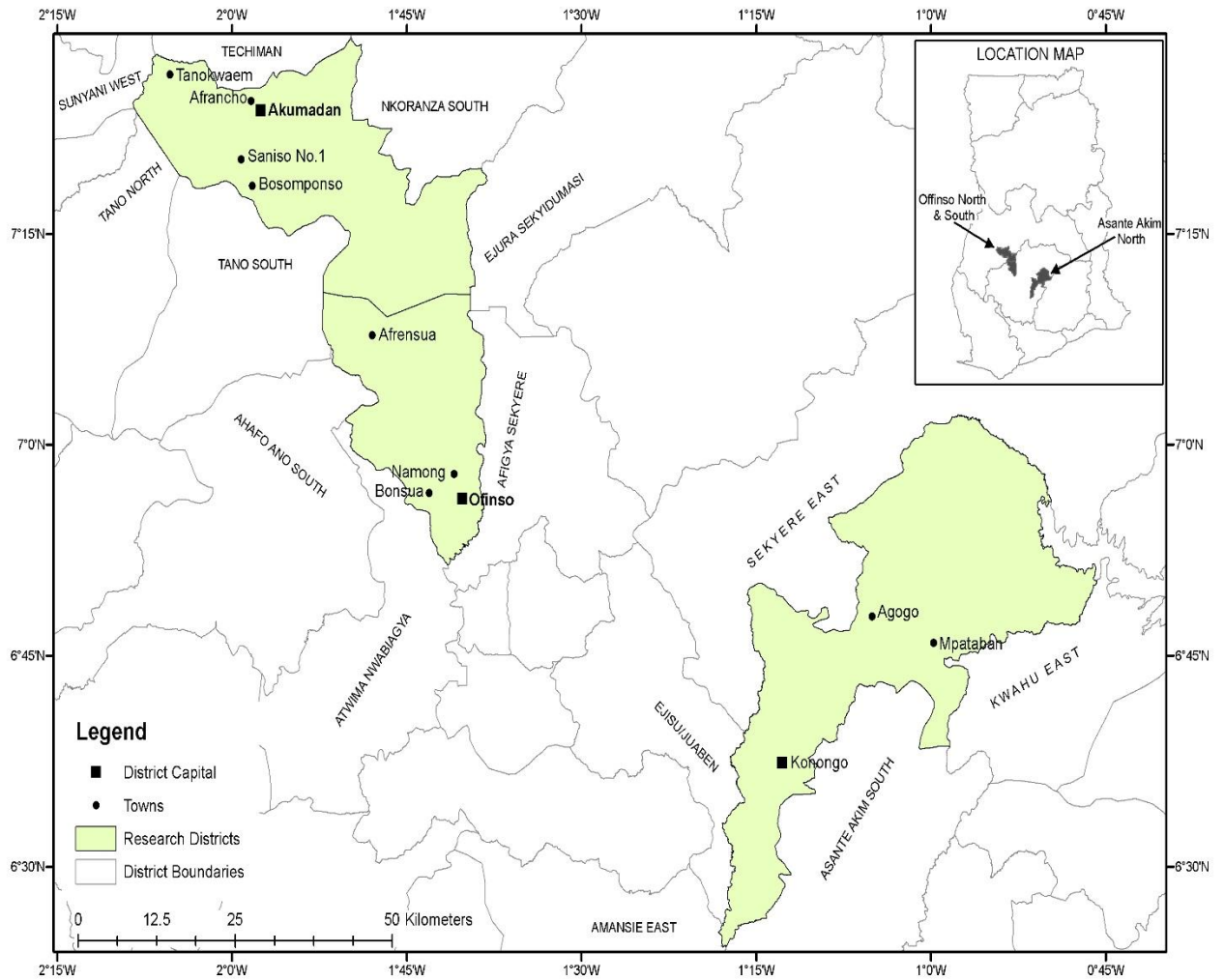
3.3 Profile of the Districts

One of the district in which this study was carried out is the Offinso Municipal also referred to as Offinso South and has its capital to be Offinso. Offinso Municipal lies between longitudes 10 50 W and 10 45 E and latitudes 70 20 N and 60 50 S with a total land area of 741 kilometres square (Ghanadistricts, 2014). Females dominate this district with a total of 39,827 and males having a total of 37,068 hence making the entire population of the district to be 76,895 (GSS, 2010).

The second district was the Offinso North District Assembly. Offinso North is a newly established district inaugurated in 2008 with Akumadan as its capital currently. It was formerly a part of the Offinso District Assembly and located at the extreme northwestern part of the Ashanti region closer to the Brong-Ahafo region. The district has a population of about 56,881 (GSS, 2010). Just like most districts in the Ashanti region, agriculture

continues to be the major economic activity in this district. Over 70% of the active population in the district are farmers (Aidoo *et al.*, 2014).

Figure 3.1 Map of Ashanti Region Showing Study Areas.



Source: Survey Department of Ghana (2009)

Tomato production is one of the sources of livelihood and income for a greater number of people in the Ofinso North district. This district as well has agents involved in the

distribution and marketing of the commodity throughout the country (Aidoo *et al.*, 2014). Major tomato producing towns include Akumadan and Afrancho as well as other communities who also produce substantial quantities. This district's population currently stands as 56,881. Females form the largest portion of this population with a share of 50.2 and a total population of 28,581 whereas males form 49.8 share with a population of 28,300 (GSS, 2010).

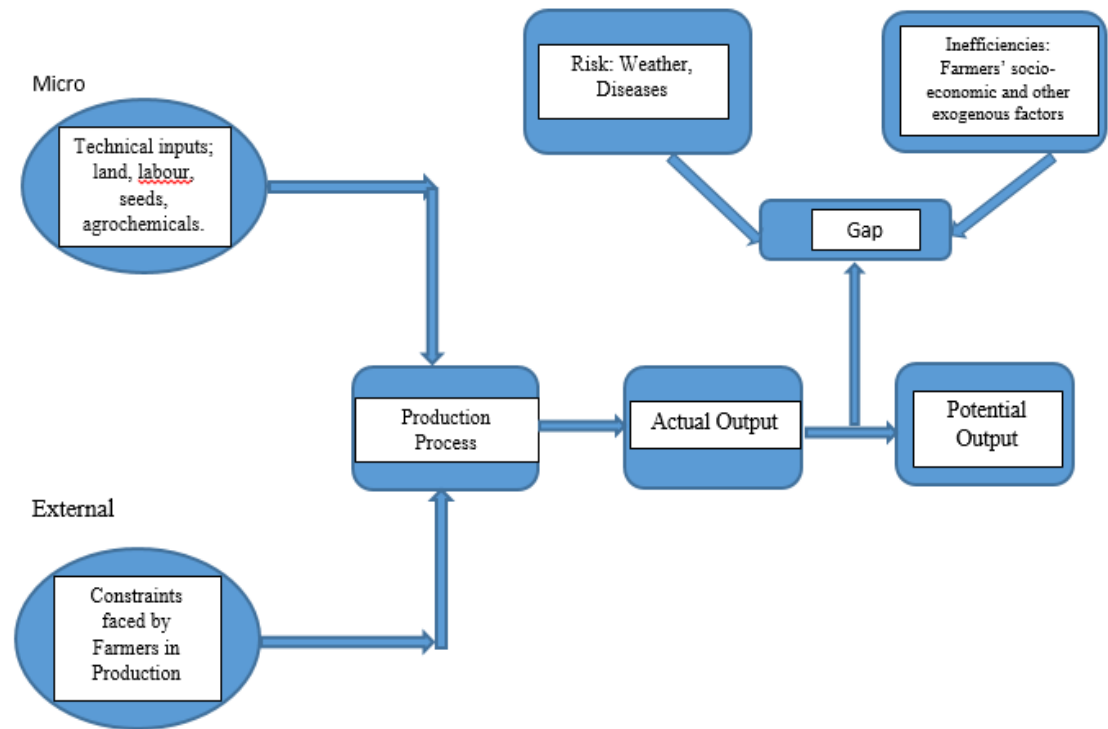
Finally, the newly carved Asante Akim North District was also selected for the study. This district was formerly a part of the Asante Akim District Council. The district lies between latitude 60 30^l N and 70 30^l N and longitude 00 15^l W and 10 20^l W (Gyasi *et al.*, 2014). It covers a total land area of 1,160 square kilometers forming 4.5 per cent of the size of Ashanti Region. It shares boundaries with other districts namely Kwahu South District on the east, Sekyere East on the north, on the west by Ejisu Juaben and finally by Asante Akim South District on its south (Mumin, 2010). The population of this district stands at 140,694 with males constituting 67,673 with a population share of 48.1 whilst females form 73,021 with a share of 51.9 (GSS, 2010).

3.4 Conceptual Framework of Technical Efficiency

Agricultural Production is basically about the conversion of inputs into outputs. A desired output can only be achieved when the commonly known technical factors, including land, seed, labour and agrochemicals are properly combined under the right managerial and farm practices or factors. The entire production process is influenced by the technical inputs and

other external factors such as constraints in production. The expected relationship between output and land is that as more land is brought under production output increases (Malassis, 1975). When these factors are combined under a particular production process given a particular technology, an actual output is achieved. The defined technology for this study comprise of the use of improved seeds, fertilizer and pesticides usage. Differences in the use of these brings about the level of inefficiencies in production. Usually, there exist a gap in agricultural production hence most often actual output is unable to meet potential output. This gap can be explained by the inefficiencies on the part of farmers and other risk factors such as weather, diseases and so on but this study makes an emphasis only on the inefficiencies on the part of farmers not the risk aspect.

