UNIVERSITY OF CAPE COAST

ECONOMIC EFFICIENCY OF MANGO PRODUCTION IN THE YILO KROBO MUNICIPALITY IN THE EASTERN REGION OF GHANA

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BY

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Thesis submitted to the Department of Agricultural Economics and Extension, School of Agriculture, University of Cape Coast, in partial fulfilment of the requirements for award of Master of Philosophy Degree in Agricultural Economics

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DECLARATION

Candidate's Declaration

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

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

Name: Emmanuel Inkoom

Supervisors' Declaration

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

Principle Supervisor's Signature………………… Date:………………..

Name: Prof. John Andoh Micah

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ABSTRACT

Mango has been the major cash crop grown by farmers in the Yilo Krobo Municipality. The productivity of this crop has been persistently low despite various private and public sector interventions. Studies have suggested that one key factor of productivity growth is efficiency in resource and technology use. This study estimated the economic efficiency of mango production to determine the scope for additional increase in mango production. A multistage sampling technique was used to randomly select and collect primary data from sixty two registered mango farmers. Descriptive statistics were used to describe the state of mango production. Stochastic production frontier analysis was used to estimate the economic efficiencies and their determinants among mango farmers. Kendall coefficient of concordance was used to measure the degree of agreement among farmers concerning the constraints associated with mango production. The results of the analysis indicated that mango farmers were economically inefficient, and that the presence of technical and allocative inefficiencies had effects on mango production. In addition, the results revealed that farm-specific and farmer-specific characteristics were significant predictors of the economic inefficiency levels exhibited by mango farmers. The Kendall W statistic also revealed a strong degree of agreement among mango farmers concerning the constraints associated with mango production. Based on these findings, policy makers should focus on promoting efficient use of existing technology and resources in mango production. For instance, the Ministry of Food and Agriculture should develop an integrated and holistic extension strategy to provide training for famers on resource use efficiency, information, and access to inputs and services.

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DEDICATION

To my parents, Mr and Mrs Inkoom and all my friends who contributed to the success of this work either in cash or kind.

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LIST OF ACRONYMS

ADRA	Adventists Development Relief Agency
AE	Allocative Efficiency
CE	Cost Efficiency
CRS	Constant Return to Scale
DAMFA	Dagme-West Mango Farmers Association
DEA	Data Envelopment Analysis
ECOWAS	Economic Community of West African State
EE	Economic Efficiency
EU	European Union
EUSMG	European Union Strategic Marketing Guide
FAO	Food and Agricultural Organization
GEPC	Ghana Export Promotion Council

Gh¢	Ghana Cedi
IPM	Integrated Pest Management
MoFA	Ministry of Food and Agriculture
MIDA	Millennium Development Authority
MT	Metric Tonnes
NGO	Non Governmental Organizations
OLS	Ordinary Least Square
PDF	Parametric Distance Function
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
VRS	Variable Return To Scale
YKMFA	Yilo Krobo Mango Farmers Association

CHAPTER ONE

INTRODUCTION

Background to the study

It has been noted that a favourable and vibrant agricultural sector in Ghana is a key to economic growth and development as it employs the majority of the poor (Adu-Gyamerah, 2008). Adventists Development Relief Agency [ADRA] (2006) identified commercial mango production as one key area to achieving this goal. According to the Ministry of Food and Agricultural [MoFA] (2013), Ghana has an undoubtedly immeasurable comparative advantage for the cultivation of mango, especially grafted mango. This rest in the fact that most of the lands of the costal savannah, the whole three northern regions, the transitional zone of Ashanti and Brong Ahafo Region, the Eastern Region and the northern part of Volta Region in the country are suitable for mango production that meet international quality specification. In the Eastern Region of Ghana, cultivation of improved exportable mango is a major economic activity and it employs about 5,000 people, making the area the most prominent in mango production (MoFA, 2013). In addition, Ghana is one of the few countries in the world with two mango production seasons, major and minor season. Therefore, with the right practices, both seasons can yield an economic output level (Asamoah, 2006).

In addition, recent studies have shown that, Ghana's comparative advantage in the production of fresh mango especially the grafted type has the potential to greatly turn around and transform the economy if attention is given to the commercial cultivation of the fruit. For instance, ADRA (2006) reported that mango production is one area within the horticultural sector, which, if well developed and provided with the necessary logistics and support, can easily become a major foreign exchange earner after cocoa. Also, Asante-Mensah (2004) and ADRA (2006) noted that mango production and processing can earn more income for Ghana than cocoa in the short to medium term if serious attention is paid to the sector. For example if an acre of cocoa earns net revenue of Gh¢ 900 per ton, the same acre of land of exotic mango can earn over Gh¢ 2,000 per ton.

The Yilo Krobo Municipality in the Eastern Region of Ghana has a comparative advantage in the large-scale cultivation and production of exotic mango varieties (MOFA, 2013). It is the only mango growing area credited with the bimodal production system. In view of this promising economic prospect in mango production, there has been some level of public and private collaboration in positioning the country to obtain some economic benefit from this potential resource. For instance, private organizations like ADRA and USAID in collaboration with MoFA in the past decades have assisted local mango farmers in the Yilo Krobo Municipality to establish commercial mango farms (MoFA, 2013). Mango farmers were provided with both technical and logistics support through the initiative. It has however been observed that despite various intervention by both private and public institutions in providing farmers with modern technologies and innovations to help increase their output level, the expected output level of 12000kg/acre has not being realized and that productivity keep declining over the years (MoFA, 2013). Agricultural Economists argue that a successful economic development policy depends significantly on promoting productivity and output growth in the agricultural sector, particularly among small-scale producers. As such, many researchers and policymakers often focused their attention on the impact that the adoption of new technologies can have on increasing farm productivity and income (Schultz, 1964).

However, the notion that to achieve growth in output, there is always the need to introduce modern technologies and innovation to farmer, have being argued out by researchers. The argument is that productivity growth is not only achieved through the introduction of new technologies to farmers but by the efficiency with which these technologies are used (Wambui, 2005). Furthermore, Farrell (1957) noted that the measurement of economic efficiency is an important factor for productivity growth and that output growth is not only achieved through technical innovation but also through the efficiency with which such technologies are used. In addition, Bravo-Ureta and Pinheiro (1993) justified the concentration of productivity gains from a more efficient use of existing technology. This implies that the presence of shortfalls in efficiency indicate that output can be increase without the use of neither additional inputs nor the need for new technology. Thus, the identification of determinants of efficiency is also essential to both public and private policies designed to improve production performance. This justifies the important role of efficiency analysis in agricultural production in order to determine the scope for additional increase in production at a given technology and inputs set. In addition, the estimation of economic efficiency is very important as it indicates performance measure of any production units. Furthermore, the measurement of determinants of inefficiency enhances the identification of the source of efficiency differentials. The elimination of these inefficiencies helps improve performance in production.

Coelli, Rao, O'Donell and Battese (2005) optioned that the reduction of inefficiencies in production is usually within the control of the farm firm. The authors argued that farm firms could increase their productivity or output growth even when there is no technical change by making a more efficient use of it inputs and by operating closer to the technology frontier. To do this the farm firm needs to choose a technology that can produce at minimum cost. Hence, efficient use of technology at a given input combinations is a necessary requirement for productivity increase in mango production. This study therefore sought to examine the current level of economic efficiency in mango production in the Yilo Krobo Municipality in the East Region of Ghana, a major stakeholder in mango production in the Country.

Statement of the Problem

The mango industry over the years has received a lot of attention due to the increasing economic potentials and prospects that it presents (ADRA, 2006). However, given the economic prospect of mango production, Ghana's mango industry is still in an infant stage and that productivity is still low (Abu, 2010). Mango production over the past decades has become a major tree crop plantation in the Yilo Krobo Municipality. To boost up productivity in the production of mango, MoFA built up the capacity of Mango farmers in collaboration with institutions like ADRA and MIDA in order to help increase their farm productivity (MoFA, 2012). However, despite the use of new technologies and innovations, and as well as interventions from both public and private institutions, empirical records shows a continuous decline in mango yield (MoFA, 2012). In addition, inefficiency in production has been identified as a major factor to the low productivity that has characterized the mango industry in the municipality (MoFA, 2013).

This phenomenon of a continuous decline in mango output level despite the various interventions in terms of new technologies and innovation raises important questions. What are the factors that limits farmers' output levels, what are the Technical efficiency, Allocative Efficiency and Economic efficiency levels in mango production, what factors contributes to productivity growth in mango production, what is the technological capacity in mango production, what are the determinants of economic efficiency in production, what is the economic potential and profitability levels in mango production.

Sentumbwe (2007) indicated that in dealing with decline in agricultural productivity, most Sub-Saharan African countries have adopted strategies to increase agricultural productivity or output growth through the use of new technologies and innovations like high yielding and disease resistant crops. However, according to Wambui (2005), output growth is not only achieved by new technological innovations but also through efficient use of these technologies. This thus implies that increase in productivity growth could also be achieved through optimal and efficient use of available technologies (Bravo-Ureta & Pinheiro, 1997). Kante, Igo and Frick (2009) indicated that inefficiency is assumed to be the cause of a declining and low agricultural output so long as differences exists in the type and use of technology among farmers. Thus, the empirical analysis of efficiency is important to determine the benefit that can be obtained by improving the performance in mango production with existing technology. Bravo-Ureta and Pinheriro (1993) suggested that productivity gains arising from a more efficient use of existing technology is necessary.

Akurugu (2011) on the evaluation of post-harvest handling and marketing of mango in Ghana revealed that poor harvesting, storage and packing of fruit were the major causes of post-harvest loses in mango production. He also reported that pest and disease situation was a major drain on farmers' productivity level and tends to limit farmers' access to export market. Avah, Dzamefe, Narh, and Eshun (2008) indicated that in order to reverse Ghana's falling trend in fruit quality, volume, timeliness, and sustainability in mango export, alternative approaches need to be adopted along the value chain.

Bakhsh, Hassan and Akhter (2006) suggested that investing in mango production would bring huge returns to the farmers on one hand and foreign exchange earnings to the country on the other hand when they estimated the profitability and cost in growing mango in Pakistan. Abu (2010) analyzed the quality criteria for mango export in Ghana and reported that a combination of several methods of assessing fruit maturity was necessary in order to establish appropriate quality criteria for export. He further reported that a single harvest maturity index figure failed always reflect the harvesting index at all given instance.

Despite the enormous research done on mongo production, empirical evidence indicates that not much has been done on estimation of economic efficiency in mango production in Ghana. This leaves questions on technical, allocative, and economic efficiency in mango production, productivity gain and growth from existing technology, determinant of efficiency in production and factors that constraints efficiency improvement unanswered. This has left a knowledge gap on the overall efficiency in mango production, a key factor to achieving productivity growth from existing technology and resources. In view of this, this study sought to estimate the economic efficiency in mango production. This study also sought to identify constraints that limit farmers' output level in the study area.

Objectives of the Study

General Objective:

The general objective of the study is to examine the economic efficiency of mango production in the Yilo Krobo Municipality in the Eastern Region of Ghana.

Specific Objectives:

The specific objectives of this study are:

1. to describe the state of mango production in the study area
2. to estimate the economic efficiency in mango production
3. to examine the determinants of economic efficiency in mango production
4. to identify the constraints to mango production in the study area

Research Questions

To achieve the set objectives of the study, the following questions were formulated to guide the study.

1. What is the state of mango production in the Yilo Krobo Municipality?
2. What is the economic efficiency level in mango production?
3. What are the determinants of economic efficiency in mango production?
4. What are the constraints to mango production in the study area?

Research Hypotheses

Based on the objectives the following research hypotheses were set and tested.

1. **H_0:** The Cobb-Douglas function is not an adequate representation of the data

   H_1: The Cobb-Douglas function is an adequate representation of the data
2. **H_0:** Inefficiency effect are non-stochastic, hence, mango farmers do not exhibit inefficiency in production

   H_1: Inefficiency effect are stochastic, hence, mango farmers does exhibit inefficiency in production
3. **H_0:** Farmer and farm-specific characteristics are significant predictors of inefficiency effects

   H_1: Farmer and farm-specific characteristics are not significant predictors of inefficiency effects

4. **H_0**: A Strong degree of agreement exists among mango farmers on the constraints associated with mango production.

   H_1: No Agreement exists among mango farmers on the constraints associated with mango production

Significance of the Study

This study aims at estimating technical, allocative, and economic efficiency in mango production in Ghana. The findings would therefore add to existing literature on technical and allocative efficiency as they relate to Ghana.

The efficiency scores that would be obtained will reveal the extent of technical, allocative, and economic inefficiencies among mango farmers. Thus, it will show the existing potential for farmers to improve output without changing the level of inputs.

In addition, the efficiency scores obtained would guide farm operators and managers in developing programs for performance improvement.

The results will also be important in extension work as it will highlight farm and farmer characteristics more likely to enhance productivity among the farmers.

This also will help policy makers as farm and farmer characteristics observed to influence efficiency among mango farmers will be used to formulate policy recommendations that will help policy makers to develop strategies that will help inefficient farmers.

NGOs, private and public agencies will also be able to focus their investments towards the promotion of those farm and farmer characteristics positively influencing productivity.

Finally, it is expected that increased productivity from efficient use of available technologies can contributed towards poverty alleviation in the study area, as farmers will be able to maximize productivity and profit from given inputs set.

Limitations of the Study

Although, the interest of this study is of much importance to the researcher and should have been expanded to cover the whole nation, this could however not be achieved due to certain constraints that were anticipated to be faced by the researcher. These constraints include time factor, finance, as well as non-cooperation by some respondents in the targeted population.

Delimitation of the Study

The study was limited to the estimation of economic (technical and allocative) efficiency and its determinants in mango production in the Yilo Krobo Municipality in the Eastern Region of Ghana. The analytical framework adopted for the estimation was the Stochastic Frontier Approach. The Frontier functions assume that all inputs have being taken into consideration. However, in this study as well as others, it is possible to raise questions about whether all inputs have being accounted for as farm firms that are inefficient may just use less of certain unmeasured inputs. The frontier framework also assumes that technologies are homogeneous across farms and mango varieties. In addition, the study was limited to registered mango farmers that grow the exotic mango varieties in the Yilo Krobo Municipality.

Organization of the study

The study is organized into five chapters. Chapter one covers the introduction to the study, which consists of the background of the study, statements of the problem, objectives of the study, research questions, hypothesis of the study, significance of the study, limitations, and delimitations of the study. Chapter two focuses on the review of related literature to the study. This includes theoretical and empirical review on mango production, efficiency, and constraints to production. The chapter also captures the conceptual framework for the study. Chapter three looks at the methodology, which includes research design, sample and sampling procedure, instrumentation, data collection and data analysis. The chapter also captures the econometric models used for the analysis and description of key variables used in the study. Chapter four presents the empirical results and discussion. Chapter five presents summary on key findings, conclusions, policy implications or recommendations and suggestion for future study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This chapter presents relevant literature about technical, allocative and economic efficiency of production. It presents a careful examination of a body of literature pointing toward the answers to the research questions of the study. In addition, it presents studies that are related to this study and the theory upon which it is based. It provides a constructive analysis of the methodologies and approaches of other researchers. It discusses what kind of work has been done on the topic and identifies any controversies within the field. The literature review presents a critical discussion and summary of statistical literature that is of importance to this study.

The Production of Mango

As noted by McGovern and LaWarre (2001), mangoes belong to family *Anacardiaceae*, genus *Mangifera* and species *Indica*, and are indigenous to India. Literature indicates that Mango is one of the most extensively exploited fruits for food, juice, flavour, fragrance, and colour. Mango is propagated either vegetatively or by seed. Seedlings are grown sometimes to produce new cultivars but mainly for use as rootstocks. Mango is successfully grown on a wide range of soils. The essential prerequisites for good development of the trees are deep soils (at least 3 m), appropriate rainfall (500-1000 mm), good drainage, suitable altitude (0-1200 m) and preferably a pH value of between 5.5 and 7.5. Among the various climatic factors, temperature, rainfall, and humidity have a greater bearing on mango production than irrigation and soils. In land preparation two main layout are often adopted; the square system and triangle system. Mango seedlings as a rule start to bear fruit within 4-7 years.

According to Griesbach (2003), productivity of farmers depends on a number of factors, including quantity of previous crop, weather and soil conditions, altitude, control of pests and diseases, fertilization and cultivar. The Food and Agricultural Organization [FOA] reported that, since 1971, the production of mango worldwide, increased by nearly 50% (FAO, 2003). Interestingly, much of this new production has occurred outside the traditional centers of mango cultures, in South and Central America, Africa and Australia. Mangoes account for approximately 50% of all tropical fruits produced worldwide (FAO, 2008). World production of mangoes is estimated at 35 million metric tons, out of which the ECOWAS region contributes 1.4 million metric tons, ranking 7th in the world compared to other countries (Saave, 2011).

Akurugu (2011) noted that, in Ghana the crop does well in savannah and transitional areas. High potential production areas include Brong Ahafo, Central, Greater Accra, Eastern, Volta, and Northern regions respectively. The crop is cultivated by both small and large-scale holders with reasonable proportion of the crop growing in the wild. Abu (2010) reported that the major cultivars or varieties of mango grown and distributed in Ghana include Haden, Kent, Palmer, and Keitt. Due to the economic potential of mango, there has been an increasing demand for it both locally and internationally. This has put mango ahead of most non-traditional crops, in the nation‘s quest to alleviate poverty through the improvement in incomes of farmers (Abu, 2010).

The Mango Industry in Ghana

Mango is being touted as the next big product in Ghana after cocoa, with the potential of generating high foreign earnings for the country (Abu, 2010; ADRA, 2006). As such having been a fruit crop growing widely in the country, it has found commercial value in the cultivation of improved exotic varieties. Over the years there has been widespread interest in the cultivation of the crop not only by development agencies under various environmental protection and poverty reduction programmes, but also by private individuals and companies for export (Avah, Dzamefe,Narh, Abakah & Eshun, 2008). Subsequently the importance of mango to many Ghanaian is epitomized in the description of the crop as "Golden tree", "next cash crop", "gold mine", "Ghana‘s future", amongst others (Avah et al., 2008).

ADRA (2006) suggested that Ghana has a great opportunity to reap economic benefit from mango production, as it is one of the few countries in the world that has the two mango fruiting seasons; the major and minor season respectively. The European Union Strategic Marketing Guide [EUSMG] (2001) reported that Ghana compared to some of the countries in the Sub-region is closer to Europe and thus gives it the urge in terms of market opportunities due to lower transportation cost and shorter delivery times.

Irrespective of these opportunities, Ghana is unable to take advantage due to the uncompetitive state of the industry. For example, a baseline study on the mango industry in Ghana by Abu, Olympio, Darko, Adu-Amankwa, and Dadzie (2011) indicated overwhelmingly among other challenges that mango farmers in Ghana have difficulty in determining when to harvest fruits for the export and local markets. Saave (2011) reported that output growth rate of mango for Ghana was seven percent from 2006-2010. The author noted that in terms of export Ghana recorded ten percent growth rate. Although, this trend has being identified, on the average Ghana is still experiencing less growth in output and export (MoFA, 2012).

Theoretical Framework of Production

Greene (2007) defined production as the process of transforming inputs into economically useful output. This indicates that the transformation process involves series of activities including changes in form; location and the time of use of the output. According to Odhiambo and Nyangito (2003), methods of production change over time and it is important to be able to capture the effects of such changes on output. The authors suggested that capturing the effects could ideally be done within the production function framework. However, in standard microeconomic theory, the concept of production function is used to describe the technology or technical relationship between the input(s) and output(s) of production process of the firm or decision-making units. It indicates the existing technologies possessed by the farm firm and shows the maximum amount of output attainable. Thus, the kind and amount of product that a production firm will obtain is a function of the kind and quantity of input employed at the given technology.

Agricultural production is commonly related to two types of production technology: multiple inputs-single outputs, and/or multiple inputs-multiple outputs (Kiatpathomchai, 2008). Often, due to scarcity of resources, a producer may not alter a production function in the short-run, but choose between alternative production functions and this emphasizes the importance of economic decision making in agricultural production. As such, Oluwatayo, Sekumade and Adesoji (2008) noted that, if a producer is concerned with profit maximization, increased output, optimization of utility or cost minimization from the use of their resources, that producer must select production functions appropriate to the achievement of the desired goal. However, from basic production theory, the quantity of any output can be determined since the quantities of inputs used are known.

Measurement of Efficiency in Production

The measurement of efficiency has remained an area of important research both in the developing and developed countries. This is especially important in developing countries, where resources are meagre and opportunities for developing and adopting better technologies are dwindling. Efficiency measures are important because it is a factor for productivity growth. It shows the extent to which it is possible to raise productivity with the existing resource base and available technology. The concept of productivity and efficiency measurement has been effectively analyzed since Adam Smith's work on pin factory. However, a rigorous analytical approach to the measurement of efficiency in production originated only with the work of Koopmans (1951) and Debreu (1951), empirically applied by Farrell (1957). Lovell (1993) indicated that the productivity of a production unit can be measured by the ratio of its output to its input. However, productivity varies according to differences in production technology, production process and differences in the environment in which production occurs. In addition, Greene (1997) noted that producers are efficient if they have produced as much as possible with the inputs they have actually employed and if they have produced that output at minimum cost.

Schultz (1964) noted that no significant increase in agricultural production is possible without a change in technology. This led to the Green Revolution age, where development of new technology was identified as key to increase in agricultural output. As such agricultural policies were tilted towards promotion of the adoption, examination and elimination of constraints to the adoption of new technology. However, as noted by Wambui (2005), output growth is not only achieved by new technological innovations but also through efficient use of these technologies. In addition, Coelli (1995a) also submitted that productivity growth could be achieved through technological process and/or efficiency. The submission of these authors justifies the increasing interest in efficiency measurement in agricultural production over the past decades building upon the initial work of Farrell (1957).

Efficiency estimation has tended to follow two main approaches, namely non-parametric and parametric approaches. In addition, there are two general paths to efficiency estimation; the full frontier where all observations are assumed to be along the frontier and the deviation from the frontier considered being inefficient. The other path has been the stochastic frontier estimation where the deviation from the frontier is attributed to the random component reflecting measurement error and statistical noise and an inefficiency component (Ogundele & Okoruwa, 2006).

Neff, Garcia and Nelson (1994), noted that the estimation of full frontier has been based on either non-parametric approach where efficiency is estimated by solving the linear programming for each individual farm firm or through parametric approach where the estimation is by statistical techniques. Under the parametric approach, there are two methods namely; deterministic and stochastic frontier method. The deterministic method just like the non-parametric approach envelops all of the data of the firm. However, Ogundele and Okoruwa (2006) noted that the major drawback of these methods is that since it forces all outputs to a frontier it is sensitive to outliers, that is, it large distorts efficiency measurements.

Ogundele and Okurowa (2006) showed that, the stochastic parametric method however incorporates the random error of regression. The random error therefore captures the effect of unimportant left out variables and errors of dependent variables as well as the farm specific inefficiencies. This decomposition of error makes this method of estimation superior to others. Also according to Neff et al. (1994), the stochastic parametric method provides the farm efficiency estimates with much lower variability than any other method due to the decomposition of the error term. In addition, Neff et al. (1994), and Ogundele and Okurowa (2006) all agreed that what should have been the major weakness of parametric methods as opposed to non-parametric measurements was its inability to construct different frontier for every observation.

Jundrow, Lovell, Materov, and Schmidt (1982) however, pointed out that this weakness of the parametric method is overcome by measuring the mean of the conditional distribution of inefficiency given the random error. Neff et al. (1994) stated that while the ability of stochastic frontier to incorporate random disturbance term to account for events beyond management's control is appealing, the need to use an estimate to measure inefficiency might result in very similar farm efficiency estimates. However, they pointed out that the weakness of the stochastic measurement though, according to several studies that have used this method, such a weakness seems not to occur.

Efficiency as defined by the pioneering work of Farrell (1957) is the ability to produce at a given level of output at the lowest cost. On the other hand, Koopmans (1951) provided a definition of efficiency that an input-output vector is technically efficient if, and only if, increasing any output or decreasing any input is possible only by decreasing some other output or increasing some other input. Furthermore, Lovell (1993) defines the efficiency of a production unit in terms of a comparison between observed and optimal values of its output and input. Debreu (1951) offered the first measure of productive efficiency with his coefficient of resource utilization. Debreu's measure is a radial measure of technical efficiency.

In addition, Sengupta (1995) and Cooper, Seiford and Tone (2000) defined both productivity and efficiency as the ratio between output and input. However, Daraio and Simar (2007) emphasized that, instead of defining efficiency as the ratio between outputs and inputs, we can describe it as a distance between the quantity of input and output, and the quantity of input and output that defines a frontier, the best possible frontier for a firm in its cluster. Timmer (1971) imposed a Cobb-Douglas production function on the frontier and computed an output-based measure of efficiency. The approach adopted here was to specify a fixed parameter frontier amenable to statistical analysis.

Farrell (1957) extended the work initiated by Koopmans and Debreu by noting that production efficiency has a second component reflecting the ability of producers to select the "right" technically efficient input-output vector in light of prevailing input and output prices. This led Farrell to define overall productive efficiency as the product of *technical* and *allocative* efficiency. This is known as the economic efficiency. Technical efficiency is the ability of the farm to produce a maximum level of output given a similar level of production inputs. Allocative efficiency is the extent to which farmers equate the marginal value product of a factor of production to its price. Economic efficiency thus, combines both allocative and technical efficiency. It is achieved when the producer combines resources in the least combination to generate maximum output (technical) as well as ensuring least cost to obtain maximum revenue (allocative) (Chukwuji et al., 2006).

In view of this, Chukwuji et al. (2006) suggested that in order to promote commercialization of agriculture from subsistence farming, farmers have to be both technically and allocativelly efficient. In addition, Ajebefun and Abudulkadir (1999) said that the identification and elimination of inefficiencies will results in higher level of output and more profit to farmers. Douglas (2008) stated that the ultimate goal of training farmers to be both allocativelly and technically efficiency is to boost their incomes by maximizing profits especially in poverty pressed countries. Thus, this study aims to know whether mango farmers in the study area are economically efficient in production, by estimating their technical, allocative, and economic efficiency.

Daraio and Simar (2007) pointed out that it is possible to distinguish other different kind of efficiency, such as scale, and structural efficiency. Farrell (1957) used the most restrictive technology having constant returns to scale (CRS) and exhibiting strong disposability of inputs to analyze scale efficiency. This model has been developed in a linear programming framework by Charnes, Cooper and Rhodes (1978). In addition, Banker, Charnes and Cooper (1984) showed that the CRS measure of efficiency can be expressed as the product of a technical efficiency measure and a scale efficiency measure. The concept of structural efficiency is an industry level concept according to Farrell (1957), which broadly measures to what extent an industry keeps up with the performance of its own best practice firms. A broad interpretation of Farrell's notion of structural efficiency can be stated as follows: industry or cluster A is more efficient structurally than industry B, if the distribution of its best firms is more concentrated near its efficient frontier for industry A than for B. In their empirical study, Bjurek, Hjalmarsson and Forsund (1990) compute structural efficiency by simply constructing an average unit for the whole cluster and then estimating the individual measure of technical efficiency for this average unit.

Economic Efficiency

Farrell (1957) showed that there are three components in the concept of efficiency: technical, allocative and economic efficiency. The author stated that the product of technical and allocative efficiency gives economic efficiency of production. Thus, according to Farrell (1957) for a firm to be considered as economically efficient, it must be both technically and allocativelly efficient. The idea of frontier production was therefore built around the concept of efficiency adduced by Farrell (1957). As components of economic efficiency, technical and allocative efficiency can be derive from production function, as production function represents the efficient input mix for any given output that minimizes the cost of producing that level of output. Though technical and allocative efficiency are required for economic efficiency, Aung (2012) submitted that farm firms might exhibit technical and allocative efficiency without having economic efficiency.

Economic efficiency (EE) measurement requires the input and/or output quantity data, together with input and/or output price data as well as producer's behavioural assumption. Behavioural assumption of producers can be cost minimization, profit maximization, or revenue maximization. The frontier of each behavioural assumption is use to measure efficiency (Kiatpathomchai, 2008). Thus, according to Chukwuji, Inoni, Ogisi, and Oyaide (2006) economic efficiency is realized when the producer combines resources in the least combination to obtain maximum output (technical) as well as ensuring least cost to generate maximum revenue (allocative). Thus, to have an economically efficient production set, technical efficiency alone is not sufficient. The input combination should be selected appropriately based on their prices. Hence, the best-practicing combination of inputs concerning the prices is the intersection point of Isoquant and Isocost curves where technically feasible production units are produced at the lowest cost (Erkoc, 2012).

In measuring economic efficiency levels of firms, two separate methods have being developed by researchers under the rubric of mathematical programming approach and the econometric approach (Erkoc, 2012). Mathematical programming approach also known as Data Envelopment Analysis (DEA) was proposed by Charnes, Cooper, and Rhodes (1978). In DEA, multiple outputs and inputs are reduce to a single output-input form after which efficiency scores are computed using linear programming.

However, because of the non-stochastic nature of DEA, it prevents researchers to attain comprehensive and sustainable results in many cases. As a result, an econometric approach or Stochastic Frontier Analysis (SFA) became preferable owing to its ability to distinguish the impact of variation in technical efficiency from external stochastic error on firm's output. Based on this the stochastic frontier analysis was adopted to estimate the economic efficiency of mango production in this study.

Kiatpathomchai (2008) indicated that farmers direct benefits of economic efficiency improvement relates to cost saving or gross margin increasing. For example, at 10 percent level of economic efficiency improvement, the farmers could cut the total variable costs from 236.5625 euro per ha to 212.89583 euro per hector (23.64583 euro, reduction per hector) and still produce 3,411kg of paddy. In other words, at 10 percent level of economic efficiency improvement, the gross margin per hector increased by 23.64583 euro.

Review of Studies on Economic Efficiency in Production

Sharma, Leung, and Zaleski (1999) analyzed the technical and economic efficiency of swine production in USA using SFA and input-oriented DEA approach. Cross-section data of 53 pig farms were used. Cobb-Douglas stochastic production function and dual cost function were assumed for SFA technical and economic efficiency analysis. The main results showed that the average levels of economic (SFA), economic (CRS), and economic (VRS) efficiency were 0.57, 0.46, and 0.60, respectively. The significant positive determinants of technical and economic efficiency were farm size, market hogs, and experience, while significant negative determinant of technical and economic efficiency was education.

Abdulai and Huffman (2000) investigated the economic efficiency of rice farms in northern Ghana using the SFA approach. Cross-section data of 256 rice farms were used and translog stochastic profit function was assumed for the analysis. The results showed that the average level of economic (profit) efficiency was 0.73. The significant positive determinants of profit inefficiency (negative impact on profit efficiency) were hours of non-farm employment, age, distance to market while the significant negative determinants of profit inefficiency (positive impact on profit efficiency) are education, access to credit, and level of rice specialization.

Kiatpathomchai (2008) investigated the Economic and Environmental Efficiency of Rice Production Systems in Southern Thailand using the DEA approach. According the results, it was found out that, the average levels of economic efficiency were 0.676 for the whole sample farms, and 0.681 and 0.671 for farms in irrigated and rain-fed areas. This means, in principle, that the sample farms could potentially reduce their overall cost of rice production approximately by 32 percent and still attain the current output level.