Figure 3.2 The Conceptual Framework for Technical Efficiency



Source: Author's Conception (2015)

3.5 Theoretical Framework

Many economists have realized the need to assess efficiency due to the role it plays in production. Efficiency has then led to several studies and development of models to achieve this. Also, many researchers have come out with different approaches to efficiency measurements. These include, Charnes *et al.* (1978) formulation of nonparametric programming approach, Aigner and Chu (1968); Ali and Chaudhry (1990) formulation of the parametric programming approach. The deterministic statistical approach was by Afriat, 1972; Schippers, 2000; and finally, Aigner *et al.* (1977), Meeusen and van den Broeck (1977) who independently laid the foundations of stochastic frontier approach (SFA).

The stochastic frontier approach has been widely used for studies and much preferred by many agricultural economists owing to its inherent stochasticity nature (Coelli, 1995). Nkegbe (2012) also confirms in his studies the inherent stochastic nature of this hence provides best estimate for technical efficiency analysis in agricultural studies.

3.5.1 Empirical Model Specification

The translog model given below shows the various specifications that was used in the analysis of the technical efficiency of tomato farmers. It is given as;

$$\ln Y_i = \beta_0 + \sum_{k=1}^5 \beta_k \ln X_{ik} + 0.5 \sum_{k=1}^5 \sum_{j=1}^5 \beta_{jk} \ln X_{ik} \ln X_{ij} + (v_i - u_i) \quad (3.1)$$

Y_i denotes the output computed as kilograms per hectare which is then normalized by dividing through by its mean and then log transformed for the analysis.

X_i 's depicts the five input variables, namely seed, fertilizer, pesticides, labour and othercosts estimated on per hectare basis. They were each standardized by dividing through by each farm sizes, then normalized by also dividing through by their respective means. They were later log transformed before incorporated into the Frontier 4.1 software for analysis. β_i 's denotes the various technology parameters to be estimated and ε_i denotes the error term which can be decomposed into the random noise component (v_i) and the inefficiency component ($-u_i$). The inclusion of the β_{jk} , that is the square and the cross products makes the production function model translog. In the absence of this ($\beta_{jk} = 0$) the model is reduced to a Cobb-Douglas Production Function given as;

$$\ln Y_i = \beta_0 + \sum_{k=1}^5 \beta_k \ln X_i + \varepsilon_i \quad (3.2)$$

3.6 Description of Variables in the Stochastic Production Function

Five main input variables (X_i 's) with a dependent variable of output (Y_i) were incorporated in the model. These variable descriptions are as follows;

Y_i = denotes the output per hectare (kilogram/ha) for the 2014 tomato production year, which comprise both the major and the minor seasons. It's was measured on per hectare basis because each output by the i-th farm was standardized by his farm size. Unit measurement for crates used were 120kg, 100kg and 80kg.

X_{1i} = denotes the weight of seeds used by the i -th farm. It was measured in kilograms. Farmers interviewed used the improved seeds in production. Hence, the various weights of seeds used by each farmer were then divided by their respective farm sizes to get the unit of measurement as kilograms per hectare.

X_{2i} = denotes weight of fertilizer used by the i -th farm measured in kilograms per hectare as well. Quantities of fertilizer used by the farmer in both seasons were computed and standardized by dividing through by the farm size.

X_{3i} = denotes the weight of pesticides measured in litres per hectare used by the i -th farm in the 2014 production year. Various quantities of pesticides used was also computed for each season and standardized by farm size.

X_{4i} = this is the labour component of the inputs measured in mandays, which is then standardized by the farm size. Tomato farmers use both hired and family labours and are assumed to be equally productive. The total labor is computed by the summation of these components. Labour mandays can be estimated using the amount of labour done by either males or females using the formula; one manday (8 hours) is equivalent to one adult male whereas one manday (8 hours) is equivalent to 0.75 and 0.5 for one female and one child (< 18years) respectively.

X_{5i} = this denotes the othercosts component. They refer to the cost of other items or services involved in the tomato production process and not necessarily the costs of inputs. Its unit of measurement is in GHS/ha. This othercost component comprises of the cost of depreciated capital asserts such hoe, cutlass, knapsack sprayer, watering cans, barrels etc, cost of transportation, fuel cost and cost of hired items of the i -th farm during the

production year. Depreciation was computed using the straight line method which is given as the difference in the cost of item and salvage value of the item divided by its useful life.

Land as an input variable was not included in the model because all the inputs of each i-th farm were standardized by their respective farm sizes. Hence, already incorporated in the model.

3.7 Elasticity of Inputs

For the Stochastic Frontier Production model, the estimated parameter $\beta_1, \beta_2, \dots, \beta_5$ represent the output elasticities of the corresponding inputs used in the analysis. For the Cobb-Douglas production function, given as;

$$\ln Y_i = \beta_0 + \sum_{k=1}^5 \beta_k \ln X_{ki} + \varepsilon_i \quad (3.3)$$

the first order parameters automatically becomes the elasticity (ε) estimates of the production function. On the other hand, for the translog function specification, the various elasticities with respect to inputs are functions of the level of inputs used and generally represented as;

$$\frac{\partial \ln E(Y_i)}{\partial \ln X_{ki}} = \left\{ \beta_k + \beta_{kk} \ln X_{ki} + \sum_{j=k} \beta_{kj} \ln X_{ji} \right\} \quad (3.4)$$

However, when the output and input variables are divided through by their respective means called normalization, the first- order coefficient can be interpreted as elasticities of output with respect to the different inputs. The summation of these elasticities of inputs give the Function Coefficient or Total Output Elasticity or the Returns to Scale. This

measures the response in output as a result of changes in the input variable. The returns to scale is either said to be increasing, constant or a decreasing one.

When: $(\varepsilon) > 1$; Increasing returns to scale

$(\varepsilon) = 1$; Constant returns to scale

$(\varepsilon) < 1$; Decreasing returns to scale

Where ε , in this instance mean elasticities of each input used.

3.8 Description of the Technical Inefficiency Model

The approach to estimating the technical inefficiency is given by the equation below;

$$\mu_i = \delta_0 + \sum_{k=1}^8 \delta_k Z_{ki} \quad (3.5)$$

μ_i denotes the inefficiency component incorporated in the translog model. Z 's denote the vector of explanatory variables associated with the technical inefficiency effects whereas δ 's are the vectors of unknown parameters to be estimated. The frontier production function concurrently estimates both technical efficiency and determinants of technical inefficiencies in one analysis (Battese and Coelli, 1995). The equation above implies the incorporation of 8 explanatory variables (Z) in the model. The various estimates of the parameters (δ) indicate the impact of variables (Z) on technical efficiency. A negative coefficient suggests a positive influence on technical efficiency and vice versa.

Z_{1i} = Age of farmer given in years. The ages of all respondents were recorded and it is expected that older farmers will reduce inefficiency. This apriori expectation was confirmed in a study conducted by Ojo (2003) on the Productivity and technical efficiency of poultry egg production in Nigeria.

Z_{2i} = Household size of farmer. This variable looks at the number of people who constitute the household of the farmer. This include the farmer, his spouse(s), children or any other relative who resides and are being catered for by the farmer. A similar approach and estimation of household size has been used by many authors such as Al-Hassan (2008).

Z_{3i} = Education. This was measured in number of years attained by the farmer. The expected sign for this variable is positive in relation to technical efficiency which will imply that the higher number of years one attains in education the efficient he becomes. And this is understandable since educated farmers are expected to make rational decisions that will help improve efficiency. Education also plays a crucial role in enhancing farmer's efficiency in the long run by aiding adoption of requisite technologies as well as analysing them. Ogundele & Okoruwa, (2006) and Kibaara (2005) in their studies measured education using this approach.

Z_{4i} = Extension visits. This was initially measured as a dummy, 1 when the response to extension visits was yes and 0 when otherwise but the frequency of visits per farmer was used for analysis. This gives a better basis for estimation since farmers who responded yes may record varying frequencies of visits. Extension is expected to exhibit a positive relationship with technical efficiency since agents are responsible for advising farming on best technologies and practices to adopt. This was confirmed by a study conducted by

Bakhsh & Ahmad, 2006 on “Technical efficiency and its determinants on potato production, evidence from Punjab, Pakistan”.

Z_{5i} = indicates experience. This was also measured in number of years in tomato production per farmer. This is expected to positively influence efficiency since it is believed that experienced farmers may have accumulated more knowledge in tomato production which will increase their likelihood of adopting improved technologies that will eventually increase their efficiency levels. A study conducted by (Awunyo-vitor *et al.*, 2013) found extension visits being consistent with this apriori expectation.

Z_{6i} = Farm distance. This measures the distance from the farmer’s house to his tomato farm and measured in kilometres. The shorter the distance the efficient the farmer is expected to be since he can get to his farm on time and often to perform the necessary activities.

Z_{7i} = Credit. Access to credit was dummied either 1 or 0. A yes response was dummied as one (1), if the farmer had any form of credit during the production period and zero (0) if otherwise. Farmers who use cash or in-kind credits are expected to be efficient because there is a high probability to use these cash credits to purchase productivity enhancing inputs.

Z_{8i} =Farmer Based Organization participation. This was also dummied, with one (1) representing those who belonged to such associations and zero (0) if otherwise. Farmer Based Organizations are expected to improve efficiency since such groups are able to access extension services easily. Such groups at times also enable farmers access credits from financial institutions.

3.9 Hypothesis Formulation

The following hypothesis given in Table 3.1 were considered for investigation in this study.