Kareem, Dipeolu, Aromolaran and Williams (2008) employed the stochastic frontier production analysis to estimate the technical, allocative and economic efficiency among fish farmers using concrete and earthen pond systems in Ogun State. The results showed that the average economic efficiency was 76 percent in concrete pond system while it was 84 percent in the earthen pond system. Further analysis revealed that pond area, quantity of lime used, and number of labour used were significant factors that contributed to the technical efficiency of concrete pond system while pond, quantity of feed and labour were significant factors in earthen pond system.

Technical Efficiency

In measuring technical efficiency, a production function is used (Wambui, 2005). Farrell (1957), defined technical efficiency as the ability of a firm to maximize output given input levels under existing technology. However, according to Koopmans (1951; p. 60) an input-output vector is technically efficient if, and only if, increasing any output or decreasing any input is possible only by decreasing some other output or increasing some other input. On the other hand, Esparon and Sturgess (1989) submitted that, technical efficiency deals with efficiency in relation to factor- product transformation. Thus, for a farm to be considered as technically efficient, it has to produce at the production frontier level, otherwise it is said to be technically inefficient. However, Battese and Coelli (1995) noted that firms are not always able to produce along the frontier due to random factors such as bad weather, animal destruction and/ or farm specific factors, which lead to producing below the expected output frontier. Technical Efficiency measurement therefore attempts to identify those factors that are farm specific which hinder production along the frontier.

Thus, according to Battese and Coelli (1995), Technical efficiency goes beyond evaluation based on average production to one based on best performance among a given category though it relate to productivity where inputs are transformed into outputs. Ogundari and Ojoo (2005), therefore, highlighted that Technical Efficiency measurement provides an opportunity to separate production effects from managerial weakness.

Technical efficiency is associated with behavioural objectives of maximization of output (Battese & Coelli, 1995). However, it has been realize that this production objective cannot be done in isolation. This is because a farm can be considered as an economic unit with scarce resources. In economic theory, a production function is described in terms of maximum output that can be produced from a specified set of inputs, given the existing technology available to the farm (Battese, 1992). When the farm produces at the best production frontier, it is considered efficient. The most common assumption is that the goal of the producers is profit maximization; however, it is believed that the objectives and goals of the producer are intertwined with farmers' psychological makeup (Debertin, 1992). Therefore, this study assumed that producers aim at maximizing output subject to existing constraints. Technical efficiency is achieved when a high level of output is realized given a similar level of inputs.

According to Esparon and Sturgess (1989), the main function of technical efficiency research is to understand factors that shift production function. However, Fraser and Cordina (1999) indicated that the general aim of measuring firm level technical efficiency is to estimate the frontier that envelopes all the input-output observations. Observations found lying on the frontier are described, as technically efficient whiles those lying below the frontier are considered technically inefficient. Battese and Coelli, (1996) however, indicated that it is important to note that technical inefficiency can only be estimated if the inefficiency effects are stochastic and has a particular distribution assumption.

Akinwumi and Djato (1997) presented that production estimation has been criticize in recent times that it results into simultaneous equation bias leading to wrong conclusions. Thus, in such cases, estimation of technical efficiency using product and input prices has been advocated. However, Neff et al. (1994), contends that prices in a given region are always homogeneous and uniform across farms. As such, differences in technical efficiency measures are likely to reflect quantity, not price difference.

Review of Studies on Technical Efficiency in Production

Binam, Tonye, Hadley, and Akoa (2004), examined factors influencing technical efficiency of groundnut and maize farmers in Cameroon and found the mean technical efficiency to be in the region of 73% and 77%. They also concluded that access to credit, social capital, and distance from the road and extension services are important factors explaining the variations in technical efficiencies among individual farmers.

A study by Awudu and Rechird (2001) using a translog stochastic frontier model to examine technical efficiency in maize and beans in Nicaragua also, revealed that the average efficiency levels were 69.8 and 74.2 percent for maize and beans respectively. The study indicated that the level of schooling, access to formal credit and farming experience were all positively related to production efficiency, while farmers' participation in off-farm employment tended to reduce production efficiency. The study also revealed that farm household with large family size appeared to be more efficient than those with small family size. The study also indicated that efficiency increased with age until a maximum efficiency was reached when the household head was 38 years old.

In addition, Wilson, Hadley, and Ashby (2001) estimated technical efficiency among wheat farmers in Eastern England. The estimated technical efficiency among wheat farmers in Eastern England was found to be between 62 and 98 percent. The study revealed that farmers who sought information, and had more years of managerial experiences and large farm, were associated with higher levels of technical efficiency.

Mochebelele and Winter-Nelson (2002) used a stochastic production frontier to compare technical inefficiencies of smallholder farmers in Lesotho who sent migrant labour to the South African mines and those who did not. It was found out that farmers who send migrant labour to South African mines were close to their production frontier than those who do not. In addition, a study by Belen, Iraizoz, Rapun and Zabaleta, (2003) on the assessment of technical efficiency of horticultural production in Navarra, Spain, revealed that tomato farmers were 80 percent efficient while asparagus farms were 90 percent efficient. They therefore, concluded that there exists potential for improving farm incomes by improving efficiency.

Wambui (2005) carried out a study to provide estimates of technical efficiency in Kenyan maize production and to explain variations in technical efficiency among farms through managerial and socio-economic characteristics. The results showed that the main technical efficiency of Kenya's maize production was 49 percent; however, this ranges between 8 to 98 percent. The estimated marginal effect showed that, the use of purchase hybrid maize seed increased technical efficiency by 36 percent. In addition, the use of tractor for land preparation increased technical efficiency by 26 percent. Furthermore, the study revealed that additional year of school increases technical efficiency by 0.84. However, technical efficiency increases at a decreasing rate with an increase in the number of years of school.

Alene, Manyong, and Gockowski (2006) analyzed the technical efficiency of maize-coffee intercropping system in Ethiopia using the SFA, DEA, and PDF (parametric multi-output distance function) approaches. Cross-section data of 124 farms were use and a translog stochastic production function was assumed for SFA analysis. The main results showed that the average levels of technical (SFA), output-oriented technical (VRS), and output distance efficiency were 0.72, 0.93, and 0.91, respectively. They conclude that DEA and PDF approaches reveal similar results.

Asogwa, Umeh and Ater (2006) carried out a study on the analysis of technical efficiency of Nigerian cassava farmers. It was revealed that the technical efficiency varied widely among farms. It ranges from 0.31 to 1.00, with a mean technical efficiency of 0.89 (89 percent), suggesting that many of the respondents produced closer to their production frontier where profit is maximized, and that technical efficiency in cassava production could be increased by 11 percent through better use of available resources, given the current state of technology. The authors attributed the variation in the technical efficiency estimates to differences in effective utilization of inputs among the respondents.

Idiong (2007) employed a stochastic frontier production function that incorporated inefficiency factors to provide estimates of technical efficiency and its determinants using data obtained from 112 small-scale swamp rice farmers in Cross River State. The results indicated that the mean efficiency was 77 percent indicating 23 percent allowance for improving efficiency. The result also showed that, farmers' educational level, membership of cooperative/farmer association and access to credit significantly influenced the farmers' efficiency positively.

Allocative Efficiency

According to Inoni (2007), allocative efficiency is a measure of how an enterprise uses production input optimally in the right combination to maximize profits. This implies that the allocativelly efficient level of production of a farm firm is where the farm operates at the least-cost combination of input. Literature have it that the first work on allocative efficiency is credited to Farrell (1957) when he decomposed production efficiency into two main component, technical and allocative efficiency and stated that the product of the two gives economic efficiency of production.

According to Farrell (1957), allocative efficiency can be defined as the ability of a firm to choose the optimal combination of input given prices. Thus according to Shahooth and Battall (2006) for a firm to be allocativelly efficient, it has to choose a combination of input to be used in right proportions and technically efficient at low prices so that output is produced at minimum costs. This results into profit maximization. Even though new methods exist for the estimation of allocative efficiency, traditionally, it has been difficult to estimate allocative efficiency without input and output prices. Farrell referred to it as price efficiency, indicating firm's ability to choose the optimal combination of inputs given input prices.

Douglas (2008) noted that, for a firm to realize allocative efficiency, the following questions need to be answered; what is the optimal combination of inputs so that output is produced at minimum cost? How much would reallocating resources increase profit? Thus, most studies have being using gains obtained by varying the input ratios based on assumptions about the future price structure of products say mango and factor markets. However, Chukwuji, et al. (2006) did a review on the assumptions used by farmers to allocate resources in order to maximize profit. Some of these assumptions included, farmers choose the best combination (low costs) of inputs to produce profit maximizing output level; all inputs are of the same quality from all producers in the market; there is perfect competition in input and output markets; producers are price takers and assumed to have perfect market information.

In addition, allocative efficiency measures the extent of the success in achieving the best combination of different inputs in producing a specified level of output given the relative prices of inputs. Given the prevailing price ratio of inputs, the point at which the price line is tangent to the technically efficient isoquant gives the allocative efficiency. It defines the least-cost point at which the amount of each input required to produce the specified level of output is the minimum possible at the given prices of inputs (Adeoti, 2011).

Chukwuji, et al. (2006) also, indicated that for a farm to achieve allocative efficiency it is require that the extra revenue (Marginal Value Product) generated from the employment of an extra unit of a resource must be equal to its unit cost (Marginal Cost = unit price of input). This then results in profit maximization.

Review of Studies on Allocative Efficiency in Production

A study by Chukwuji, et al. (2006) to determine allocative efficiency of broiler production in Delta state of Nigeria, revealed that the estimated allocative efficiency for stock size, feed expenses, variable expenses and fixed capital inputs was 24.9, 24.8,-4.6 and 11.9 respectively. As a result, farmers were allocativelly not efficient and needed to increase the quantity of the inputs to enable them to maximize profits since marginal value product was greater than marginal cost or unit price of inputs.

Inoni (2007) examined the efficient resource utilization in pond fish production in Delta State, Nigeria. The estimated allocative efficiency of production resources employed were 3.22, 0.0025, 0.00064, –0.00017, and 0.00025 respectively for pond size, feed resources, fingerlings, labour, and fixed costs. With exception of pond size which was under-utilized, all inputs used in fish farming were said to be over-utilized implying sub-optimal resource allocation in fish production. Based on results, fish farmers in Delta state of Nigeria needed to reduce on the use of over-utilized resources to achieve optimal resource allocation and this would raise productivity of resources, increase output, and hence increase revenues and net returns.

In addition, a study by Bravo-Ureta and Pinheiro (1997) revealed that peasant farming in the Dominican Republic were 0.44 allocativelly efficient. This result was said to be in line with a 0.43 allocative efficiency for a sample of wheat and maize farmers in Pakistan. In addition, the authors further indicated that peasant farms in Paraguay were more efficient with 0.70 and 0.88 allocative efficiency levels compared with peasant farmers in the Dominican Republic.

Scale of Production

Farrell (1957) used the most restrictive technology having constant returns to scale (CRS) and exhibiting strong disposability of inputs (that is, an increase in inputs cannot decrease output) to analyze scale efficiency. Coelli (1995), using a Cobb-Douglas stochastic frontier production, estimated parameters $\beta_1, \beta_2, \beta_3 \ldots \beta_n$, representing elasticities of the corresponding input variables. These parameters represent elasticities of production factors such as land, labour, equipment, insecticides/pesticides, and fertilizer. The elasticities represent the ratio of the percentage change in output to the respective percentage change in the level of production factors. Hence, the sum total of the output elasticities represents the estimated scale elasticity (ε). It represents the percentage change in output from one percent change in all input factors. This thus measures the return to scale for any firm. Basically, when

(ε) > 1 → increasing return to scale (IRS)

(ε) < 1 → decreasing return to scale (DRS)

(ε) = 1 → constant return to scale (CRS)

Production Constraints

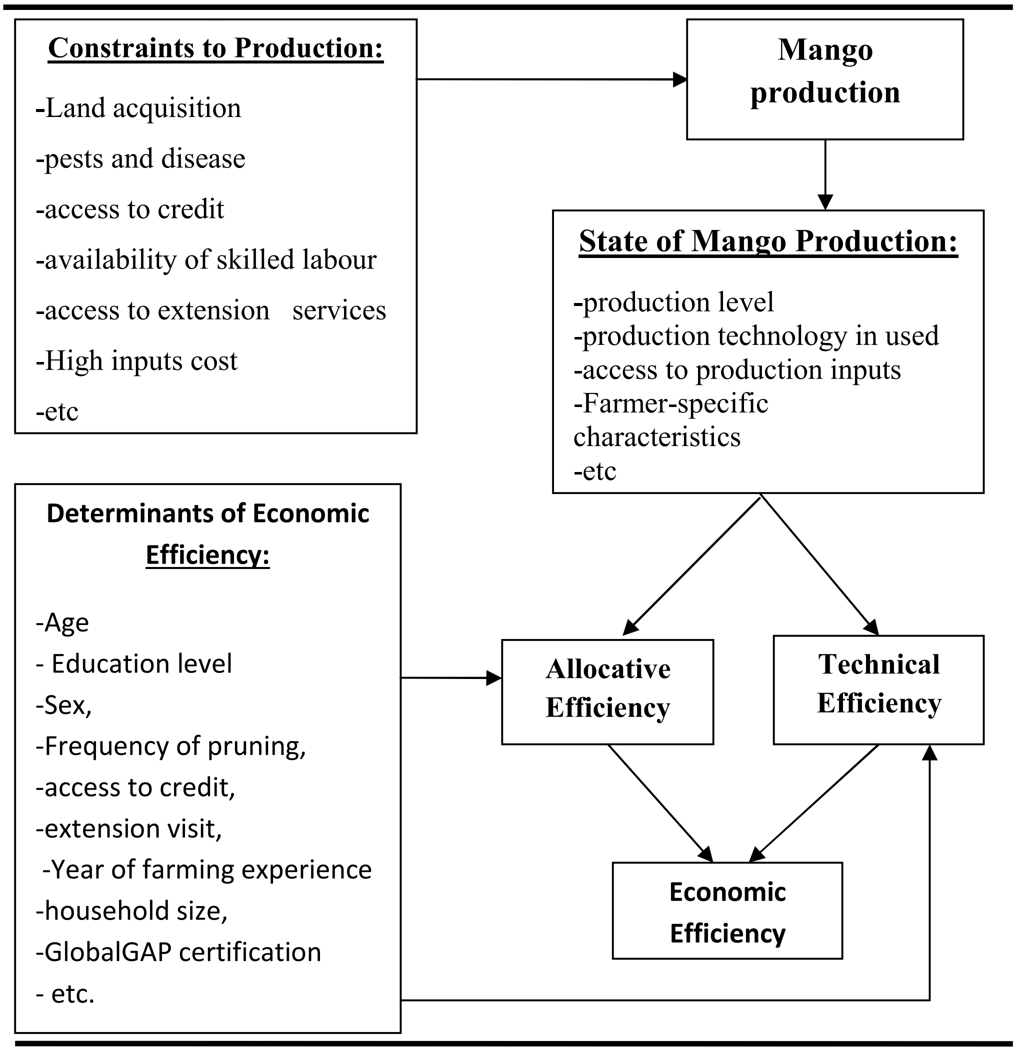
Production constraints are factors that limit farmers' ability to realize their production objective. Akurugu (2011) carried out a study on the evaluation of post-harvest handling and marketing of mango in Ghana: A case study in the Northern Region. The study revealed that, lack of storage facility, perishability of fruit, poor road network and high cost of transport, pest and disease infestations, low price of product and as well as lack of market are some of the major constraints facing mango farmers in Ghana.

According to Yaro (1999) and Abubakur (2006), one major constraint to production is the amount of land available. In addition, Akintayo (2011) also noted that one of the major constraints to production is availability and quality of planting material, particularly high quality seeds. The author also indicated that labour (both family and hired) present a major constraint to production. Liverpool-Tarsie et al. (2011) also submitted that contact with extension agents, access to new technology and improved varieties of inputs (particularly seed), access to credit, and high cost of inputs including fertilizers and herbicides were major constraints to Nigerian farmers. Fasoranti (2006) and Abubakar (2006) all agreed that availability of good quality affordable inputs was clearly a major constraint for smallholder Nigerian farmers.

Furthermore, Shivanand (2002) carried out a study on the performance of banana plantation in northern Karnataka. The results of the study revealed that non-availability of labour, high labour wages and non-availability of technical assistance for improved cultivation of banana posed severe problem in production of banana. Abu (2010) did a study on the quality criteria for mango export in Ghana. The study reveals that one of the major constraints to mango production was access to international market especially the US market due to quality standard. In addition, Ava et al. (2008) reported that Ghanaian mango producers find it hard to meet certain export quality standards. As a result, the sufficient quantities of mango that importers demanded could not be met. Besides, quality and presentation standards fail to meet the requirements of fresh mango importing countries from Ghana (Norman, 2003).

However, Abu et al. (2011) posited that one major constraint in mango production is the high wastage of fruits during harvesting, particularly of the exotic mango varieties. Litz (2003) noted that both domestic and international trade of fresh mango is also been limited by its highly perishable nature and its susceptibility to post-harvest diseases, extremes of temperature and physical injury.

Conceptual Framework of the Study



Source: Author's Construct, 2014

The conceptual framework of the study specifies the relationship or interaction between the key variables of the study. As indicate, mango production in the Yilo Krobo Municipality is explain by the state of mango production with key indicators like production level, production technology in used, farmer-specific characteristics, access to production inputs and market information and so on. However, it is believed that mango production is usually associated with certain production constraints some of which include access to land for agricultural production, availability of skilled labour, access to credit facilities and so on.

As shown in the conceptual framework, the state of mango production influences the level of economic efficiency in mango production in the municipality. The economic efficiency is determined by the composite effect of the level of allocative efficiency and technical efficiency in production. This is because as stated by Farrell (1957) economic efficiency is the product of the allocative efficiency and technical efficiency. Also, economic efficiency level is influence by certain determinants which also affects both the allocative efficiency and technical efficiency levels in mango production. These determinants of economic efficiency either increases or decreases the efficiency level exhibited by the mango farmers. Some of these determinants include age of farmers, educational level of farmers, access to credit, frequency of extension visited received, and frequency of pruning.

Thus, the interest of any efficiency analysis is to identify these determinants to access their contribution to efficiency level in production. This then help propose ways of improving the productivity level of farmers with the existing technologies and production resources.

CHAPTER THREE

METHODOLOGY

Introduction

This chapter covers the study area, the research design, the population, sample and sampling procedure, instrumentation and data collection. In addition, data analysis procedures and econometric models consideration are included in this chapter.

Study Area

Yilo Krobo Municipality is located in the Eastern Region of Ghana with Somanya as its capital. It falls approximately within latitudes $6^0$00'N-$0^0$30'N and $0^0$30'E-$1^0$00'W. It covers an estimated area of 805sq.km, constituting 4.2 percent of the total area of the Eastern Region. The municipality is bordered on the north and east by Manya Krobo District, on the south By Akwapim North and Dangme West Districts and on the West by New Juaben, East Akim and Fanteakwa Districts. The Yilo Krobo is characterized by bi-modal rainy season. The annual rainfall is between 750mm in the Lower Yilo and 1600mm on the slopes of the ranges in the Upper Yilo. In the municipality, temperature ranges between a minimum of 24.9^{0}C and a maximum of 29.9^{0}C and a relative humidity of 60 to 93 percent. The vegetation of the municipality is characterized by a semi-deciduous rain forest and savanna grassland. The predominant soil in the district can be divided into three major groups namely soil developed over sand stone, soil developed over Buem, and soil developed over Togo rocks.

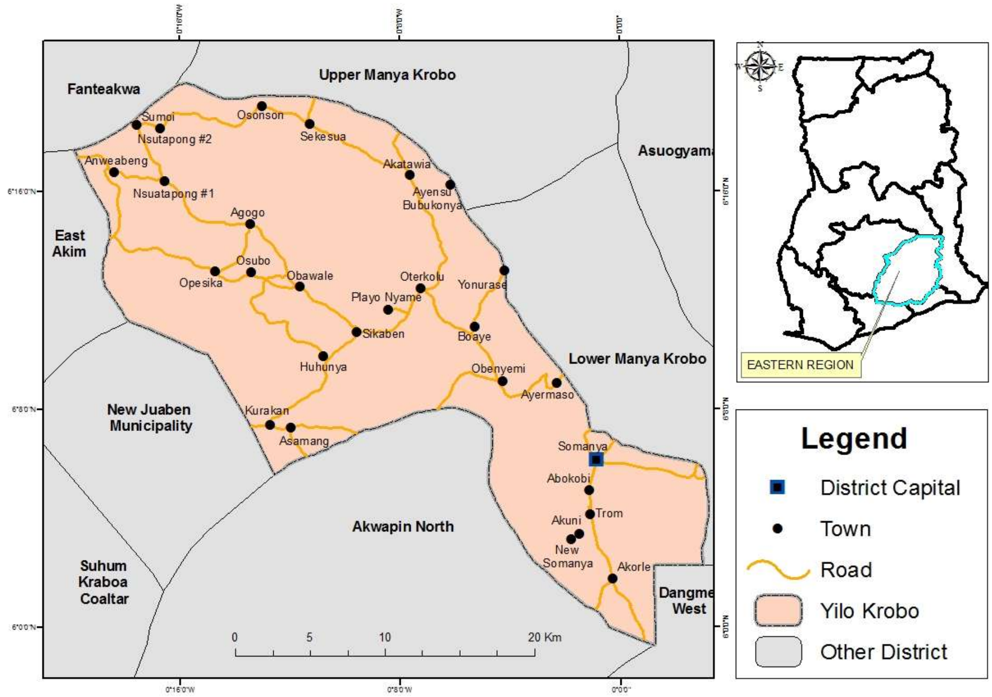


Figure 1: Location Map of Yilo Krobo Municipality

The main productive activity in the Yilo Krobo Municipality is agriculture. A household survey conducted in 2002 indicated that fifty eight percent of the populations are into agriculture (MOFA, 2012). The dominant farming activities in the municipality include food crop cultivation, livestock rearing and mango plantations. Maize, cassava, yam, cocoyam and plantain are grown in almost all parts of the municipality. A wide range of vegetables like tomato, garden eggs, pepper and okra are also grown. The main types of livestock reared in the municipality are cattle, goats, sheep, chicken and pigs.

Mango as the major tree crop cultivated in area has both ecological and economic potentials. In responses to this economic potential in mango production, Yilo Krobo has seen the emergence of medium to large-scale mango farms. Large-scale mango plantation has become a very important income generating activity as a result of interventions made by MOFA in collaboration with some agencies and institutions such as ADRA, MIDA and Hunger Projects (MOFA, 2013). The Municipality is considered as a major mango production area in Ghana with two major mango seasons. This background explains the rationale for the selection of the municipality for this study.

Research design

A cross sectional research design was used for the study. It involves observation of all of a population, or a representative subset, at one specific point in time. The aim is to provide data on the entire population under study. Here we take a snapshot of the performance of each respondent (producer) during a period, such as a calendar year (Khumbakar and lovell, 2000). This was used because its appropriateness in investigating the prevalence of a phenomenon, situation, problem, attitudes, or issue by taking a cross section of the population. This design was considered appropriate since respondents were contacted at one point in time to collect data for the study. Even though, it has the disadvantage of not being able to measure change and show production trends, it was comparatively simple to undertake and easy to analyze when respondents are to be contacted once (Kumar, 2005). It was also the most appropriate given that most of farmers did not keep documented production records making obtaining panel data quiet difficult.

The Population of the Study

The population for the study included all registered mango farmers under the mango growers association with MoFA in the Yilo Krobo Municipality who grew the exotic mango varieties. These groups were chosen because of the current increasing economic importance of the exotic mango varieties both locally and internationally. These groups were considered more relevant to the research topic of estimating the economic efficiency in mango production in the municipality; because they were into commercial mango production. The mango varieties cultivated in the municipality by farmers include keitt, Kent and palmer but keitt is the most predominant one.

Sample and Sampling Procedure

A multistage sampling technique was use in obtaining the sample size for the study. In the first sampling stage, the Yilo krobo municipality was purposively selected for the study. This was based on its comparative advantage of having a bimodal system in mango production in Ghana. A list of all registered mango farmers in the municipality was then obtained to form a sampling frame of 276 mango farmers for the study. At the second stage, to minimize the effect of yield differential due to plant age, a stratified sampling technique was used to divide the farmers into two groups. Farmers whose farm establishment was 7 years and above were put into one group and farmers whose farms was below 7 years in another group. Mango farmers whose farm establishment were 7 years and above were then selected to form a sample of 85 mango farmers. Furthermore, fruit production is considered to be on the optimal scale from the seventh year onwards where farmers are able to produce economically marketable output size. It was also to guarantee obtaining more valid and useful information to address the research objectives.

Though the study aimed at covering all the 85 mango farmers, due to certain inherent constraints that was not possible. It was realized that not all the 85 farmers would be available for the study. It was therefore necessary to work out a sample size that would be a good representation. Using a sample size determination method proposed by Sarantakos (1997), a sample size of 62 was obtained from the sample of 85 mango farmers.

$$n = \left(\frac{z_{\frac{\alpha}{2}} \otimes \sigma}{E} \right)^2 \Rightarrow \quad n = \left(\frac{1.92 \otimes 2}{0.5} \right)^2 = 62$$

Where n represent the sample size, E and σ are the standard error and standard deviation respectively. For this study, a standard error of 0.5 and a standard deviation of 2 were assumed at 95 percent confidence level. This was base on the fact that, the results from the pretest did not show any significant variation among the individual farmers in terms of output and production activities.

A simple random sampling procedure was then use to select the 62 mango farmers out of the 85 registered mango farmers whose farm establishment were 7 years and above using the lottery approach. The selected mango farmers were contacted and interview using a structured interview schedule.

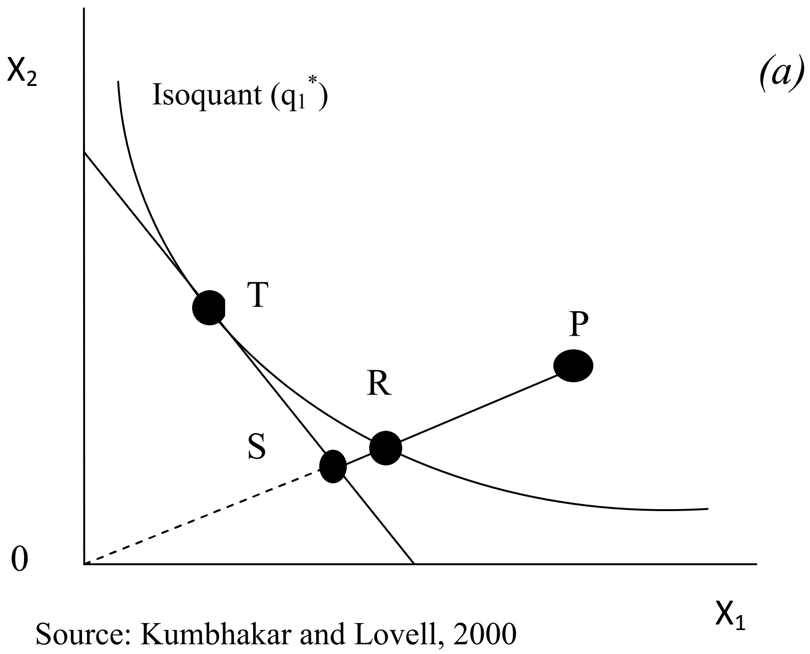
Instrumentation

A structured interview schedules, structured interview guide, and a survey guide for focused group discussion was employed to collect the necessary information needed. The structured interview schedule captured information on farmer and farm-specific variables; techniques of production and organization of inputs. In addition, output (yield of mango) and inputs data as well as price data on output and inputs employed in production were captured. Information on constraints to mango production in the municipality was captured in the structured interview schedule. The structured interview guide captures technical information on mango production. Lastly, a survey guide for focus group discussion and field observations were adopted to gain more insight into the general state of mango production in the study area.

Analytical Framework of the Study

The determination of economic efficiency combines both technical and allocative efficiencies as indicated by Farrell (1957). Thus, economic efficiency is realized when the firm allocates resources in the optimum combination of inputs at the least cost to obtain maximum output (technical) and maximum revenue or profit (allocative). However, the ability of the farm firm to achieve both technical and allocative efficiency is influence by inefficiency sources. As such, in this study the optimal combination of land, labour, equipment, agro-chemicals, and fertilizer to maximize output of mango, as well as ensuring least cost to maximize revenue is expected to be influenced by efficiency sources like age, educational, sex, experience, access to credit and household size. The rest include access to extension service, frequency of pruning, government support, availability of processing factory and GlobalGAP certification respectively. When a farmer who has the aim of maximizing profit makes allocation errors that result in inefficiency he/she is considered allocativelly inefficient. As such, technical efficiency can only be achieved together with the achievement of allocative efficiency.

The concept of producing maximum output with available inputs (technical efficiency) and the optimal use of these resources to maximize profits given the input prices (allocative efficiency) can be illustrated graphically as shown in Figure 2. This can be explained using a simple example of a two input (x_1, x_2)-two output (q_1, q_2) production process (Figures 2 and 3). Efficiency can be considered in terms of the optimal combination of inputs to achieve a given level of output (an input-orientation), or the optimal output that could be produced given a set of inputs (an output-orientation) (Sentumbwe, 2007).



Source: Kumbhakar and Lovell, 2000

Figure 2: Input - Oriented Efficiency Measure

As illustrated in Figure 1, the firm is producing a given level of output (q_1*) using an input combination defined by point P. By radially contracting the use of both inputs back to point R which lies on the isoquant associated with the optimum level of inputs required to produce (q_1*) (Isoquant (q_1*)), the same level of output could be achieved. Technical efficiency (TE (q, x)) according to the input-oriented approach is thus specified by 0R/0P. However, the point T defines the least-cost combination of inputs that produces (q_1^*). This is because the point T defines the point where the marginal rate of technical substitution is equal to the input price ratio (w_2/w_1). By contracting the input combination to the point S, the same level of cost can be achieved. Thus, OS/OP specifies the cost efficiency (CE (q, x, w)). Allocative efficiency is obtained by finding the ratio of CE to TE. That is, CE (q, x, w)/TE (q, x), or 0S/0R (Coelli, 1995).