The first hypothesis which tests for the functional forms of the model is given as

$H_0; \beta_{jk} = 0$. This null hypothesis states that the first order coefficients in the translog

production function have zero values therefore when this is true, then the Cobb-Douglas

production function best fits the study. The second hypothesis, given as

$H_0 : \gamma = \delta_0 = \delta_1 \dots \delta_8 = 0$, seeks to identify whether inefficiency is present in the model.

The hypothesis indicates that the inefficiency effects in the frontier model are not present.

Hence, when the null hypothesis (H_0) is rejected at an acceptable confidence level, it

implies that the effect of inefficiency is present. With the third hypothesis, the null

hypothesis is given as $H_0 : \gamma = 0$, when all the δ -coefficients are zero, then it indicates that

the inefficiency effect is non-stochastic.

The next hypothesis also stated as $H_0 : \delta_0 = \delta_1 \dots \delta_8 = 0$, indicates that the inefficiency

effects are half normally distributed. When the technical inefficiency effects is said to have

a half-normal distribution, it implies that all the coefficients of the explanatory variables in

the inefficiency model are equal to zero. When this hypothesis is proven to be true, then

the technical inefficiencies of tomato production are not influenced by the explanatory

variables in the inefficiency model. A rejection of this hypothesis means that the

coefficients of the explanatory variables in the inefficiency model are not equal to zero

hence technical inefficiency effects have a truncated normal distribution and thus influence

the level of inefficiency in tomato production.

The null hypothesis, $H_0 : \delta_1 = \delta_2 \dots \delta_8 = 0$, indicates that the exogenous variables included in the inefficiency model do not jointly influence technical inefficiency. On the other hand, when it is rejected, then a joint effect of these variables on technical inefficiency is statistically significant.

Table 3.1 Hypotheses Tests for Model Specification.

Hypothesis	Implication
1. $H_0 : \beta_{jk} = 0$	The Cobb Douglas production function best fits the model
2. $H_0 : \gamma = \delta_0 = \delta_1 \dots \delta_8 = 0$	Inefficiencies are absent at every level
3. $H_0 : \gamma = 0$	The inefficiency effects are not stochastic
4. $H_0 : \delta_0 = \delta_1 \dots \delta_8 = 0$	The null hypothesis states that the inefficiency effects are half normally distributed
5. $H_0 : \delta_1 = \delta_2 \dots \delta_8 = 0$	The hypothesis that the exogenous variables do not jointly influence technical inefficiency

The generalized likelihood ratio test statistics, LR (λ) was used to test the various null hypotheses. This is given in the equation below;

$$LR = -2[In\{L(H_0)\} - In\{L(H_1)\}] \tag{3.6}$$

The $L(H_0)$ and $L(H_1)$ refers to the log likelihood values for the null and alternate hypothesis respectively. Depending on the hypothesis to be tested, the likelihood ratio test statistic has approximately a chi-square distribution or a mixed chi-square distribution. The degrees of freedom or number of restrictions is equal to the number of parameters specified under any of the hypotheses. On the other hand, when the hypothesis involves gamma (γ

), that is the ratio of the variance of technical inefficiency effects to the variance of the pure noise, then the log likelihood statistic has a mixed chi-square distribution and hence the critical value should be read from table 1 of Kodde and Palm (1986).

3.10 Method for Analyzing the Constraints Affecting Tomato Farmers

The last objective was to rank the various constraints facing tomato farmers in the Ashanti region. The identified constraints that were reviewed from literature were given to farmers to rank from the most pressing to the least pressing using numerals: 1, 2, 3,....., n, in that order. In estimating the total rank score for each constraints identified, the constraint with the least mean score is ranked as the most pressing whereas the one with the highest mean score is ranked as the least pressing one.

The Kendall's Coefficient of Concordance (W) measures the agreement among several tomato farmers (respondents) who are assessing and ranking a given set of constraints (Legendre, 2005). The total rank score computed is then used to calculate for the Coefficient of Concordance (W), to measure the degree of agreement in the rankings. The coefficient of concordance W ranges from zero (0) to one (1). The closer the results is to 1 the higher the degree of agreement.

It is given in the formula below:

$$W = \frac{12 \left[\sum T^2 - (\sum T)^2 / n \right]}{nm^2(n^2 - 1)} \quad (3.7)$$

where;

T = sum of ranks for each constraint.

m = number of rankers (farmers)

n = the number of constraints being ranked.

Hypotheses and Significant Test for W: (chi-square statistic)

H_0 : There is no agreement among the rankings of the constraints by the farmers.

H_A : There is an agreement among the rankings of the constraints by the farmers.

where H_0 and H_A denote null and alternate hypotheses respectively.

The coefficient of concordance (W) will be tested for significance by using the Chi-square statistic which is obtained from W by the formula. The Chi-square critical (χ^2_{crit}) is read from the conventional chi-square table and compared to that of the chi-square calculated (χ^2_{cal}) by the model. Based on the figures, when the chi-square calculated is greater than that of the critical we then reject the null hypothesis (H_0) and vice versa.

3.11 Method of Data Analysis

The socio-economic characteristics of respondents were described using Descriptive statistics. The study adopts the Stochastic Frontier Production Model (SFA) using the Maximum Likelihood Estimates (MLE) method by the FRONTIER 4.1 SOFTWARE.

3.11.1 Descriptive Analysis of the Socioeconomic Variables

The use of maximums, minimums, means, frequencies and percentages were employed in describing the socioeconomic variables. The socioeconomic variables considered were age, household size, education, extension visits, experience, farm distance, credit and Farmer Based Organization participation.

3.12 Data Type for the Study

Primary data was mainly used for the study and gathered through the use of a well-structured questionnaire.

3.12.1 Sample Size and Sampling Technique

A multi-stage sampling technique was employed for the collection of data. The Ashanti region was purposely selected for the study because it is known to be one of the leading tomato producing regions in the country (Asante *et al.*, 2013). Three districts were selected through a simple random sampling procedure (lottery method) where the names of five districts were written on pieces of paper and tossed. The five districts Offinso North, Ahafo Ano South, Atwima Nwabiagya, Offinso South and Asante Akim North.

Communities in fresh tomatoes production within the three chosen districts were selected through the same random sampling procedure (lottery procedure) as well. Finally, the selection of the total number of respondents in these communities was done using simple random sampling procedure. With the aid of a well-structured questionnaire, relevant

information on socioeconomic characteristics, farming practices, output, inputs and price data were taken.

At the first stage of the data collection process, a pilot survey of the questionnaire was carried out to ensure that the respondents understood the questions and also to validate the suitability and the appropriateness of the questions and expected responses by the respondents. Changes were then made on the questionnaire in light of errors detected from the pilot survey. Table 3.2 gives the distribution of districts and communities where this study was carried out.

Table 3.2 Distribution of Respondents by Districts and Communities.

	Districts	Communities	Number of Respondents
Ashanti Region	Offinso North	Afrancho, Akumadan, Tano Kwaem, Bosomponso, Mmeredane, Saniso 1	91
	Offinso South	Namong, Bonsua, Tutuase, Akwadum, Ayensua Fufuo, Ayensua Korkor	40
	Asante Akim North	Agogo, Oyimso, Pataban	19
Total			150

Source: Field survey (2015)

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter seeks to discuss the results of the study. Section 4.2 discusses the socio-demographic characteristics of the respondents. The subsequent sections give the estimates of the productivity analysis, technical efficiency estimation, technical inefficiency determinants and finally the constraints encountered in tomato production.

4.2 Socio-Demographic Characteristics of Respondents

Table 4.1 shows the socio-economic characteristics of tomato farmers as well as indicating their frequencies and percentages. A total of one hundred and fifty (150) respondents were interviewed for the study. Out of this number, males formed 84.7%, whereas females 15.3%. A study conducted by Donkoh *et al.* (2013) also recorded males forming 70% and females 30%. This indicates that tomato production is dominated by males. Secondly, the minimum and maximum age recorded were 25 and 65. Ages were categorized into the ranges of 25-35, 36-46, 47-57, 58-68.

The maximum number of respondents were in the age range of 36 and 46. Males within the range of (36-46) are considered to be strong and energetic to withstand the demanding work nature of tomato cultivation. The mean age recorded was 44. Also looking at the various age ranges, one can conclude that tomato farming serves as a source of livelihood for people with diverse ages. The minimum and maximum ages recorded were similar to

Adenuga *et al.* (2013), who also recorded 26 and 65 as the minimum and maximum ages respectively in his study.

Table 4.1: Socio- Demographic Characteristics of Respondents

Characteristic		Frequency	Percentage
Gender	Male	127	84.7
	Female	23	15.3
Age	25-35	24	16
	36-46	66	44
	47-57	46	30.7
	58-68	14	9.3
	Minimum	25	
	Maximum	65	
	Mean	44.05	
Education	0-5	19	12.7
	6-11	30	20.0
	12-17	85	56.6
	18-23	16	10.7
	Minimum	0	
	Maximum	20	
Mean	12.50		
Experience	0-10	64	42.7
	11-21	56	37.3
	22-32	22	14.7
	33-44	8	5.3
	Minimum	0	
	Maximum	40	
Mean	15.29		
Household size	1-4	49	32.67
	5-8	86	57.33
	9-12	15	10
	Minimum	1	
	Maximum	12	
Mean	5.55		
Credit	Yes	47	31.3
	No	129	68.7
Extension visits	Minimum	0	
	Maximum	8	
	Mean	2.37	
FBO	Yes	21	14
	No	129	86
Seed type	Improved	150	100

Source; Field survey (2015)

Education as a socio-economic variable was also measured in terms of the number of years acquired. This was calculated right from nursery education to the tertiary level. The minimum year recorded was zero, which implies no education at all and the maximum was 20 years. A total of 19 respondents were in the category of 0-5 years, which recorded a percentage of 12.7%. The second range of 6 to 11 years recorded a total of 30 respondents with a percentage of 20. The third range of 12 to 17 recorded the highest respondents of 85 forming a percentage of 56.6. The final range of 18 to 23 recorded the least number of respondents. The frequency of this was 16 and the percentage was 10.7. The third range of 12 to 17 which recorded the highest respondents show those who have completed either SHS/Vocational/Technical or the Tertiary.