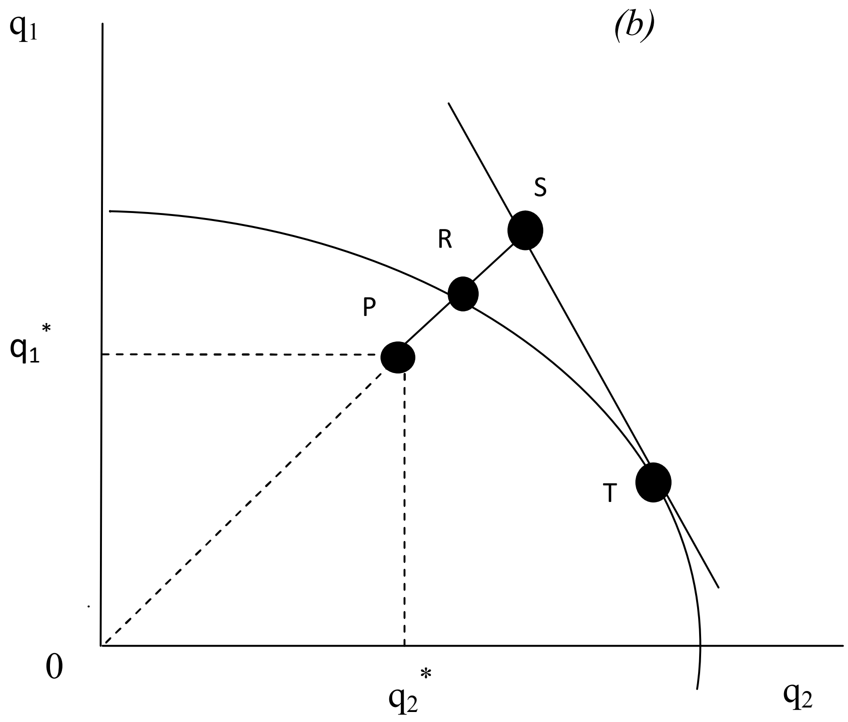


Figure 3: Output - Oriented Efficiency Measure

From Figure 2, if the firm employs inputs efficiently, the output of the firm, producing at point P, can be expanded radially to point R. Thus, the output-oriented measure of technical efficiency (TE (q, x)) can be given by 0P/0R. Although, point R is technically efficient, as it lies on the production possibility frontier, higher revenue could be obtained by producing at point T (i.e. where the marginal rate of transformation is equal to the price ratio

$\{p_2/p_1\}$). At this point, to maximize revenue the farm firm should produce more of q_1 and less of q_2. To realize the same level of revenue at point T while maintaining the same input and output combination, output of the firm would need to be expanded to point S. The revenue efficiency (RE (q, x, w) is thus given by 0P/0S. Hence, Output allocative efficiency (AE (q, w, w)) is given by RE (q, x, w)/TE (q, x), or 0R/0S in Figure 1.2 above (Coelli, 1995).

Farrell's (1957) overall efficiency measure which is referred to as economic efficiency (EE) can now be specifies as; EE = TE x AE = OP/OR x OR/OS = OP/OS, for the output-oriented approach or EE = TE x AE = OR/OP x OS/OR = OS/OP, for the input-oriented approach.

Data Type and Sources

Primary data were collected from individual mango farmers on the output level, input levels and production activities and as well as production constraints and used for the analysis. In addition, technical information on mango production was obtained from selected key informants from the MoFA office and the office of mango growers association the municipality.

Data Collection Procedure

A pre-test was conducted at Gomoa East District and Awuto-Senya District in January 2014 to test the validity and reliability of the instruments and the analytical techniques. The data obtained from the preliminary study was coded and analyzed. Cronbach alpha was use to test the reliability the instrument and a value of 0.71 was obtained which indicated that the instrument was reliable. The instrument was then revised to effect the necessary corrections and improvement to capture accurate and correct information relevant for efficiency estimation. The revised Structured Questionnaire and interview schedule were than administered to individual mango farmers in the Yilo Krobo Municipality with assistance from one MoFA staff and one official from the mango farmers association in the municipality. Farmers were interviewed on a one-to-one basis to find out their views. The farmers were contacted once during the survey. In addition, field observation and focus group discussion were adopted as tools to gain more and better insight on issues relating to mango production in the study area. A structured questionnaire or interview guide was administered to key informant to solicit technical information on mango production by the researcher. The key informants were selected from the offices of MoFA and the Mango farmer association. Data collection lasted from to February 5, 2014 to April 15, 2014.

A Priori Expectations

The input variables land, labour, equipment, agrochemical, and fertilizer affect both technical and allocative efficiencies of mango production. As such, it was expected that they all have a positive signs, indicating that they all have positive effect on mango production. Thus, in order to test the hypothesis that mango farmers are both technically and allocativelly efficient, quantities and respective prices of these variables were very relevant.

It was expected that through the scale economy, the amount of land would have a positive effect on mango production. In addition, it was expected that increased labour productivity would have a positive effect on mango production. The cost of equipment to increase with increased mechanized unit of operations as such it expected that equipment as inputs to have a positive coefficient. Agrochemicals (pesticides and herbicides) and fertilizers as important input in mango production were expected to have a positive relationship with output level.

The farmer and farm-specific variables were also expected to have significant relationships with mango output. Age often goes with experience and as such, it was expected to have negative relationship with inefficiency since adoption of new technologies by older farmers can also be achieve through experience. In addition, male farmers often contribute higher amount of labour as well as devoting more time to work than female farmers do, hence sex as variable was expected to have a negative relationship with inefficiency. It was also expected that household size would relate negatively with inefficiency. This is because all things being equal, the higher the household size the more family labour would be supplied to support production, hence generating higher level of output. The number of years spent in formal school as the measure of educational level was expected to have a negative relation with inefficiency. This stems from theory that farmers with higher educational level are often are able to acquire and use relevant technical knowledge in optimal resource allocation to obtain higher output at minimum cost possible. Experienced farmers are considered to allocate their economic or production resource efficiently to generate higher output level at minimum cost. Experience as a farmer and farm-specific variable was therefore expected to have a negative relationship with inefficiency.

Access to credit as an important variable in mango production was expected to increase level of production as such, was also expected to have a negative relation with inefficiency. In addition, GlobalGAP provides guidelines that farmers are supposed to comply with in order to gain access to both the local and international market to sell their produce. The comparatively favourable prices they get for their product serve as an incentive to adopt more economically efficient input allocations measures. GlobalGAP certification therefore was expected to have a negative relationship with inefficiency. Pruning was expected to have negative relationship with inefficiency. Both government support and presence of processing factory in the catchment area were expected to affect output level positively, hence a negative relationship with inefficiency.

The parameter estimates (coefficients) in the mean and variance functions of inefficiency will shows how exogenous variables influence the expected levels and the stability of production inefficiency, respectively. Here positive coefficients of exogenous variables in the mean function of inefficiency indicate that these variables have negative impact on production efficiency. However, their negative coefficients in the variance functions of inefficiency indicates that their employment in production decrease the variance of production inefficiency (i.e. efficiency enhancing). On the other hand, negative coefficients of variables in the mean function of production inefficiency indicate their employment in production has positive effects on production efficiency. Positive coefficients in the variance function of inefficiency imply increasing variance of inefficiency (i.e. efficiency decreasing).

Data Processing and Analysis

After content analysis of the raw data, it was coded and cleaned. SPSS template was created and the coded and cleaned data was entered. The data was further cleaned in SPSS software package. Data for descriptive statistics was retained in SPSS for the descriptive statistical analysis. Data for efficiency analysis was exported into EXCEL spreadsheet and for further processing and cleaning. The organized and cleaned excel data was subsequently imported into R programming software package for the Stochastic Frontier Analysis. In R programming software, several diagnostic tests were conducted to evaluate the quality of the models in explaining the data to see if it would pass for regression analysis. Shapiro-Wilk normality test confirms that the data was normally distributed. In addition, the Breusch-Pagan test revealed that heteroskedasticity was absent in the data. Finally, the Dabin-Waston test revealed that there was no autocorrelation in the data.

Table 1: Diagnostic test for evaluating model quality in explaining the data

Diagnostic test	Technical efficiency model	Cost efficiency model
Shapiro-Wilk normality test (W)	W: 0.9766 P-value: 0.2826	W: 0.9486 P-value: 0.1148
Breusch-Pagan test for heteroskedasticity (BP)	BP: 8.5559 P-value: 0.1281	BP: 22.8795 P-value: 0.1120
Durbin-Watson test for autocorrelation (DW)	DW: 2.1877 P-value: 0.8087	DW: 1.9767 P-value: 0.3692

Source: Filed Data, 2014

Information from focused group discussion and observation were manually organized. This was used as guide for better understanding of mango production and for precise discussions of results. Empirical analysis of data collected was done using Descriptive statistics and econometric analytical techniques.

Descriptive statistic was employed to analyze the State of Mango Production

Means, percentages, frequencies, and standard deviations were statistically generated, and used to describe the state of mango production. The coordinates that were analyzed and described included farm-specific variables, techniques and processes of production, levels and organization inputs, market information, output and input quantity levels, output price and input cost levels, profitability level and the distributions of efficiency levels.

Choice of Efficiency Estimation Method: Stochastic Frontier Analysis method was employed to analyze economic efficiency

The Stochastic Frontier Analysis (SFA) was chosen because it takes into consideration the random noise around the estimated production frontier. That is the SFA method decomposes random errors into error of farmer's uncontrollable factors, dependent variable as well as farm specific inefficiencies. A Standard stochastic frontier production and cost frontier functions were employed to estimate the technical and allocative efficiency in mango production, from which the economic efficiency was computed from the product of the two. The stochastic frontier production and cost frontier functions incorporate inefficiency factors that estimate the respective efficiency scores of producers.

The Cobb-Douglas functional form was adopted for the specification of the stochastic frontier production and cost frontier functions. The estimation was done using the Maximum Likelihood Estimation (MLE) technique. Even though, Coelli (1995a) indicated that the translog frontier function is less restrictive and permits combination of square and cross product terms to improve the fit of the model, the translog function being quadratic logarithmic function requires the estimation of many parameters. This makes interpretation of results difficult. On the other hand the Cobb-Douglas function being a linear logarithmic, requires estimation of fewer parameters and as such, is simpler to interpret. Furthermore, the translog model presents major problem in the significance of the estimated coefficients. This is because multicollinearity is an inherent problem within the translog model (Murillo-Zamorano & Vega-Cervera, 2000; Charoenrat & Harvie, 2013). In this regard, the Cobb-Douglas function presents itself as a better option if one wants to eliminate the problem of multicollinearity. The Cobb-Douglas model also meets the requirement of being self-dual, thus allowing an estimation of economic efficiency. Although, the Cobb-Douglas frontier restricts return to scale to take the same value across all farms and assumes elasticity of substitution to be equal to one, Kopp and Smith (1980) suggested that the Cobb-Douglas functional form does not sacrifice empirical efficiency.

The estimation was carried out for each production unit or decision-making unit separately, then for the sample, to obtain technical and allocative efficiencies as well as determinants of inefficiencies (technical and allocative). Coelli (1996) employed the Frontier 4.1c computer program in estimating the stochastic frontier. In addition, most literature on efficiency measurement employed the Frontier 4.1c computer program. However, in this study, stochastic frontiers were estimated for the individual mango farmers and the entire sample using R-Programming software package.

Specification of the Analytical Model for Stochastic Frontier Production Function (The Cobb-Douglas functional form):

The stochastic frontier production function originally and independently proposed by Aigner, Lovell, and Schmidt, (1977) was adopted. In a simple case of a single output and multiple inputs, the approach predicts the output from input by the functional relationship:

$$q_i = f(x_i\beta) + \varepsilon_i \ (i = 1, 2, ..., N) \quad (1.0)$$

Where q_i represent output of the i^{th} production unit (PU) being evaluated; X_i is a vector of functions of actual input quantities used by the i^{th}PU; β is a vector of parameters to be estimated; ε_i is composed error term (u which represent inefficiency effects and v stands for statistical noise effects) and N is the number of PUs.

The composed error term ε_i is decomposed into

$$\varepsilon_i = v + u \quad (1.1)$$

Thus, equation 1.1 can be written as:

$$q_i = f(x_i, \beta) + v_i + u_i \quad (1.2)$$

Where q_i represent output of i^{th} farmer; f (x_i; β) denotes a suitable function (in this case the Cobb-Douglas) of the row vector of input X_i

$$In(q_1) = \beta_0 + \sum_i \beta_i InX_{ij} + v_i - u_i \quad (1.3)$$

The estimation of parameters in equation (1. 3) depends on the distributional assumptions concerning the two error terms. $v_i s$ are assumed to be independent and identically distributed normal random errors having mean zero and variance (σv^2)and are also distributed independently of u_i; where $u_i s$ are non-negative inefficiency effects denoting management factors and are assumed to be independently distributed with mean u_i and variance σ^2 (Battese, Malik, and Gill, 1996). When the value of u_i is equal to zero, then it said that the i^{th} farm exploits the full technological potential. At this the farmer is said to be then producing at the production frontier, beyond which he cannot produce. Also, the greater the magnitude of u_i the far away will be the farmer from the production frontier and be operating more inefficiently.

Basically, estimation of the production frontier assumes that the boundary of the production function is defined by the "best practice" firm. Thus the stochastic frontier production function specified in model (1.3) distinguishes the observed output (q_i) from the frontier output ($.\mathrm{q}_i^*$) This is expressed mathematically as:

Observed output: $\mathrm{q}_i = X_i\beta + v_i - u_i$ (1.4)

Frontier output: $\mathrm{q}_i^* = X_i\beta + v_{ij}; \; u_i = 0$ (1.5)

Thus, the measure of technical efficiency of the i^{th} firm relative to the production frontier (1.3) of an individual production can be calculated as:

$$TE_i = \frac{q_i}{q_i^*} = \frac{X_i\beta + v_i - u_i}{X_i\beta + v_i} = \exp(-u_i) \qquad (1.6)$$

The TE expressed above depends on the value of the unobservable u_i being predicted. The difference between observed output (q_i) and the frontier output (q_i^*) is rooted in u_i. In this study u_i is assumed to have a truncated normal distribution and as stated by Battase and Coelli (1995), it is assumed to have a mean of μ_i and a variance $\delta^2 u$, $[u_i - (\mu_i, \delta^2 u)]$. TE picks a value between 0 and 1 in a production frontier. Thus, when $u = 0$ then the firm is said to be producing on the frontier (i.e., $q_i = q_i^*$) and is said to be technically efficient. On the other hand if $u > 0$, production will lie below the frontier and the firm is inefficient. Therefore, technically efficient firms are described as those that operate on the production frontier (that is Technical efficiency is equal to one). Hence, the measure of the level of technical inefficiency of any mango producing farm firm is described by the margin by which a mango producing farm firm lies below its production frontier.

In measuring efficiency in production, it is important to separate the composed error term (ε_i) as $\varepsilon_i = (v_i - u_i)$. Jondrow, Lovell, Materov, and Schmidt (1982) used the conditional distribution of u_i , given ε_i to extract the information that ε_i contains on u_i. The expected value of u_i conditioned on the composed error term ε_i is, estimated as $E(u_i / \varepsilon_i)$. Thus, having gotten the conditional estimates of u_i the individual producer's level of technical efficiency is computed by:

$$\mathrm{TE}_i = E(\exp\{-u_i\} \mid \varepsilon_i) \tag{1.7}$$

In this study, equation (1.3) is adopted. As indicated by Battese and Coelli (1988), the correct estimator should be based on the conditional expectation of the exponential of u_i. However, based on the distributional assumptions of the random errors maximum-likelihood single-stage estimation procedure proposed by Battese and Corra (1977) for the estimation of the parameters of model (1.2), and (1.3) and the firm-specific TE_i defined by (1.7) are expressed in terms of the parameterization below:

$$\delta^2 = \delta^2 v + \delta^2 u \tag{1.8}$$

$$\gamma = \frac{\delta^2 u}{\delta^2} = \frac{\delta^2 u}{(\delta^2 v + \delta^2 u)} \tag{1.9}$$

Battese and Corra (1977) indicated the parameter γ to be bounded between zero and one. Where the value of $\gamma = 1$ means that the deviation from the frontier are entirely due to technical inefficiency (inefficiency effects are completely stochastic). On the other hand, if the value of $\gamma = 0$, it indicates that the deviation from the frontier are entirely due to noise effects (inefficiency effects are non-stochastic). Hence, for $0 < \gamma < 1$, variability in output is characterized by the presence of both technical inefficiency and statistical noise.