These representations of education in the three districts sampled implies that the majority of farmers had at least primary education, hence they can read and know the right quantities of chemicals to apply. In a study conducted by Al-Hassan (2008) concluded that in order to achieve the frontier output, it is imperative that farmers have at least some basic formal education to understand and use modern technologies applied in farming.

Marital status was categorized into single, married, separated and widowed. Amongst the respondents, the status “married” recorded the highest respondents of 139 and a percentage of 92.67. This was followed by those respondents who were single, a frequency of 8 and a percentage of 5.33 were recorded. Finally, those in the category of separated and widowed had 1 and 2 respondents respectively. This gave the least percentages of 0.7 and 1.3. Studies

by (Asante *et al.*, 2013) and (Tambo and Gbemu, 2010) all showed married status with the highest frequency. Farmer's experience was also measured. The minimum and maximum years recorded were 0 and 40 years. Asante *et al.* 2013 recorded similar minimum and maximum figures of 1 and 40 respectively. The ranges were given as 0-10, 11-21, 22-32, and 33-43. These recorded frequencies and percentages of 64 and 42.7%, 56 and 37.3%, 22 and 14.7% and finally 8 and 5.3% respectively. These results show that the majority of farmers has at least 15 years of experience in tomato production. This result thereby makes the region one of the highest tomato growing regions in Ghana since it is believed that the more one gains experience in a particular endeavour the better results he achieves.

Household size also play a critical role when it comes to farming. Household size was measured in terms of the number of members. They were put in ranges of 1 to 4, 5 to 8 and 9-12. Each recorded a frequency of 49, 86 and 15 respectively. The minimum, maximum and mean numbers recorded were 1,12 and 5.55 respectively. Kebede (2001) in his work on rice included household as a socio-demographic characteristic as well. He indicated 5, 10 and 2 as mean, maximum and minimum.

Access to credit is a major constraint faced by farmers in Ghana. From my study in the three districts sampled, a total of 103 out of 150 received no form of credit whereas 43 farmers had access to credit. These recorded 68.7% and 31.3% respectively. The sources of their credit were mainly from financial institutions, friends and family members. Many research works usually show a lower percentage of respondents with access to credit.

Awunyo-vitor *et al.* 2013 in his study recorded 34.3% having access to credit, whereas 66% had no access to credit. Extension services are of much significance in agricultural activities. Agents involved provide advice on proper agronomic practices to employ in production. Although the majority of farmers complain of poor services provided by these agents, others benefit from their visits as well. In the Offinso Municipal farmers are in various groups and these groups are headed by an extension agent who advise them on best practices and even facilitate some to access loans for their farms.

Extension was measured in terms of the number of visits a farmer gets in the production season. The minimum recorded was no visits at all and the maximum was 8 visits in the year. The average number of visits was about twice per year. The distance from ones house to his farm which was labelled as farm distance was also recorded. The maximum and average distance recorded was 12km and 5.8km respectively. A minimum distance of 0km were recorded for respondents who actually lived on his farm.

Within these three districts exist a number of Farmer Based Organizations, but only a few of the respondents found themselves in such organizations. A total of 21 farmers forming 31.3% were in such associations whereas the remaining 129 indicating 86% weren't in any of these farmer based organizations. Members, in such organizations benefit by acquiring training on proper book-keeping and best agronomic practices. Seed variety also plays a significant role in the productivity of tomato. Farmers sampled for the study used the improved or the locally improved (hybrid) for production.

4.3 Summary Statistics on Output and Input Variables

Tomato production is an important activity in the Ashanti region of Ghana. This crop due to its ability to grow in most soil types and under a wide variety of climatic conditions enables it to be grown almost everywhere. The major inputs used in tomato production are seeds, land, agrochemicals (fertilizer and pesticide) and labour. The table 4.2 below gives a summary of the minimum, maximum, mean and standard deviations of the various inputs used in the analysis. The average output recorded for tomato production in the region was 7041.42 Kg/Ha with a standard deviation of 2132.67 Kg/Ha.

The maximum output recorded in the study was almost 11827.2 Kg/Ha per hectare. Subsequently, the maximum values recorded by seed, fertilizer, pesticides, labour and other costs were 0.99Kg/Ha, 742.57Kg/Ha, 7.43L/Ha, 24317.93 Manhours/Ha and 108.84 GHS/Ha. These inputs are highly needed for output to be realized.

Table 4.2: Summary on Statistical Output

Variable	Unit	Minimum	Maximum	Mean	Std. Deviation
Output	Kg/Ha	2710.74	11827.2	7041.42	2132.67
Seed	Kg/Ha	0.26	0.99	0.54	0.09
Fertilizer	Kg/Ha	152.86	742.57	358.08	67.91
Pesticides	L/Ha	2.68	7.43	4.8	0.63
Labour	Manhours/Ha	404.57	24317.9	4683.18	4974.28
Othercosts	GHS/Ha	18.54	335.42	108.84	60.05

Source; Field survey, 2015

Seeds which are considered as one of the major inputs used in tomato production recorded a mean of 0.54 Kg/Ha and a standard deviation of 0.09 Kg/Ha. Fertilizer, Pesticides, Labour and Othercosts contributed significantly in tomato production during the planting period and recorded a mean of 358.08 Kg/Ha, 4.80L/Ha, 4683.18 Manhours/Ha and 108.84 GHS/Ha. Their respective standard deviations are given as 67.91 Kg/Ha, 0.63 L/Ha, 4974.28 Manhours/Ha and 60.05 GHS/Ha. Agrochemicals such as fertilizer and pesticides are needed in substantial quantities to give higher output. This implies that they play significant roles in tomato production. Labour is highly essential for the production of tomato to take place considering the fact that tomato production involves many activities right from the nursery stage to harvesting. Hired labour is mostly employed on most tomato farms though family labour also has a role to play in production.

However, MoFA (2013) presented the achievable yields of tomato for the nation to be 15 tonnes per hectare which leaves the results of the maximum output of 12 tonnes slightly closer. This is quite understandable because this maximum figure was recorded in Offinso North, where tomato production is known to be high but still remain lower than achievable yields. A study conducted by Aidoo *et al.* (2014) also recorded an output of 11 metric tonnes during the 2012 production season.

The average output also recorded in this study was 7.0 metric tonnes. This also goes a long way to confirm that the Ashanti region is one of the high tomato producing regions. Hence, when farmers are able to employ all the appropriate technologies involved in tomato

production, there is a high possibility that achievable yields can be reached. Table 4.3 below gives the various productivity levels of tomato farmers with respect to the input land.

The highest productivity recorded in the region was in the range of 10.1-13.0 metric tonnes and the least was within the range of 1.0-3.0 metric tonnes. The former had a total of 19 respondents and the later had two (2) respondents. The highest productivity estimated in the study was less than the achievable yield of 15 metric tonnes estimated in the nation (MoFA, 2013). Majority of farmers were in the range of 5.1-7.0 metric tonnes. Eighteen respondents were recorded in the range of 3.1-5.0 metric tonnes which is lower than the average yields recorded in Ghana.

Table 4.3: Productivity Estimates of Tomato Production in the Ashanti Region

Output (MT/Ha)	Frequency	Percent
1.0-3.0	2	1.33
3.1-5.0	18	12
5.1-7.0	66	44
7.1-10.0	45	30
10.1-13.0	19	12.67
Total	150	100.0

Source; Field Survey (2015).

4.4 Hypotheses Testing

The results of the various hypotheses tested are given in the table below. The validity of these hypotheses were based on the various estimates derived from the analysis. These

estimates are either compared to readings on the conventional chi-square table or the mixed chi-square table depending on the hypothesis being tested for. All the hypothesis were rejected at 0.001% with the exception of the third one, $H_0: \gamma = 0$, which was rejected at 0.005%. The first hypothesis tested for functional forms. The null hypothesis implies that, the traditional production function model (Cobb-Douglas) best fits the study. From the results shown, the null hypothesis was rejected which implies that the translog model rather best fits the study. The second hypothesis also tests for the presence of inefficiencies in the model.

Table 4.4: Hypothesis Tests for Model Specification and Statistical Assumption.

Null hypothesis(H_0)	Test Statistics	Critical Value	Decision Rule
1. $H_0: \beta_{jk} = 0$	68.24	37.70	Reject H_0
2. $H_0: \gamma = \delta_0 = \delta_1 \dots \delta_8 = 0$	57.88 ^a	27.13	Reject H_0
3. $H_0: \gamma = 0$	8.7 ^a	6.64	Reject H_0
4. $H_0: \delta_0 = \delta_1 \dots \delta_8 = 0$	49.2	27.83	Reject H_0
5. $H_0: \delta_1 = \delta_2 \dots \delta_8 = 0$	69.36	26.12	Reject H_0

Test statistic with ^aValues refers to the test of one-sided error estimate from the Frontier output. The correct critical value for the hypothesis involving γ are obtained from the Table 1 of Kodde and Palm (1986, p. 1246)

The null hypothesis states that inefficiency is absent in the model. The t-statistic value read was greater than the critical value hence the null hypothesis was rejected. This indicates that inefficiency is present at every level in the model. The null hypothesis, $H_0: \gamma = 0$, was also rejected at a confidence level of 0.005%. This implies that all the δ -coefficients are not equal to zero, thereby making the inefficiency effect stochastic. This shows that the

Cobb-Douglas function model is not an adequate representation of the data, given the assumptions of the stochastic frontier model.

The fourth hypothesis $H_0 : \delta_0 = \delta_1 \dots \delta_8 = 0$, based on the results from the analysis was also rejected at 0.001% significant level implying that the coefficients of the explanatory variables in the inefficiency model are not equal to zero hence technical inefficiency effects has a truncated normal distribution and thus influence the level of inefficiency in tomato production. Last but not least, the null hypothesis $H_0 : \delta_1 = \delta_2 \dots \delta_8 = 0$, was also rejected at a confidence level of 0.001%. The null hypothesis stated that exogenous variables do not jointly influence technical inefficiency. Rejection of this hypothesis implies that exogenous variables jointly influence technical inefficiency.

4.5 Stochastic Frontier Estimates

The translog estimates for the various parameters is presented in table 4.5. The coefficients displayed were significant at different confidence levels. Further discussions were however based on the output elasticities with respect to the inputs presented. Table 4.6 gives the elasticities with respect to inputs used in the study. Determination of elasticity is highly important for the estimation of responsiveness of output to the various inputs. The coefficients of the input variables in the translog model are given in table 4.5 below. This coefficient represents the elasticities of the various inputs. The elasticities of seeds, fertilizer, pesticides, labour and other costs are 0.32, 0.39, 0.50, 0.01 and 0.13 respectively. All the coefficients showed a positive relationship to output. These positive coefficients

imply that a 1% increase in any of those variables will increase output by 0.32%, 0.39%, 0.50%, and 0.13% respectively.

Table 4.5: Maximum Likelihood Estimates of Translog Mean Output Function

Variable	Parameters	Coefficients	S.E	T-statistics
Constant	β_0	0.201***	0.046	4.344
Seed	β_1	0.324**	0.148	2.194
Fertilizer	β_2	0.391***	0.165	2.374
Pesticides	β_3	0.495***	0.184	2.698
Labour	β_4	0.006	0.031	0.188
Othercosts	β_5	0.127***	0.048	2.625
0.5Ln(Seed) ²	β_6	2.209***	0.579	3.816
0.5Ln(Fertilizer) ²	β_7	-0.235	1.832	-0.283
0.5Ln(Pesticides) ²	β_8	-1.916*	0.996	-1.924
0.5Ln(Labour) ²	β_9	-0.127***	0.049	-2.553
0.5Ln(Othercosts) ²	β_{10}	-0.117	0.101	-1.152
LnSeedLnFertilizer	β_{11}	-1.293	1.009	-1.281
LnSeedLnPesticides	β_{12}	-2.580***	0.961	-2.685
LnSeedLnLabour	β_{13}	-0.717	0.175	-0.410
LnSeedLnOthercosts	β_{14}	-0.638**	0.303	-2.109
LnFertilizerLnPesticides	β_{15}	1.423	0.969	1.468
LnFertilizerLnLabour	β_{16}	0.175	0.175	0.999
LnFertilizerLnOthercosts	β_{17}	0.159	0.268	0.593
LnPesticidesLnLabour	β_{18}	0.440**	0.208	2.118
LnPesticidesLnOthercosts	β_{19}	-0.420	0.309	-1.358
LnLabourLnOthercosts	β_{20}	0.196***	0.053	3.671
Sigma squared (σ^2)	0.09			
Gamma (γ)	0.78			
Log-likelihood	34.81			

Where *, **, *** represent 10%, 5% and 1% significant levels respectively.

Source: Authors analysis from field data (2015)

Labour was however not significant in this study. It showed a rather smaller elasticity, hence a lower response of this input to output. This indicates that for this particular study, output is influenced minimally by the use of labour. Pesticides in this study recorded the highest scale elasticity, followed by fertilizer application, improve seed use and other costs. Hence, this implies that pesticide contributes the most to tomato output in the region.

Table 4.6: Elasticities of Production and Returns to Scale Estimates

Variable	Elasticity
Seed/ha	0.32**
Fertilizer/ha	0.39***
Pesticides/ha	0.50***
Labour/ha	0.01
Othercosts/ha	0.13***
RTS	1.35

Source: Authors analysis from field data (2015)

The use of pesticides are essential in the control of pests, diseases and weeds in tomato production because they have the tendency of reducing output drastically when measures are not taken. Fertilizer, pesticide application and othercosts were significant at 1% whilst improved seed use was significant at 5%. The presence of othercosts also contribute to an increase in output in tomato production. Fertilizer use plays a significant role in tomato production since it provides the plant with adequate nutrients required to ensure high output. Fertilizer use was statistically significant in this study which implies that a 1% increase in it will cause output to increase by 0.39%.

Asante *et al.* (2013), in their study using the Cobb-Douglas production function model, estimated scale elasticities of output with respect to land, labour, fertilizer and pesticides as 0.130%, 0.052%, 0.124% and 0.001% respectively. He found land, labour, fertilizer and pesticide to be significant in the study. Improve seed use gave an elasticity of 0.32, implying that a 1% increase in the use of quality seeds will increase output by 0.32%. This agrees with the results of Kibaara (2005) who worked on maize and concluded that there is a high tendency to increase maize output due to the usage of more quality varieties. Gamma measures the level of inefficiency in the variance parameter of the stochastic translog model and ranges between 0 and 1. From the analysis, the estimated gamma parameter was 0.78. This indicates that 78% of the variations in tomato output are due to inefficiencies of tomato farmers in the study area.

The variation in output was as a result of a small percentage change in the error component (random), implying that a greater percentage was due to inefficiency variables incorporated in the study. The random component of the error term does not make significant contribution in this analysis (Coelli, 1995). Thus 22% of the error variation was due to random factors which are not under the influence of the farmer such as weather. The estimated σ^2 was 0.09 which is significantly different from zero and implies a good fit and the correctness of the specified distributional assumption for the composite error term.

From the table above, the summation of the input variables referred to as the function coefficient, or returns to scale was estimated to be 1.35, which implies that farmers in the

Ashanti region are exhibiting increasing returns to scale because its magnitude is greater than 1. A result of 1.35 implies that if all input variables were to increase by 1%, tomato output will also increase by more than 1% (1.35) in the region. This result suggests that farmers are operating in the stage one of the production surface which is an irrational stage because the output can still be increased by the addition of more of the inputs. A study conducted by Donkoh *et al.* (2013), on the “Technical Efficiency of Tomato Farmers in Northern Ghana” also estimated a returns to scale of 1.57.

4.6 Technical Estimates

The technical efficiency of the study ranges from 35%-97% and the average technical efficiency recorded was 86%. Mari & Lohano (2007) documented 74% as the mean technical efficiency in his study. Another article published by Adenuga *et al.* (2013) also recorded a mean technical efficiency of 79%. Bakhsh & Ahmed (2006) also recorded that potato farmers in Pakistan are 84% technically efficient. This implies that tomato farmers in the region are 14% below the frontier output at the given technology. Hence, in the short run there is a 14% possibility of increasing the output of tomato in the region by adopting the practices being employed by best farms.

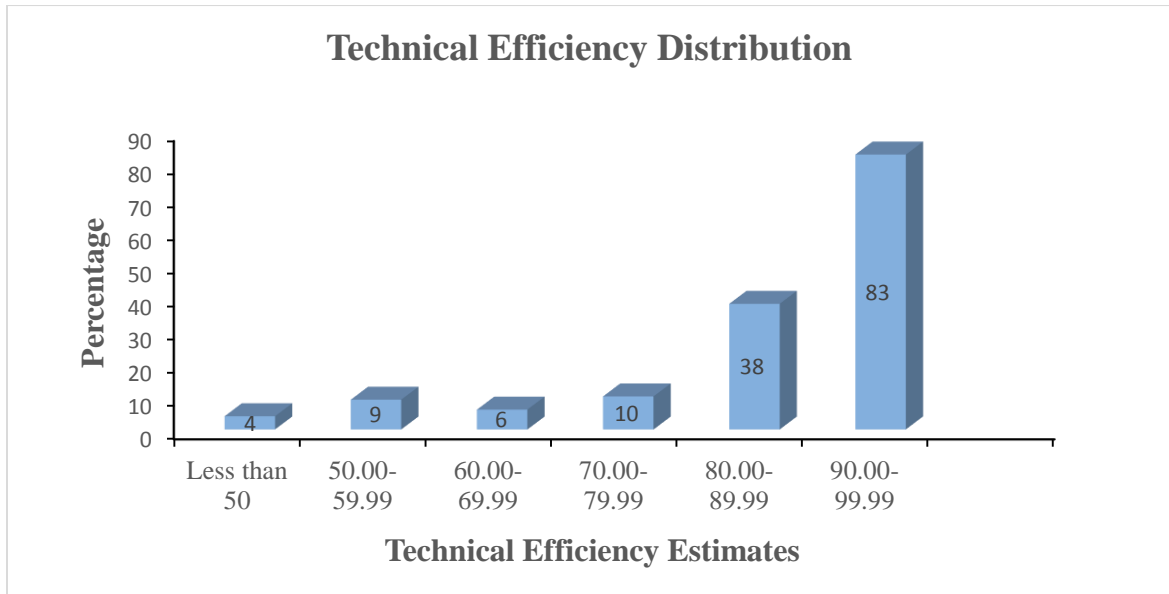
The technical efficiency distribution of tomato farmers is given in the table 4.7. These estimates were analysed by categorizing them in ranges showing the minimum, maximum, frequencies and percentages of each range.