Specification of the Operational Model for Estimating Technical Efficiency of Mango Farmers: (The Cobb-Douglas function form)

The yield (q) obtained from the production of mango involves the use of several inputs. The relation between output of mango and inputs used is thus, expressed as:

$$q = f(\text{Land}, \text{Labour}, \text{Equipment}, \text{Agrochemicals}, \text{fertilizers})$$

As indicated in equation 1.3, a Cobb-Douglas function fitted to the stochastic frontier production function is implicitly specified as:

$$In(q_1) = \beta_0 + \sum_i \beta_i InX_{ij} + v_i - u_i \quad (i = 1, 2, ..., 62; j = 1, 2, ..., 5)$$

Thus, the operational Cobb-Douglas model is specified as:

$$Inq_i = \beta_0 + \beta_1 InX_{i1} + \beta_2 InX_{i2} + \beta_3 InX_{i3} + \beta_4 InX_{i4} + \beta_5 InX_{i5} + v_i - u_i \qquad (1.10)$$

Where *j* represents the *j*th input (*j* = 1, 2…5) of the *i*th firm (1, 2, 3…62) for all *j* and *i*. q_i represents the physical output of mango produced measured in kilogram. However, this output will excludes the portion that is home consumed, stolen, rotten and given away as gift. X_{i1} is the total area planted with mango (in hectares); X_{i2} represents labour (measured in man-day equivalent); X_{i3} represents costs of Equipment used in production (measured in Ghana cedis); X_{i4} represents quantity of agrochemicals in liters; and X_{i5} represents quantity of chemical fertilizer (measured in kilograms). βs denotes a (Kx1) vector of parameters to be estimated. v_i represents the random variation in output (q_i) due to factors outside the control of the farmer such as weather and natural disasters. u_i denotes inefficiency due to factors within the control of the farmer, e.g. management.

Specification of the Analytical Model of Stochastic Frontier Cost Function used in estimating AE (Cobb-Douglas functional form)

This study adopted the SPF approach to estimates the AE of mango farmers in the Yilo Krobo municipality in the Eastern Region of Ghana by obtaining the cost frontier component of the self-dual production technology. This is achieved by transforming the production frontier into cost frontier. As indicated by Coelli (1996), in order to specify the cost frontier function, the composite error term specification of the production frontier is simply converted from $(v_i - u_i)$ to $(v_i + u_i)$. That is, the production frontier function becomes:

$$q_i = f(x_i, \beta) + v_i + u_i \qquad (1.11)$$

Thus, the cost frontier dual is specified as:

$$\mathrm{C}_i = f(\alpha W_{ij}) + f(q_i^a) + v_i + u_i \qquad (1.12)$$

When a linear homogeneity condition in input prices is imposed the above function becomes

$$\mathrm{C}_i / \mathrm{W}_n = f(\alpha W_{ij} / \mathrm{W}_n) + f(q_i^a) + v_i + u_i \qquad (1.13)$$

Where C_i is the minimum cost to produce output q, W_{ij} is a vector of input prices, and α is a vector of parameters to be estimated. q_i^a is the observed output adjusted for statistical noise and is specified as:

$$\mathrm{Inq}_i^a = \beta_0 + \sum \beta_i InX_{ij} - u_i = In(q_i) - v_i \qquad (1.14)$$

As indicated by Coelli (1996), the measures of technical efficiency relative to the production frontier $q_i = X_i\beta + (v_i - u_i)$, and cost efficiency relative to the cost frontier $q_i = X_i\beta + (v_i + u_i)$ are both defined as:

$$\text{EFF}_i = E(q_i^* \mid u_i, X_i) / E(q_i^* \mid u_i = 0, X_i) \tag{1.15}$$

Where q_i^* is the production (or cost) of the i^{th} firm, which will be equal to q_i when the dependent variable is in original units and will be equal to $\exp(q_i)$ when the dependent variable is in logs. In the case of a production frontier, EFF_i (i.e. efficiency) will take a value between zero and one, while in the case of cost function; it will take a value between one and infinity. In this cost function the u_i now defines how far the firm operates above the cost frontier. If allocative efficiency is assumed, the u_i is closely related to the cost of technical inefficiency. When this assumption is not made, the interpretation of the u_i in a cost function is less comprehensible, with both technical and allocative inefficiencies possibly involved.

Allocative efficiency (AE) of individual farmers is now expressed in terms of the ratio of the predicted minimum cost (C_i^*) to observe cost (C_i).

That is:

$$AE = C_i^* / C_i = \exp(u_i) \tag{1.16}$$

Thus as indicated by equation (1.16), allocative efficiency is simply the reciprocal of the cost efficiency given by the production frontier model. As such, allocative efficiency varies between zero and one. The mean economic efficiency score is thus, obtained by computing the product of the mean technical efficiency score and the mean allocative efficiency score.

Specification of the Operational Model for Estimating Cost Efficiency of Mango Farmers: (The Cobb-Douglas Function form)

For the estimation of allocative efficiency, the cost frontier dual to the production frontier function presented in equation (1.13) is adopted for this study. Adopting the Cobb-Douglas function, equation (1.13) now becomes:

$$\text{InC}_i / \text{W}_n = \alpha_0 + \sum_i \alpha_i (InW_{ij} / \text{W}_n) + \theta In(q_i^a) + v_i + u_i \qquad (1.17)$$

In this function, independent variables are the prices of input for production and the total output that will be adjusted for any statistical noise computed by the model (1.14).

Now the operational model for estimating cost efficiency with linear homogeneity in input prices imposed becomes:

$$\text{InC}_i / W_{i6} = \alpha_0 + \alpha_1 InW_{i1} / W_{i6} + \alpha_2 InW_{i2} / W_{i6} + \alpha_3 InW_{i3} / W_{i6} +$$
$$+ \alpha_4 InW_{i4} / W_{i6} + \alpha_5 InW_{i5} / \text{W}_{i6} + \theta_6 Inq_i^a + v_i + u_i \qquad (1.18)$$

Where C_i denotes minimum cost of production per farm (measured in GH¢); W_{i1} stands for cost per hectare of land (measured in GH¢); W_{i2} represents hired cost of labour per persons-day (measured in GH¢); W_{i3} denotes cost of equipment (measured in GH¢); W_{i4} denotes cost of fertilizer (measured in GH¢); W_{i5} stands for cost of agrochemical (measured in GH¢); W_{i6} represents total cost incurred on transportation; and q_i^a represents the observed output of mango adjusted for any statistical noise, contained in v_i; $\alpha_0 \ldots \alpha_6$, and θ_7 are the coefficients of unknown parameters to be estimated.

Computation of Economic efficiency

The economic efficiency of mango production for individual farm firm was then estimated by computing the product of Technical efficiency score and Allocative efficiency score obtained. That is $EE_i = TE_i * AE_i$

Specification of the Analytical Model for Estimating Technical and Allocative inefficiencies of Mango Farmers

Battese and Coelli (1995) indicated that the distribution of mean inefficiency (m) is correlated to the farmer-specific and farm-specific characteristics of producers. Mean inefficiency (m_i) would be equal to the mean of u_i if this random variable were not truncated. Due to the truncation, m_i is no longer equal to the expectation of u_i. Thus for a truncated random variable with distribution parameters m and δu, the expectation is given as:

$$E(m_i) = m + \delta u\{\varphi(\frac{-u}{\delta u})[1 - \Theta(\frac{-u}{\delta u})]^{-1}\} \tag{1.19}$$

Where φ represents the probability density function of a standard normal distribution, and Θ is the corresponding cumulative distribution function. The m_i in the model, considered to explain inefficiency, is parameterized to be a function of vector Z_i (i.e. the potential explanatory variables for differences in inefficiency) in order to relate Z_i to the distribution of the inefficiency (m_i).

The inefficiency model is specified in this study as:

$$m_i = \delta_0 + \sum_{n=1}^{t} \delta_n Z_{in} \qquad (1.20)$$

Where t represent the total number of explanatory Z variables and δ s represents the parameter coefficients of the explanatory Z variables. Thus, regression analysis was employed as the estimation technique for the determinant of technical and allocative efficiency in mango production.

Specification of the Operational function for the inefficiency model:

The operational functional form which was incorporated into the single-stage Stochastic Frontier model proposed by Battese and Coelli (1995) is expressed as

$$\begin{aligned} m_i = {} & \delta_0 + \delta_1 Z_{i1} + \delta_2 Z_{i2} + \delta_3 Z_{i3} + \delta_4 Z_{i4} + \delta_5 Z_{i5} + \delta_6 Z_{i6} \\ & + \delta_7 Z_{i7} + \delta_8 Z_{i8} + \delta_9 Z_{i9} + \delta_{10} Z_{i10} + \delta_{11} Z_{i11} \qquad (1.21) \end{aligned}$$

Where the Zs represents the exogenous variables causing inefficiency and δs are the coefficients associated with inefficiency variables. Z_1 stands for age of farmer in years; Z_2 stands for gender of farmers (dummy); Z_3 stands for household size, in numbers; Z_4 stands for level of education, in ranks; Z_5 stands for experience of famers, in years; Z_6 stands for number of extension visits in numbers; Z_7 represent access to credit (dummy); Z_8 represent GlobalGAP certification (dummy); Z_9 represent access to government support (dummy); Z_{10} represent effect non-availability of processing factory (dummy), and Z_{11} represent number of times pruning is done in the year.

Definition of Output and Input Variables

Output (Q): Amount of mango harvested from a hectare of land, measured in kilogram.

Land (LA): Total area planted with mango in hectares.

Labour (LB): Total number of family and hired labour employed in mango production, measured in person-day. Eight person-hours are equal to one person-day. Eight female-hours is equal to 0.75 person-day and eight child-hours are equal to 0.50 person-days (Olayide and Heady, 1982)

Equipment (EQ): Cost of items that are directly involved in the production process, measured in Ghana cedi.

Fertilizer (FT): Quantity of commercially formulated plant nutrient used per hectare of land, measured in kilogram.

Agro-chemicals (AC): Quantity of agro-chemical used per hectare of land, measured in litres.

Definition of Cost Variables (All measured in Ghana cedi)

Cost of Land (CLA): Cost assigned to the use of land for the production period under review

Cost of Labour (CLB): Total amount paid on the total amount of labour used within the production period under review

Cost of Equipment (EQ): Cost of items that are directly involved in the production process, measured in Ghana cedi.

Cost of Fertilizer (CFT): total amount spent on the total quantity of commercially formulated plant nutrient used within the production period under review.

Cost of Agro-chemicals (CAC): total amount spent on the quantity of agro-chemical used within the production period under review.

Definition of Farmer and Farm-Specific Variables

Age: Age of the mango farmer measured in years.

Sex: Sex of the mango farmer, measured as a dummy variable and has a value of 1 is recorded if the farmer is a male and 0, if female.

Educational level: The highest level of education attained by farmers, measured in years (i.e., the number of years spent in school by the farmer).

Experience: defines the numbers of years farmers have being engaged in mango production and this was measure in years.

Access to extension services: Number of extension visit received, measured in numbers.

Pruning: measured in number (i.e., the number of time pruning is carried out in a production year).

Access to credit: Measured as a dummy variable, where a value of 1 represents a yes response and 0 for no response.

GlobalGAP certification: This is to determine whether the farmer is GlobalGAP certified or not. Measured as a dummy variable, where 1 stands for a yes response and 0 for a no response.

Access of Government Support: This determines whether there exist any specific government supports for the mango industry Measured as a dummy variable, where 1 stands for a yes response and 0 for a no response.

Establishment of processing factory in the study: This was to access the effect of absence of processing factory in the production catchment area on farmers' output level measured as a dummy variable 0 for a No and 1 for a Yes.

Kendall's Coefficient of Concordance was employed to test degree of agreement among farmers concerning constraints facing mango production for objective four.

Kendall's W was used to establish and test the degree of agreements and disagreements among farmers in ranking the constraints facing mango production. Kendall's W, is a strength of relationship index that measures the degree of agreement among several judges (λ) who assess a given set of *m* concerns. Mango farmers were the judges in this study. The coefficient of concordance ranges from 0 to 1, where higher values indicate a stronger relationship and 0 indicates no agreement across judges (raters).

Basically, Kendall's W statistic is an estimate of the variance of the sums of ranks (K) divided by the maximum possible value that the variance can take. The idea of this statistic is to find the sum of ranks for each concern being rated and then examine variability of this sum. Mattson (1986) noted that when the ranking are in perfect agreement, the variability among these sums will be a maximum. The analysis is a statistical procedure that is used to identify and rank a given concerns (constraints) from the most constraining one to the least constraining one, using numerals in the order 1,2,3,4….m. The degree of concordance between these constraints is then measured after the ranking.

The total rank score computed is then used to estimate the Coefficient of Concordance (W) which measures the degree of agreement (concordance) in the rankings. To derive the formula for W, the sum of all ranks in data, given as $\frac{\lambda m(\mathrm{m}+1)}{2}$ and the sum of squares of all ranks, given as $\frac{\lambda^2 \mathrm{m}(\mathrm{m}+1)(2m+1)}{6}$ has to be estimated.

The limits for Kendall's W cannot be greater than one and cannot be negative as well. Thus the index can only be positive in sign. Kendall's W picks the value of 1 when the ranks assigned by each farmer are exactly the same as those assigned by other farmers (indicating total agreement among producers). On the other hand, if Kendall's W becomes 0 then, there is a total disagreement among the respondents.

Now Since K denotes the sum of ranks for each concern being ranked, the variance of the sum of ranks, Var_k , can be expressed as:

$$\mathrm{Var}_k = \frac{\sum K^2 - (\sum K)^2 / \mathrm{m}}{m} \tag{2.0}$$

From this the maximum variance of K is can be specified as:

$$\frac{\lambda^2(\mathrm{m}^2-1)}{12} \quad (2.1)$$

From the above specification, Kendall's W can be stated as:

$$w = \frac{\{\sum K^2 - (\sum K)^2 / \mathrm{m}\} / \mathrm{m}}{\lambda^2(m^2-1)/12} \tag{2.3}$$

Equation 2.3 above can now be simplify as $w = \frac{12\{\sum K^2 - (\sum K)^2\} / \mathrm{m}}{m\lambda^2 (m^2 - 1)}$

Where:

K = sum of ranks for each constraint being ranked,

λ = number of rankings (farmers) and

Total mean score for each constraint ranked was calculated and the constraints with the highest mean score was rank as the most pressing whereas the one with the lowest mean score was rank as the least pressing constraint. In the study the constraints associated with mango production in the Yilo Krobo municipality was measured on a scale of 1 to 10; where 1 means the least and 10 means the highest.

Hypotheses Testing

The generalized likelihood ratio test (LR) was use to test hypotheses1, 2 and 3.This was specified as:

$\lambda = -2\{\log [\text{Likelihood (Ho)}] - \log [\text{Likelihood } (H_1)]\}$,

Where, L (H_0) and L (H_1) are values of likelihood function under the null hypothesis (H_0) and alternative (H_1) hypothesis. LR approximately has a chi-square (or mixed Chi-square) distribution if the given null hypothesis is true with a degree of freedom equal to the number of parameters assumed to be zero in (H_0). According to Coelli (1999b) all the critical values can be obtained from appropriate Chi-square distribution. However, as noted by Kodde and Palm (1986, p.1246), if the test hypothesis involves $\gamma = 0$, then the asymptotic distribution necessitates mixed chi-square distribution.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Introduction

This chapter presents the empirical findings of the study. The analyses and interpretation of data collected presented covers the state of mango production, the estimation of economic efficiency in mango production, the determinant of economic efficiency and the constraints to mango production respectively.

STATE OF MANGO PRODUCTION IN THE YILO KROBO MUNICIPALITY

To answer the first objective data was collected and analyzed on the following variables: farm-specific variables, techniques of production, market information, input and output levels, input cost and output price levels and profitability. A descriptive statistics (means, frequency, percentages, and standard deviation) was employed as the analytical tool to describe the state of mango production in the study area.