Table 4.7: Technical Efficiency Distribution of Tomato Farmers

T. E (%)	Minimum	Maximum	Frequency	Percentage
Less than 50	35.30	46.52	4	2.7
50.00-59.99	51.90	59.01	9	6.0
60.00-69.99	66.06	69.69	6	4.0
70.00-79.99	70.11	79.82	10	6.7
80.00-89.99	80.11	89.98	38	25.3
90.00-99.99	90.03	97.45	83	55.3
Total			150	100
Mean Technical Efficiency = 85.95%				

Source: Authors analysis from field data (2015).

The least and highest technical efficiency recorded amongst the respondents was 35.30% and 97.45% respectively. The highest range (90.00-99.99), recorded the highest frequency and percentage of 83 respondents and 55.3 respectively. The range of 0 to 50 recorded the least number of respondents of 4 and a percentage of 2.7. The majority of farmers are within the ranges of 90.00-99.99. This can be further illustrated in the figure 4.1 below. This distribution is said to be left skewed (negatively skewed) implying majority of the respondents recorded efficiencies towards the maximum.

Figure 4.1 Distribution of technical efficiency using the SFP model

Source: Field Survey (2015)

4.7 Technical Inefficiency Estimates

Table 4.8 below shows the coefficients and significant levels of the determinants of inefficiencies among tomato farmers in the Ashanti region. The socio-economic variables age, household size, education, extension visits, experience, farm distance, credit and FBO were incorporated into the stochastic frontier model for analysis.

A total of eight (8) inefficiency variables were incorporated in the model out of which four (4) were significant and had a negative relationship with technical inefficiency. These variables were household size, extension visits, experience and credit. Education and farm distance were significant but had a positive relationship with technical inefficiency in this study. This implies that, these variables do not influence technical efficiency in the study area. Age and Farmer Based Organizations (FBO) were statistically not significant which

means they do not contribute to efficiency in this study hence do not require further discussion.

Table 4.8: Estimates of Technical Inefficiency Model

Variables	Parameters	Coefficients	Standard Error	T-statistics
Constant	δ_0	0.180	0.392	0.460
Age	δ_1	-0.004	0.009	-0.440
Household size	δ_2	-0.087***	0.033	-2.666
Education	δ_3	0.045***	0.019	2.364
Extension visits	δ_4	-0.145***	0.047	-3.076
Experience	δ_5	-0.460***	0.012	-3.698
Farm distance	δ_6	0.102***	0.040	2.544
Credit	δ_7	-0.483**	0.232	-2.084
FBO	δ_8	0.187	0.216	0.863

Source: Field Survey (2015)

Education and farm distance surprisingly showed a positive relationship with technical inefficiency which implies an increase in any of these will decrease efficiency. Though education showed a weaker relationship. Household size indicated a negative relationship with technical inefficiency hence, the larger the house hold size, the more efficient that farmers can be. This is because the larger the household size the greater will be the release of labour for the various farming activities employed on the farm. Tomato cultivation entails quite a number of activities right from the nursery stage to final harvesting. More hands employed will facilitate proper division of labour for these activities, hence efficiency will be increased.

Al-Hassan (2008), also had household size being positively related to technical efficiency which is very significant because a larger family size provide farmers with a variety of labour (children, youth, men and women), which results to division of labour and specialization. Frequent extension visits also enhances technical efficiency in the region. With the help of extension agents dispatched into various districts by the Ministry of Food and Agriculture, (MoFA), farmers are able to acquire information on good agricultural practices such as crop husbandry that will inevitably contribute significantly in increasing their efficiency of production.

They as well play advisory roles to farmers and engage them in trainings that will equip them with the requisite knowledge on the best input to employ that will enhance their productivity. Extension visit was significant at 1% and a negative coefficient implies that the more visits a farmer gets, the more he is able to acquire substantial knowledge on management and best farming practices, hence he is able to increase efficiency. This confirms Bakhsh & Ahmed (2006) who also found extension to be positively related to efficiency and concluded that there is the need to strengthen the role of the extension department in the crop sector in order to make it more effective.

Farmers experience incorporated in the model also showed a negative relationship with technical inefficiency as well. The more experienced a farmer is as a result of a greater number of years acquired in tomato production or due to certain practices he may have adopted which worked or didn't, he is able to combine all these which results to an increase

in output and technical efficiency. This result is consistent with that of Yiadom-Boakye *et al.* (2013) who also found experience to be statistically significant and positively related to technical efficiency. More experience also equips farmers with relatively greater management of resources abilities which tend to increase technical efficiency in most cases.

Lastly, credit was also found to show a negative relationship with inefficiency. It was statistically significant at 5%. This implies that farmers who get access to credit rely on them to adopt best farming practices more than those who do not. This will go a long way to increase their productivity and efficiency. There are basically two sources of loans, the institutional and the non-institutional. The non-institutional comprise the moneylenders, friends/family, cooperatives, consumers and so on. The institutional are the Commercial Banks, Agricultural Development Banks, National Investment Banks and so on. Farmers with access to credit will also enable them acquire the right quality and quantity of seed for production. Murthy *et al.* (2009) found credit to influence technical efficiency negatively which was contrary to the aprior expectation which raises the concerns as to whether small scale tomato farmers were appropriately using these funds for the purpose they were meant for. But the authors such as Nyagaka *et al.* (2010) and Obwona (2006) found credit to influence technical efficiency positively.

Education was found to be statistically significant but positively related to technical inefficiency. This implies that the more years attained in schooling the lesser ones

efficiency which was contrary to the apriori expectation. It is highly understandable when education is negatively related to technical inefficiency because it equips farmers with the requisite knowledge in the use of modern technology, farm organizations in terms of record keeping and the optimal utilization of various farm inputs which enhances efficiency. Though education is an important factor influencing efficiency, Kalirajan & Shand (1985) argues that farmers' education is not necessarily positively related to their yield achievement and efficiency. Illiterate farmers, can as well understand a modern production technology as their educated counterparts, provided they are trained and the technology is communicated properly.

Farmer Based Organization (FBO), as one of the inefficiency variables showed a weak relationship with technical inefficiency. It was statistically insignificant. This implies that ones participation in FBO activities in the study area has no effect on his technical efficiency level. This could be as a result of lack of participation in the group activities by farmers.

4.8 The use of Kendalls' Coefficient of Concordance to Analyse the Constraints in Tomato Production

A total of eight constraints identified from studies by Anang *et al.* (2013) and Adu Dapaah and Oppong-Konadu, (2002) which as a result of pretesting the questionnaire, farmers confirmed those were the challenges they face with regards to tomatoes in the Ashanti region. Farmers were presented with these constraints and made to rank from the most

pressing constraint to the least. The Kendall's Coefficient estimated was 0.744, which implies a strong agreement among rankings of the various constraints by tomato farmers. This also shows that farmers in these three different regions encounter similar challenges, hence policy recommendations can be made towards the most pressing constraint in the region to help improve production.

Table 4.9 Ranked Constraints of Tomato Farmers in the Ashanti Region

Constraints	Mean Ranks	Ranks
Inaccessibility of Credit Facilities	1.79	1
High Cost of Production	2.49	2
Diseases and Pest Attacks	3.28	3
Lack of Standard Prices per crate	3.89	4
Lack of ready market	4.15	5
Unstandardized crates bought by farmers	5.81	6
Inaccessibility of improved tomato seeds	6.96	7
Land Tenure and Land Acquisition problems	7.66	8
N	150	
Kendall's W^a	.744	
Chi-Square	781.394	
df	7	
Asymp. Sig.	.000	

Source: Field Survey (2015).

The results of the ranking is given in table 4.9 above with inaccessibility of credit facilities having the least mean score which signifies that it is the most pressing constraint farmers encountered in the region. This phenomenon is due to the risky nature of agriculture and specifically with tomato production. Banks find it difficult giving out loans to smallscale

farmers in most cases. A few respondents from the Offinso Municipal had access to credits through the help of their extension agents. On the other hand, land tenure and acquisition problems recorded the highest mean score which implies that it is the least constraint faced by farmers.

High cost of production which is a well-known constraint especially in tomato production was ranked as the second most pressing constraint in the region. Inputs such as seed, agrochemicals, cost of hired labour, cost of tools and cost of irrigation if applicable all goes into the cost of production. This is confirmed by Aidoo *et al.* (2014) who also found high cost of production to be a challenge and ranked as the second most pressing constraint in their study. Diseases and Pest Attacks, Lack of Standard Prices per crate and Lack of ready market constitute the third, fourth and fifth constraints respectively. They each recorded mean scores of 3.28, 3.89 and 4.15 respectively. The white fly has been a major constraint which has the potential of causing up to 100% economic losses in tomato production when not controlled.

Subsequent constraints of Unstandardized crates bought by farmers, Inaccessibility of improved tomato seeds, Land Tenure and Land Acquisition problems also ranked 6th, 7th and 8th with mean ranks of 5.81, 6.96, and 7.66 respectively. Unstandardized crates has been as issue of concern since market queens and sellers tend to provides crates greater than the normal 52kg used. The inaccessibility of improved seeds also poses a challenge to an extent since they have been found to give much yield but for this study, this particular

challenge was not very severe in the region, hence ranked as the 7th most pressing challenge. To most respondents land tenure and land acquisition was the least of their constraints. This goes a long way to confirm the findings on a study conducted by Anang *et al.* (2013).

The Kendall's Coefficient of Concordance estimated to be 0.74, shows that, there is a 74% agreement among the rankings of the constraints by farmers in the region. This index (W) was significant at .000 with a degree of freedom of 7. Finally, in testing for the hypothesis, values of both the chi-square calculated and estimated from the chi-square table was used. The chi-square calculated by the model is 781.394 and the critical read from the chi-square table at degrees of freedom (df) 7 under a confidence level of 1% is 18.48. Hence the decision rule which states that when the chi-square calculated is greater than the chi-square critical one will reject the null hypothesis holds for the study.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary and major findings, conclusions and policy recommendations of the study.

5.2 Summary and Major Findings

This thesis examined the technical efficiency of 150 tomato farmers in the Offinso South, Offinso North and Asante Akim North districts in the Ashanti region of Ghana. The study aimed at analyzing the productivity levels of tomato farmers, determining the level of technical efficiency and also identifying the determinants of technical inefficiency of tomato farmers in the Ashanti region of Ghana. The Stochastic Frontier Production Model was adopted for the study using the Maximum Likelihood Estimates (MLE) from the FRONTIER 4.1 Software. The study as well tested for the functional forms, the presence of inefficiencies and also the joint effect of exogenous variables on technical efficiency.

Finally, the constraints faced by tomato farmers in the Ashanti region were identified and ranked using the Kendall's Coefficient of Concordance. Major findings indicated that all the input variables incorporated in the model, improved seed, fertilizer, pesticide, labour and othercosts showed a positive relationship with output. Their individual elasticities recorded were 0.32%, 0.39%, 0.50%, 0.01% and 0.13%. Pesticides use contributed the

highest to output. Labour use was insignificant in this study. The first hypothesis which states that Cobb-Douglas production best fits the data was rejected in favour of the translog production model. The second hypothesis indicated the presence of inefficiencies in the model. Also, the third hypothesis showed that the inefficiency effects are stochastic. The model used also showed that technical inefficiency effects has a truncated normal distribution and thus influence the level of inefficiency in tomato production. Finally, the fifth hypothesis tested showed that exogenous variables jointly influence the level of technical efficiency.

The production technology exhibited in the study area was an increasing returns to scale of 1.35. Technical efficiency estimates recorded were in the range of 35% to 97% with a mean efficiency of 86%. Exogenous variables contribute to technical efficiency in tomato production as well. Those incorporated in the model were age, household size, education, extension, experience, farm distance, credit and Farmer Based Organizations (FBO). Household size, extension, experience and credit were found to be significant and positively affected technical efficiency. Age and FBO participation was not statistically significant in the study area. Inaccessibility of credit by farmers was ranked as the most pressing constraint by tomato farmers and the least constraint encountered was land tenure and land acquisition problems. The Kendall's Coefficient of Concordance was also estimated to be 0.74.

5.3 Conclusion and Implications of Findings

This study found improved seed use, pesticide use, fertilizer application and other costs to be significant in the study “Technical Efficiency of Tomato Farmers in the Ashanti Region of Ghana”. This implies that output responds more with improvements in these variables. Overall, pesticides use contributed the highest to output. The functional form, translog stochastic frontier production specification was found to best fit the data for analysis.

The indication of increasing returns to scale in the study area suggests that farmers can still increase their output and productivity by improving on their inputs of production. It can also be concluded that farmers in the region are operating on smaller scales, hence there is the need to expand their farm sizes in order to increase production. The mean technical efficiency estimate of 86%, implies that, in the short run there is a 14% possibility of farmers in the study area of increasing their output by adopting practices being employed by the best farms.

The technical efficiency was jointly influenced by the exogenous variable incorporated in the model. Household size, extension visits, experience and access to credit were found to be statistically significant and positively influences technical efficiency whilst age and farm distance negatively affected technical efficiency. Finally, the major constraint faced by tomato farmers in the region is the lack of access to credit. Some reasons for lack of interest by banks on administering credits are the high cost associated with the distribution of small credits over a wide area, coupled with the comparatively high level of default on

the part of recipients. High cost of inputs of production was ranked as the second most pressing constraint. The least constraint ranked was land tenure and land acquisition problems.

5.4 Policy Recommendations

These results have led to the formulation of these policy recommendations to help boost productivity as well as finding ways of enhancing technical efficiency in tomato production in the Ashanti region where the study was conducted. The conclusion above indicate opportunities to raise the productivities of the individual inputs in the production process. The productivities of inputs that were statistically significant and had a positive relationship should be keenly looked at by policy makers in the tomato industry since they contribute to an increase in output.

Farmers should also be trained on the recommended agrochemicals and the efficient ways they can be applied to obtain maximum output. Also, training especially on the pesticides to apply at every stage of growth should be ensured by government since diseases and pest attacks are inevitable challenges in tomato production. Farmers should also be encouraged to apply adequate quantities in order to prevent the situation of chemical residues being left on the vegetable which becomes harmful to humans when consumed. In addition, extension agents should also train farmers on appropriate equipment and expertise to ensure proper rates are applied and that human health and safety are protected.

Tomato farmers in the study area should be encouraged to expand their scale of production by increasing inputs such as their farm sizes in order to benefit from economies of scale. Conscious efforts must be made on the part of farmers to reduce their technical inefficiencies so as to improve productivity. Technical inefficiency levels amongst farmers can be reduced when government ensures that the ratio of extension agent to farmer in the Ashanti region is increased, thereby facilitating frequent contact with farmers and acquiring training on best practices.

The Ministry of Food and Agriculture (MoFA) responsible for the allocation of extension agents in various regions should intensify its extension services programme in training and deploying qualified extension agents. There is therefore the need to train more extension agents and motivate existing extension agents to work more effectively.

Technical efficiency can also be improved in the region by creating and encouraging associations which will enable the less experienced farmers to interact with the more experienced ones by sharing ideas on best practices to adopt as well as educating them on technologies that will help boost their efficiency levels.

Government should show keen interest in agricultural credit schemes and formulate policies that will enable farmers have easy access to credit in the region. Also, farmers should be willing to repay credits when payments are due.

Policies on input subsidizes should be formulated by government to reduce their otherwise high cost inputs

5.5 Suggestion for Future Study

A comprehensive study on assessing the technical efficiency of all tomato producing regions in the country could be considered for further studies whilst adopting the metafrontier technique to compare the different technologies used across the different tomato producing regions of the country could also be looked at.

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APPENDICES

**UNIVERSITY OF GHANA
DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS**

**TECHNICAL EFFICIENCY OF TOMATO FARMERS IN THE ASHANTI REGION OF GHANA
QUESTIONNAIRE**

This questionnaire has been purposely designed to address the above topic in partial fulfillment for the award of a Master of philosophy in Agribusiness at the University of Ghana, Legon. Any information provided by respondents will be purposely used for data analysis in respect of the above mentioned topic.

Identification Code

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Introduction

Name of Enumerator..... District:

Town: Date:/...../2015

Name of farmer:

Name of farm:

Telephone

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 Number:

SECTION A: Socio-Economic Characteristics of Tomato Farmers

Please tick the appropriate response

A1. Gender: 1 = Male [] 0 = Female []

A2. Age of farmer:

A3. Marital status of farmer: 0 = Single [] 1 = Married [] 2 = Separated [] 3 = Divorced

- A4. Religion: 1 = Christian [] 2 = Muslim [] 3 = Traditionalist [] 4 = Others (specify)
- A5. Indicate the number of years of education.....
- A6. Please indicate your household sizeperson(s)

Number of adults >18yrs		Number of adults <18yrs	
a. Males	b. Females	c. Males	d. Females

SECTION B: Basic information on tomato farming

- B7. How many years have you been in tomatoes production..... years.
- B8. Is tomato farming your major occupation? 1=Yes [] 0= No []
- i. If no, please indicate your main occupation. 1= Other Farming [] 2= Trading [] 3= Salary Worker [] 4= Voluntary Worker [] 5= Artisan [] 6. Others (specify).....
- B9. Do you belong to any farm based group/association? 1= Yes [] 0= No []
- B10. Please indicate the most important contribution received from the group since you joined.
1= Book-keeping Training [] 2= Agronomic Practices [] 3= Credit Management [] 4= Others (specify).....
- B11. Please indicate the seasons in which you usually cultivate your tomatoes. 1= Only in the main season [] 2= Only in the minor season [] 3= In both seasons []
- B12. Did you ever have contact with any extension agent in the 2014 production year? 1 =Yes [] 0= No []
- B13. If yes, how many times in: a. Major season b. Minor season.....
- B14. What was the primary information rendered by extension agents in the 2014 production year? 1= Production Information [] 2= Marketing Information [] 3= Handling and Storage Information [] 4= Others (specify)
- B15. Have you received any formal training since you began tomatoes farming? 1= Yes [] 2= No []

- B16. If yes, when? 1= current year [] 2= a year ago [] 3= two years ago [] 4= Others (specify)
- B17. Where was the training conducted? 1= On the farm [] 2= Off farm [] 3= Others (Specify).....
- B18. What was the training on? 1= Postharvest technology [] 2= Agronomic practices [] 3= Credit application processes [] 4= Others (specify).....
- B19. Did you have access to credit in your last production season? 1= Yes [] 0= No []
- B20. If yes, please indicate the major source. 1= Bank [] 2= Family/Friends [] 3= Informal money lenders [] 4= MoFA [] 5= Others (specify).....
- a. How much did you receive from the major source? a. GHS..... b. What was the interest rate charged..... per annum
- B21. Please indicate the kind of implements employed on your farm?
1= Only simple farm tools [] 2= Plough [] 3=Ridge [] 4= Only 1 and 2 [] 5= Only 1 and 3 [] 6= All []
- B22. Did you use the services of the agricultural mechanization centre for 2014 production year? 1= Yes [] 2= No []
- B23. Does the farm rely on any source of irrigation for production? 1= Yes [] 2= No []
- B24. If yes, please indicate the source. 1= Well [] 2= Dam [] 3= Stream [] 4= River []

SECTION C: Land Systems and Crop Production

- C25. How many acres of land did you cultivate for tomatoes during the 2014 production year.
1= Major season..... 2= Minor season.....
- C26. How did you acquire your land for farming?
1= Purchase [] 2= Rented/Leased [] 3= Family land [] 4= Borrowed []
- C27. How much does an acre of land cost if it was rented? GHS (per acre).....