Production level:

Input and Output Quantity Levels

From the result, it was discovered that the average total output level of mango was 38814.55kg. As shown in the Table 2, this output level was obtained by using inputs combination of 2.54 hectare of land, 372.73 person-day of labour, Gh¢ 554.50 of equipment, 438.71kg of fertilizer, and 127.42 litres of agrochemicals. In addition, the results revealed that the average plant population was 433.00 mango trees with a mean output level of 20217.74kg for the first mango season and 19943.55kg for the second mango season. The z-test test results proved that there was no significant difference in output levels between the first and second mango seasons as experienced in the study area. This result implies that, farmers can obtain satisfactory and optimum yield from both seasons. This cushioned farmer against the risk of seasonal output loses.

Table 2: Summary Statistics for Inputs-Output levels

Input Quantity Level of Respondents				
Inputs	Mean	Maximum	Minimum	Standard Deviation
Land (hectares)	2.54	3.20	2.00	0.33
Labour (man-day)	372.73	462.00	300.00	48.24
Equipment(GH¢)	554.50	800.00	400.00	18.23
Fertilizer (Kg)	438.71	550.00	300.00	81.69
Agrochemicals(liters)	127.42	160.00	100.00	19.24

			Output Quantity Levels of Respondents		
Output (in kg)	Mean	Maximum	Minimum	Standard Deviation	Z-value & *P-Value
First Season	20217.74	27000.00	14500.00	333.44	0.4057
Second Season	19943.55	26000.00	14500.00	318.37	
					*0.6849
Overall	38814.55	53500.00	25000.00	801.48	

Source: Field Data, 2014 alpha level= 0.05

Input Cost and Output Price Levels

From the empirical results as presented in Table 3, the average total cost incurred in producing 38814.55kg of mango in the study area was found to be Gh¢ 6040.98 with a range of Gh¢ 8720.00 to Gh¢ 4446.00. In addition, the average costs for the various inputs combined in the production process were found to be Gh¢ 382.26 as cost of land, Gh¢ 3727.26 as cost of labour, Gh¢ 554.50 as cost of equipment, Gh¢ 614.19 as cost of fertilizer, Gh¢ 551.05 as cost of agrochemicals, and Gh¢211.69 as cost of transportation.

Table 3: Summary Statistics for Inputs Cost and Output Price Levels

Input Price Level face by Respondents				
Input Cost (GH¢)	Mean (GH¢)	Maximum (GH¢)	Minimum (GH¢)	Standard Deviation (GH¢)
Land	382.26	480.00	300.00	57.73
Labour	3727.26	4620.00	3000.00	82.42
Equipment(GH¢)	554.50	800.00	400.00	18.23
Fertilizer	614.19	770.00	420.00	43.26
Agrochemicals	551.50	780.00	390.00	31.56
Transportation	211.69	300.00	150.00	50.64
Output Price and Profit levels of Respondents				
Output (GH¢)	Mean (GH¢)	Maximum (GH¢)	Minimum (GH¢)	Standard Deviation (GH¢)
Total Revenue	23288.71	32100.00	15000.00	492.89
Total Cost	6040.98	8720.00	4446.00	159.08
Profit	17247.33	25030.00	10410.00	424.03

Source: Field Data, 2014

The analysis showed that labour alone accounted for 61.69% of total cost of production. The rest is as follow Land 6.33%, fertilizer 10.17%, agrochemical 9.13%, transportation cost 3.50% and equipment 9.18% respectively. In addition, the average total revenue obtained from mango production was Gh¢ 23288.71 and the average profit was Gh¢ 17247.33 respectfully.

Production Technology:

Land Preparation and Weed Control Methods

The results presented in Table 4 are multiple response questions and as shown in the Table, the land preparation method that was used by farmers were slash and ploughing method (62 farmers), and slash, burn and ploughing method (61 farmers) respectively. In addition, the results revealed that in controlling weeds, slashing (62 farmers) and chemical applications (61 farmers) were jointly used by the respondents in the study area. Farmers indicated that they adopt these land preparation methods due to the nature of the land and vegetation type in the area. Farmers said after clearing the land, stumps are remove after which the land is again plough before seedlings are planted.

Table 4: Land Preparation and Weed Control Methods used by Farmers

Land Preparation Method	
Method	Frequencies
Slash and ploughing with machines	63
Slash, burn and ploughing with machines	61
Weed Control Method	
Method	Frequencies
Slashing with cutlass	62
Use of Chemicals	61
Use of Tractor	1

Source: Field Data 2014

Varieties of Mango Grown by Respondents

As shown in Table 5, Keitt and Kent were the major varieties of mango grown by farmers in the municipality. The results indicated that the number of farmers that grew Keitt was sixty and that of Kent were forty-six. This result implies that an individual farmer grows both varieties and either Keitt or Kent variety. Interview with farmers revealed that they cultivate these varieties due to the good market that exist for their fruits. Farmers also indicated that in terms of yield, these varieties guarantees high returns on investment.

Table 5: Varieties of Mango Grown by Farmers

Mango Variety	Frequencies	Percentages
Keitt	60	96.8
Kent	46	74.2
Palmer	1	1.6

Source: Field Survey, 2014

Pest and Disease Control Method

The results from the analysis indicated that all the 62 respondents interviewed adopted chemical means in controlling pests and disease situations in their production. This they do in conjunction with good farm sanitation. Chemical control seemed best to farmers as it provided the fast and effective way of checking pests and disease effect on fruit quality and output level. Respondents indicated that some of the major pests and diseases facing farmers in the municipality include fruit flies, anthracnose and other fungal and bacterial infestations. This according to farmers was a major drain on their productivity as it has affected their access to the export markets.

Pruning Activity and Harvesting Methods

Pruning as an activity is very important in mango production as it determines output level and fruit size of mango. As such, the result from the analysis indicated that all the respondents interviewed carried out pruning on their farmers. However, in terms of the frequency of pruning activity within the production year, 38 representing 61.3% of the respondents said they carry out pruning twice in the year. That is one at the end of the major season and one at the end of the minor season to prepare the trees for the next fruit season. In addition, 24 representing 38.7% responded that they carry out pruning once in the production year. An interview with a technical officer and an expert in mango production revealed that, the canopy area is proportional to the root area. As such, pruning is a very important single factor that can influence the level of mango output.

Table 6: Pruning activity and harvesting methods

Number Of Times Pruning is done in the Production Year		
Method	Frequencies	Percentages
Twice	38	61.3
Once	24	38.7
Harvesting Techniques used by farmers		
Method	Frequencies	
Use of harvesting cutter	62	
Hand plucking of fruit	61	

Source: Field Data, 2014 n = 62

On the issue of harvesting methods, as indicated in Table 6, farmers employed a multiple of techniques in harvesting their fruits. From the Table, all the respondents indicated they used harvesting cutter for fruit harvesting. In addition, 61 of them adopted hand plucking as a means of harvesting fruit.

This does not support the finding of Akurugu (2011) in which he indicated that mango farmers in the northern region used knife (57.8%) in carrying out harvesting whereas 20.13% handpicked their fruit and 16.7% shake the tree. Impact from fruit dropping was found to cause bruises to fruit and this reduces the market quality of harvested fruit.

Means of Transporting Mango Fruits to the Market

As shown in Table 7, majority of respondents transports their fruits to markets by either commercial vehicle or processing companies' vehicle, where commercial transport represents 95.2% and processing companies' vehicles making up 62.9% respectively. The result also indicated that all respondents (100%) packaged their fruit in boxes/crates for transport. From this, it can be inferredred that the average farmer is using the standard packaging methods and this reduced extensive bruise to fruit thus minimizing post-harvest lost due to handling of fruits during transit to market.

Table 7: Means by which Respondent Transport their Fruit to Market

Means of Transport	Frequencies	Percentages
Commercial Vehicle	59	95.2
Company Vehicle (Processing Companies)	40	64.5
Own Vehicle	3	4.8

Source: Field Data, 2014 n = 62

Access to Production Inputs:

Land Acquisition System in the Study Area

As shown in Figure 4, 61.2% of the respondents indicated that the land they use for their production was their own land and this they indicated it was an outright purchase or by inheritance. Also, 19.4% of them acquired their land through leasehold whiles 19.4% acquired theirs from family land. The impulse of this finding suggests that on the medium to long-term basis, the survival of majority of the farms is highly guaranteed. This is because the farmers are secured against danger of farmers losing their farms due to land litigation.

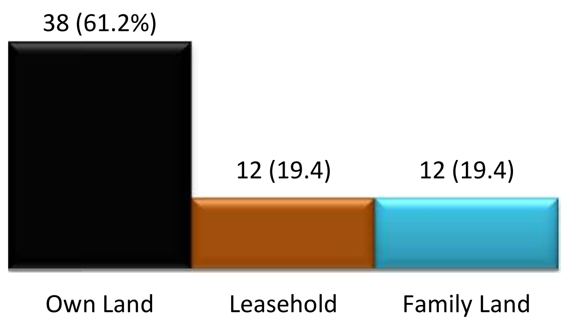


Figure 4: Land Acqusition Process by Famers

Source: Field Survey, 2014 n = 62

Access to Credit Facilities and Sources of Finance

As shown in Table 8, 87.1% of the respondent did not have access to credit. The result also indicated that majority of the farmers (98.4%) depended on their own saving to finance their farming business. By implication, it can therefore be inferredred that the farmers' capacity to intensify their production is limited. This is because credit is a major factor to increasing farmers' capital resource base as well as improvement in their human resource through capacity building. As indicated by Zeller, Schrieder and Heidhues (1997) access to credit help alleviate capital constraints on agricultural household and as well, as increase household's risk-bearing ability. As such, access to credit impacts on farmers ability to access agricultural inputs and altering of risk-coping strategies.

Table 8: Access to Credit and Source of Finance

Sources of Finance for Production		
Source Of Finance	Frequencies	Percentages
Own Savings	61	98.4
Family and Relatives	6	9.7
Financial Institutions	6	9.7
Access to Credit		
Response	Frequencies	Percentages
Access	8	12.9
No Access	54	87.1
Total	62	100

Source: Field Data, 2014

In addition, according to Diagne and Zeller (2001) inadequate access to credit is believed to have significant negative consequences for various aggregate and household-level outcomes, including technology adoption, agricultural productivity as well as overall household welfare. Based on this we can conclude from the results of this study that farmers' ability to expand their capital base and their risk-bearing ability is somewhat limited.

Access to Extension Services

It was discovered that, most (98.3%) of the respondents had access to extension services as shown in Table 9. The result also showed that, on the average, farmers receive about 6 times extension visits within the production year. This indicated that farmers are able to access information on innovations and technologies as well as sharing their problems and production constraints. Given this, farmers would be able to improve on their productivity. Access to extension service has been identified as a major factor that influences farmers' productivity level. As such, when farmers' access to extension service is at a significant level, productivity impact is usually good.

Table 9: Access to Extension Services

Access to Extension Services		
Responses	Frequencies	Percentages
Access	61	98.3
No Access	1	1.7
Total	62	100
Number of Times Respondents Receive Extension in a Production Year		
Responses	Frequencies	Percentages
0	1	1.7
1 – 5	39	62.9
6 – 10	22	35.5
Total	62	100.0
Mean = 5.819; Standard deviation = 2.217; Min = 0 ; Max = 10		

Source: Field Data, 2014 n=62

Access to Technical Training on Mango Production

The results from the study indicated that all the respondents interviewed had received technical training on mango production and that access to technical training and information on mango production is now not a problem. As shown in the Table 10, majority of this training is provided by the mango farmers association followed by NGO's and processing companies, AEAs and as well as fellow farmers in that order. This result implies that farmers would be able to improve on their productivity as they continue to receive current and modern information and training on mango production. It can also be concluded that, inefficiency in production could be reduce as the training help to increase farmers' efficiency in production as they are taught to adopt and use best production practices.

Table 10: Source and Access to Technical Training

Service Provider	Frequencies	Percentages
NGOs and Processing Companies	47	75.8
Mango Growers Association	62	100.0
AEAs	45	72.6
Fellow Farmers	38	61.3

Source: Field Data, 2014 n = 62

Access to Storage and Good Transport Facilities

All the 62 respondents interviewed indicated that they do not have access to storage facilities in the municipality. As a results of this in situations of bumper harvest most of the fruit goes rotting, especially when buyers are not able to absorb all the produce from their farms. On transport facilities, 44 representing 71% of the respondent said that, they have access to good transportation system. These farmers had their farms close to the main road system so were not having any difficulties transporting their produces to the buying centers. On the other hand 18 representing 29% of the respondent said that that they lack access to good roads. This was due to the fact that their farms were far from the main road system making access to their farms quiet difficult especially when there are heavy rains.

GlobalGAP Certification

From the result, it was discovered that 54 respondents interviewed, representing 88% had GlobalGAP certification. Also, 8 representing 12% did not have GlobalGAP certification. This implies that most of the farmers are able to market their products to international and local buying companies as they adopted and uses best agricultural practices internationally accepted in their production practices.

Availability of Government Support and Effect of absence of Processing Factory in the municipality on famer productivity

As shown in Table 11, it was discovered that most (91.9%) of the respondents interviewed indicated they do not have access to any government support for the industry, neither have they received any support from the government.

Table 11: Availability of Government Support and Processing Factories

Access to Government Support for the Mango industry		
Response	Frequencies	Percentages
No Access	57	91.9
Access	5	8.1
Total	62	100
Effect of unavailability of Processing Factories in the Municipality affecting your output level		
Response	Frequencies	Percentages
Significant impact	59	95.2
No significant impact	3	4.8
Total	62	100

Source: Field Data, 2014

The result further indicated the majority (95.2%) agreed the absence of a processing facility or company in the municipality or catchment areas is indeed having a downturn on their productivity as most of their fruit most a time goes waste. In addition, it was realize that these two factors affect the production capacity of the industry in the municipality given the greater economic prospect and viability the municipality shows in the production of mango. As a matter of fact it is the only mango growing area that has the bimodal season of mango production in Ghana (MoFA, 2013).

Farmer-specific characteristic

The mean age of mango farmers was found to be 56 years with a minimum age of 29 and maximum age of 75 years respectively. This result shows that the average age of mango farmers in the study area is within the active working age class. However, by implication one could inferred from this result that mango farmers in the study area are ageing, a condition that may affect their overall efficiency level. However, the average age in this study is four years more than the average age of cocoa farmers in Ghana estimated by Anaani, Anchirinah, Asamoah and Owuso-Ansah (2011). In addition, it was realized from the results that out of the 62 mango farmers interviewed, 56 representing 90.3% of them were males and 6 representing 9.7% were females. This suggests that the industry is male dominated. The result confirms the fact that cash crop production in Ghana is generally male dominated. In addition, this result confirms the findings of Akurugu (2011) in a study conducted in the northern region of Ghana on the evaluation of post-harvest handling and marketing of mango in which 85.9% of the mango farmers interviewed were males.

The result revealed that majority (98.3%) of the respondents had some level of education. Out of this, 48.4% had tertiary education. Asadullah and Rahman, (2005) emphasized the needs to acknowledge the importance of education in an agrarian society. As education is expected to improve productivity in human activity, it can be concluded from this findings that, there would be a positive returns to farm productivity. This is so because, educated farmers are often better managers, adopt more modern farm inputs and technologies. In addition, from the result it was realized that the mean household size was 6 with a range of 2 to 12 and standard deviation of 2.25. From the result, it could be deduced that on the average, household labour that can be supplied to mango production is six persons.

The average farming experience in mango production was found to be 11.2 years with a minimum of 7 years and a maximum of 21 years respectively. This result indicated that the average farmer has acquired significant level of experience in the production activity involved in mango production. It is thus expected that the average mango farmer would be more efficient in resource allocation due to his/her appreciable level of experience in mango farming. This is because it has been realized that experience turns to improve the way farmer do things, which in turns improve their productivity over time.