C28. Please indicate the type of seeds used in planting during 2014 crop year

1= Improved Seeds [] 2= Locally developed improved [] 3= Recycled locally developed improved [] 4=Both 3 and 4 []
5= Others (specify)

C29. Where did you purchase your seeds during the last production season?

1=Local seed sellers [] 2= Certified seed dealers [] 3= Own stored seeds [] 4= Others (specify).....

C30. Please indicate the variety of tomatoes cultivated in the last production season?

1= Pecto mesh [] 2= Pecto-fake [] 3= “Akoma” [] 4= “Rasta” [] 5= Both 1 and 2 [] 6= Others (specify).....

C31. Please indicate the quantity of seeds nursed before transplanting?

a. Main season..... b. Minor season.....

C32. How much does the seeds used in production cost per kg?

a. Main season..... b. Minor season

C33. Please indicate the cropping system employed during the 2014 production year.

1= Mono cropping [] 2= Mixed cropping [] 3= Others (specify).....

C34. If mixed cropping, please indicate the number of acres allocated to tomatoes production.....

C35. Do you use organic fertilizer on your farm? 1= Yes [] 0= No []

C36. If yes, please indicate the a. Quantity used (indicating the unit)..... b. Total cost per year.....

C37. Did you apply inorganic fertilizer during the 2014 production year? 1= Yes [] 0= No []

C38. Please indicate the quantity of inorganic fertilizer used during the 2014 production year.

C39. Did you use any agro-chemical during the 2014 production year? 1= Yes [] 2= No []

C40. If yes, please indicate the types, quantity and the total cost involved.

Inorganic Fertilizer	Unit	Quantity used		Price per unit(GHS)		Total cost(GHS)	
		Major season	Minor season	Major season	Minor season	Major season	Minor season
NPK	50kg						
“Winner”	50kg						
Urea	50kg						
Sulphate of Ammonia	50kg						
Others:							

Agro-chemical used	Unit	Quantity used		Price per unit(GHS)		Total cost(GHS)	
		Major season	Minor season	Major season	Minor season	Major season	Minor season
Field Fungicides:							
i. Dietin	1000ml						
ii. Sampreforce	1000ml						
iii. Combat	1000ml						
iv. Champion							
Nematicides	1000ml						
Weedicides	1000ml						
Others:							

C41. Other cost

Item	Total cost per year (GHS)
Transportation	
Fuel	
Hired items	
Others(Specify)	

Item	Quantity	Year of purchase	Cost price (GHS)	Lifespan (years)
Hoe				
Cutlass				
Knapsack sprayer				
Others(Specify)				
i.				
ii.				

SECTION D: Labour requirements

D42. What is the major source of labour employed on your farm?

1= Family labour [] 2= Friends labour [] 3= Hired labour [] 4= Others (specify).....

D43. How many days do you work on your farm per week days

D44. How many hours in a day do you spend working on your farm..... hours

i. Labour types and requirements for 2014 production year. (Major season)

Role of Worker (Production)	Number of workers		Total cost per day (GHS)	Total cost per month (GHS)	Total cost per year (GHS)
	Males	Females			
Hired labour: i. Nursery preparation					
ii. Weeding					
iii. Removal of stumps and clearing					
iv. Raising of beds (Building ridges)					
v. Earthening-up					
vi. Transplanting					
Others(specify)					
Family labour					
Children(<18 years)					
Role of Worker (Harvesting)					
Hired labour					
Family labour					
Children(<18 years)					

ii. Labour types and requirements for 2014 production year. (Minor season)

Role of Worker (Production)	Number of workers		Total cost per day (GHS)	Total cost per month (GHS)	Total cost per year (GHS)
	Males	Females			
Hired labour: i. Nursery preparation					
ii. Weeding					
iii. Removal of stumps and clearing					
iv. Raising of beds (Building ridges)					
v. Earthening-up					
vi. Transplanting					
Others(specify)					
Family labour					
Children(<18 years)					
Role of Worker (Harvesting)					
Hired labour					
Family labour					
Children(<18 years)					

SECTION E: Output Measurement

Quantity Harvested			Quantity Sold			Self-Consumption			Gift			Rejects		
Qty	Price per box	Total Amt	Qty	Price per box	Total Amt	Qty	Price per box	Total Amt	Qty	Price per box	Total amt	Qty	Price per box	Total amt

E45. How many times did you harvest tomatoes during the 2014 production year?

- a. Major season times
- b. Minor season times

E46. Please provide information on the output for the major season in the table below.

E47. Please provide information on the output for the major season in the table below.

Quantity Harvested			Quantity Sold			Self-Consumption			Gift			Rejects		
Qty	Price per box	Total Amt	Qty	Price per box	Total Amt	Qty	Price per box	Total Amt	Qty	Price per box	Total amt	Qty	Price per box	Total amt

E48. Do you have access to ready market? 1= Yes [] 0= No []

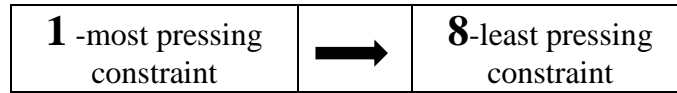
E49. If yes, state the distance from your farm to the market centre..... kilometers.

E50. Please state the distance from your farm to your house..... kilometers

SECTION F: Farm Constraints.

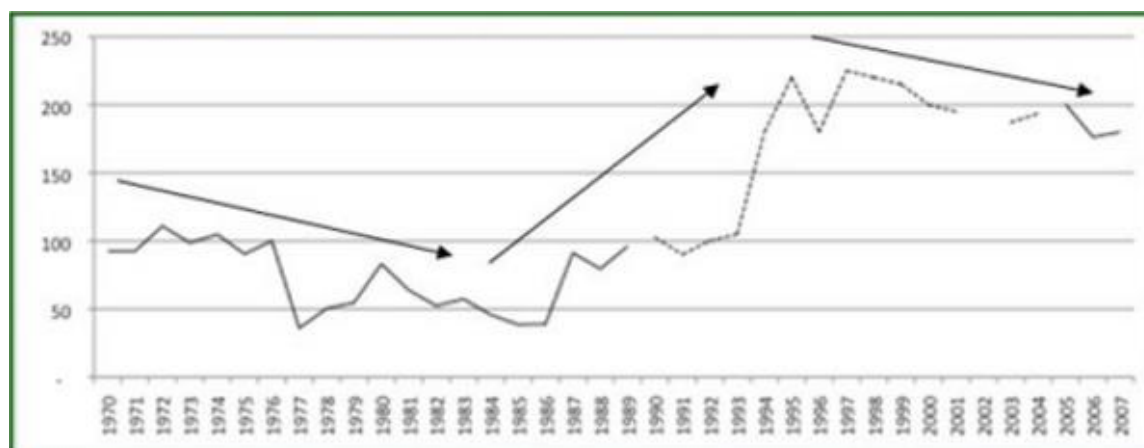
F51. Kindly use the scale below to rank these constraints inhibiting tomato farming in your district

Scale:



Constraints	Ranks (1-8)
Inaccessibility of improved tomato seeds	
Lack of a standard price of tomatoes per box	
High cost of Production	
Inadequate storage facilities and post-harvest losses	
Land tenure and land acquisition problems	
Inaccessibility of credit facilities from banks	
Lack of a ready market for produce harvested	
Unstandardized crates brought by farmers	

APPENDIX 1: Production Trends of Tomatoes in Ghana ('000 tons per year)



Source: (FAO-SRID, 2010)

APPENDIX 2: Production Trends of Some of the World's leading Tomato Producers

Rank	Area	Production (Int \$1000)	Production (MT)
1	China, mainland	18,478,200	50,000,000
2	India	6,467,370	17,500,000
3	United States of America	4,880,813	13,206,950
4	Turkey	3,565,330	11,350,000
5	Egypt	3,187,570	8,625,219
6	Iran	2,217,384	6,000,000
7	Italy	1,896,593	5,131,977
8	Brazil	1,431,685	3,873,985
9	Spain	1,425,408	4,007,000
10	Mexico	1,268,922	3,433,567
11	Uzbekistan	979,344	2,650,000
12	Russian Federation	907,686	2,456,100
13	Ukraine	840,425	2,274,100
14	Nigeria	576,519	1,560,000
15	Portugal	514,691	1,392,700
16	Morocco	450,524	1,219,071
17	Iraq	406,520	1,100,000
18	Tunisia	406,520	1,100,000
19	Greece	362,024	979,600
20	Indonesia	328,008	887,556

Source: (FAOSTAT, 2012)

APPENDIX 3: Current Production Figures of Tomato in Ghana

Year	Production quantity(tons)	Year	Production quantity(tons)
2013	340.218	1995	213.000
2012	321.000	1994	181.500
2011	320.500	1993	107.000
2010	318.520	1992	100.200
2009	317.520	1991	91.700
2008	284.000	1990	86.400
2007	180.000	1989	96.000
2006	176.264	1988	79.400
2005	200.300	1987	91.100
2004	223.516	1986	38.900
2003	202.136	1985	38.400
2002	205.178	1984	45.600
2001	175.076	1983	57.200
2000	200.000	1982	52.300
1999	215.000	1981	63.800
1998	216.200	1980	83.700
1997	219.800		
1996	182.000		

Source: (FAOSTAT, 2013)