Productivity Level:

Scale of Production and Returns to Scale in mango production

Table 12 shows the empirical results on the output elasticities of production with respects to the various input employed. This represents the coefficient of the parameters obtained from the Cobb-Douglas production function. The Returns to Scale (RTS) of 1.1291 represent the summation of the output elasticity of production of the inputs variables employed in mango production. As shown in Table 12 this value indicated that, mango production in the study area exhibit increasing returns in production.

Table 12: Elasticities of Production and Return to Scale

Variables	Coefficient
Land	0.8391***
Labour	0.1133*
Equipment	0.0645*
Fertilizer	0.0581*
Agrochemicals	0.0435*
RTS	1.1291

Source: Field Data, 2014

From the results it as presented in Table 12, it was identified that an output elasticity of land is 0.8391, labour is 0.1133, equipment is 0.0645, fertilizer is 0.0581 and agrochemical is 0.0581 respectively. Intuitively mango farmers have the potential to optimize their farm output level from the efficient allocation and combination of the various inputs at their disposal.

Market Information:

Target Market and Access to Mango Market (local and Export)

From the analysis, it was realized that all the respondents indicated that access to the export market was very difficult. One reason they gave was high fruit quality requirement and this they indicated was difficult to meet due to prevailing pests (especially fruit flies) and disease (especially anthracnose) situation confronting them. However, access to local market as indicated by all respondents was better. This is because farmers have access to processing companies who buys their produce. Respondents also indicated that market women come in to buy the portion that the processing companies are not able to absorbed. All farmers interviewed said that both the local and export prices received for mango fruits were satisfactory.

Table 13: Target markets for mango producing farmers

Target Market for farmers		
Market	Frequencies	Percentages
Local Market Women	62	100.0
Local Processing companies	62	100.0
Export	39	62.9
Proportion of famers were able to export some of their output		
Response	Frequencies	Percentages
Not able to Export	39	62.9
Able to Export	23	37.1

Source: Field Data, 2014 n = 62

As shown in Table 13, all the respondents said they produced for both the local market women and local processing companies like Blue Skies. However, only 62.9% of the respondents indicated they produce for the export market. The results also indicated that 37.1% of the respondents were able to export some of their produce last production season. Farmers attributed the situation to poor fruit quality due to the effect of fruit flies and anthracnose.

ECONOMIC EFFICIENCY OF MANGO PRODUCTION

The economic efficiency in mango production in the Yilo Krobo Municipality was examined by estimating the technical efficiency and allocative efficiency in mango production. The product of the technical efficiency scores and allocative efficiency scores for the individual farmers gave the economic efficiency score for the individual mango farmers.

Estimates of Technical and Allocative Efficiencies in Mango Production:

Technical Efficiency Estimates

Table 14 presents the empirical results for the maximum likelihood estimates of the parameters for the Cobb-Douglas stochastic production function used in estimating the technical efficiency of mango farmers in the study area. The estimates were obtained by using the frontier (sfa) function in the R statistical package version 3.0.3. The result shows that the estimated production function is monotonically increasing in all inputs. In addition, the estimated sigma square (σ^2) of 0.0062 and gamma of 0.9182, which were found to be significantly different from zero, suggest a good fit of the model and the correctness of the specified distributional assumptions. In addition, the gamma parameter of 0.9182, which was significant at 1 percent, indicates the presence of inefficiency and that technical inefficiency effects are significant in determining the level and variability of mango yield in the Yilo Krobo Municipality. From theory, the gamma picks values between zero and one and this indicate the importance of the inefficiency term. when gamma equal to zero, it means that inefficiency term μ is irrelevant or absent and when it equal to one it means noise term v is irrelevant and that technical inefficiency accounts for all deviations from the production frontier (Henningsen, 2013).

The estimated gamma parameter of 0.9182 implies that both inefficiency and statistical noise are important for explaining the deviations from the production frontier. However, inefficiency is more important than noise. To estimate the proportion of total variance due to inefficiency the R programming language was used and a value of 0.9162 was obtained. This implies that 91.62% of the variance is totally due to technical inefficiency effects whiles only 8.38% was due to statistical noise effects.

Table 14: Maximum Likelihood Estimates of Stochastic Frontier Production Function

Variables	Parameters	Coefficient	Standard Error	Z-value
Constant	β_0	8.2328***	0.6875	11.9749
Log(LA)	β_1	0.8391***	0.1575	5.3278
Log(LB)	β_2	0.1133*	0.0633	1.7891
Log(EQ)	β_3	0.0645*	0.0391	1.6494
Log(FT)	β_4	0.0581*	0.0421	1.3814
Log(AC)	β_5	0.0435*	0.1432	0.3037
Variance parameters				
Sigma-squared	σ^2	0.0061***	0.0017	3.6703
Gamma	γ	0.9182***	0.0758	12.1203
Log Likelihood function		100.3145		

Note:*, **,; Statistically significant at alpha levels of 10 %, 5 % & 1 % respectively***

Source : Field Data, 2014

The gamma value of 0.9182 obtained in the study was found to be 0.1012 more than that obtained by Ogundari and Ojo (2007) when they examined the technical, allocative, and economic efficiencies of smallholder farmers. It was also realized that estimated gamma parameter for this study is almost twice that obtained by Khan and Saeed (2011) when they estimated the technical, allocative, and economic efficiencies of tomatoes farms. They found a gamma parameter of 0.47 and this implies that the level of inefficiency exhibited by mango farmer in the Yilo Krobo municipality was higher than those farmers investigated by these authors. The results also revealed that all the coefficients of the parameters were positive and that they were all significant predictors of output level of mango in the study area. The explanatory variables labour equipment, agrochemical and fertilizer in the stochastic production frontier function were significant at ten percent alpha level whiles that of land was significant at one percent alpha level. The positive coefficients of land, labour, equipment, fertilizer, and agrochemicals means that as these variables are increase by one percent, output level of mango will increase. The coefficients of the input variables therefore define the output elasticities of production. Thus, it can be concluded that for the mango industry in the Yilo Krobo Municipality land, labour, equipment, fertilizer and agrochemical are very important resources. From this result an efficient and optimal use agrochemical would help reduce if not eradicate the negative impact of pest and disease on mango production in the area. This is so because, the increasing incidence of pests such as fruit flies and diseases such as anthracnose has been identified as major treat to the promising mango industry in the municipality and that it results in major decline in output level of mango (MoFA, 2013).

Cost Efficiency Estimates

The empirical results of the coefficients of the parameters of the stochastic cost frontier function was estimated by the R programming software and the maximum likelihood estimates for the parameters of the cost frontier is presented in Table 15. In estimating the Cobb-Douglas stochastic cost frontier, a linear homogeneity in input prices was imposed. The results revealed that all the parameter coefficients were positive and this implies the estimated cost function is monotonically increasing in all inputs. The high gamma value of 0.9546 obtained implies that cost inefficiency was presents. This value being close to one suggests that both inefficiency and statistical noise explains the variance in the cost frontier function. As such, to know the total variance due to cost inefficiency, the R programming language was use to extract the proportion of variance due cost inefficiency and value of 1.00 was obtained. Thus, it can be concluded that the variance found was fully due to cost inefficiency. The large gamma value also suggests that there is a vast difference in cost efficiencies among mango farmers in the Yilo Krobo Municipality.

Table 15: Maximum Likelihood Estimates of Stochastic Frontier Cost Function for Allocative Efficiency with Linear Homogeneity in Input Prices

Variables	Parameters	Coefficient	Standard Error	Z-value
Constant	α_0	1.4182*	0.9957	1.4243
Log(CLA/CTR)	α_1	0.0042***	0.9413	0.0045
Log(CLB/CTR)	α_2	0.4082***	0.6736	0.6060
Log(CEQ/CTR)	α_3	0.0171	0.8174	-0.0209
Log(CFT/CTR)	α_4	0.2124***	0.5381	0.3948
Log(CAC/CTR)	α_5	0.0553***	0.9959	0.0555
Log(Output)	θ_7	0.0675***	0.1440	0.4684
Variance parameters				
Sigma-squared	σ^2	0.1224***	0.0001	844.8141
Gamma	γ	0.9546***	0.1569	6.0806
Log Likelihood function		38.2334		

Note: **, **,***; statistically significant at alpha levels of 10%, 5%, and 1% respectively*

Source: Field Data, 2014

The results also revealed that mango farmers have about ninety nine percent opportunity to improve their cost efficiency level as indicated by the statistically significant sigma squared (σ^2) value of 0.1223. Intuitively it can also be conclude from this result that out of the total variance cost efficiency level exhibited by the mango farmers, fifteen percent is attributed to factors outside the control of farmers such as market forces and climatic factors.

Analysis of Technical, Allocative and Economic Efficiencies of Mango Production

Table 16 presents the summary statistics of technical efficiency, allocative efficiency and economic efficiency as exhibited by mango farmers in the Yilo krobo Municipality. From the results, it was realize that the Technical Efficiency scores varied widely with a range of 0.9886 to 0.8319 and an average score of 0.9425. This result suggests that on the average, mango farmers were 94% technically efficient in their production. It can be concluded from this finding that, given the average Technical Efficiency score, for an average mango farmer to obtain the Technical efficiency level of its most efficient colleague farmer, the farmer could achieve six percent cost saving {i.e., [1-(94/99)]}. Likewise, estimation for the technically inefficient mango farmer suggests a cost saving of sixteen percent {i.e., [1-(83/99)]}. The results also revealed that, mango famers who obtained a technical efficiency scores above 90 percent were 51 farmers representing 82.3 percent.

Table 16: Summary Statistics of Technical, Allocative, and Economic Efficiencies

Efficiency	Mean	Maximum	Minimum	Standard Deviation
Technical (TE)	0.9425	0.9886	0.8319	0.0379
Allocative (AE)	0.9455	0.9900	0.8409	0.0353
Economic (EE)	0.8927	0.9765	0.7092	0.0675
Frequency Distribution TE, AE and EE				
Efficiency levels (%)		TE	AE	EE
90 - 99		51 (82.3%)	55 (88.7%)	40 (64.5%)
80 - 89		10(16.1%)	7 (11.3%)	17 (27.4%)
70 -79		1 (1.6%)	-	5 (8.1%)

Source: Field Data, 2014

The empirical result indicates that, the average Allocative Efficiency score was 0.9455 with a range of 0.9900 to 0.8409 as shown in Table 16. The allocative efficiency score of 0.8948 obtained for this study implies that resource allocation and efficiency use by farmers given the prevailing inputs prices faced by farmers is around 95 percent. Thus, the average farmer is about 0.5-distance point away from the frontier. In addition, the results indicated that most (88.7%) of the respondents had an allocative efficiency score above 90 percent. It can thus be concluded from this result that resources could be allocated to their best alternative uses and prices could as well as be allowed to perform their allocative functions in the use of inputs.

The average Economic Efficiency score according to the empirical results was found to be 0.8927 with a range of 0.9765 to 0.7092. Looking at the minimum scores for technical, allocative and economic efficiencies, a farmer may be technical efficient but not economically efficient. This is because the minimum technical efficiency score of 0.8319 (i.e., 83% efficiency level) may suggest that mango farmers in the study area are performing well. However, a further analysis of the economic efficiency in production (minimum economic efficiency score of 0.7092) reveals that farmers are not performing well, hence the need to improve on their overall efficiency. This is necessary because inefficiency is costly as it causes a reduction in profit below the maximum value attainable under full efficiency (Bifarin *et al.,* 2010). The economic efficiency mean score of be 0.8927 also indicate the average potential in mango production in the Yilo krobo Municipality. From this empirical result, it can be concluded that economic inefficiency exists in mango production in the Yilo Krobo Municipality. The result revealed that 64.5 percent of the respondents had an efficiency scores above 90 percent, 27.4 percent had an efficiency scores between 80 to 89 percent, and 8.1 percent had an efficiency scores within the range of 70 to 79 respectively. The average economic efficiency score obtained for this study thus suggests that on average, mango farmers in the study area could reduce cost of production of mango by 11 percent at the current level of mango outputs.

DETERMINANTS OF ECONOMIC EFFICIENCY IN MANGO PRODUCTION:

The determinants of technical inefficiency were estimated from the technical inefficiency model and that of allocative inefficiency from the cost inefficiency model respectively. This was base on the theory that the composite effects of technical efficiency and allocative efficiency in production determine economic efficiency.

Determinants of Technical and Allocative Inefficiency

. The determinants give indication on the sources of technical inefficiency and allocative inefficiency (derived from cost inefficiency model) and this helps to know what factors to tackle if improving farmers' efficiency level in production is the goal of any policy intervention. From literature, various factors have being identified to influence efficiency in agricultural production. As such, to identify the factors that influence the efficiency in mango production, the following farmer specific, firm-specific variable and institutional variables were incorporated into the technical and cost inefficiency models to examine their influence on efficiency level in mango production. The variables includes Age of farmer, sex of farmer, household size (HS) of farmer, years of farming experience (EXP)and number of times pruning is carried out per production year (NUP). The rest are GlobalGAP certification (GGAP), number of years spent in school (EDU), access to credit (CRD), number of extension visits (EXT), access to government support (GOV), and establishment of a processing factory in the municipality (APF).

Table 17 and 18 presents the empirical results for the estimates for the determinants of technical inefficiency and allocative inefficiency in mango production respectively.

Table 17: Estimates for Determinants of Technical Inefficiency in mango production

Variables	Parameters	Coefficient	Std. Error	Z-value
Constant	δ_0	0.3234***	0.1343	2.4071
AGE	δ_1	-0.0019 **	0.0016	-1.2220
SEX	δ_2	-0.0392 ***	0.0429	-0.9122
HS	δ_3	-0.0061***	0.0095	-0.6410
EXP	δ_4	0.0038**	0.0065	0.5778
NUP	δ_5	-0.0200 **	0.0288	-0.6943
GGAP	δ_6	0.0036	0.0472	0.0756
EDU	δ_7	-0.0027***	0.0049	-0.5227
CRD	δ_8	-0.0141 ***	0.0465	-0.3037
EXT	δ_9	- 0.0016 *	0.0069	0.2360
GOV	δ_{10}	-0.0352 ***	0.0562	-0.6265
ABF	δ_{11}	-0.0599 ***	0.0521	-1.1505

Note: ****, **,***; Statistically significant at alpha levels of 10%, 5%, and 1 % respectively***

Source: Field Data, 2014

The results showed that apart from GobalGAP certification, all the explanatory variables had a negative relationship with technical inefficiency. On the contrary, in the cost inefficiency function, all the explanatory variables had a negative sign indicating that the turns to reduce inefficiency. In addition, the result revealed that with the exception of GlobalGAP certification, all the explanatory were significant predictors of the inefficiency level exhibited by the mango farmers in the study. For instance, Age was included in the technical and cost inefficiency models to reflect the managerial ability of the farmer. As noted by Shafiq and Rehman (2000), age of the farmer is expected to have either a positive or a negative relationship with efficiency of the farm firm. This is because older farmers are assumed to be more experienced and efficient in carrying out their farm operations. However, most often than not, older farmers tend to be traditional and conservative and as such often show less willingness to adopt new farming technologies and innovations, hence could be less efficient. However, it was expected that age would have a negative sign.

From the empirical results as shown in Table 16 and 17, the coefficients of age in the technical inefficiency and cost inefficiency functions had a negative sign, which was significant at 5 percent and 10 percent respectively. This indicates that old farmers were less inefficient than young farmers. Thus, age is a significant contributing factor to reducing technical and cost inefficiencies identified among the mango farmers in the study area. This result also implies that older farmers were more cost efficient and as such allocativelly efficient in their production than younger farmers. From these results, it can therefore be intuitively inferred that age influences economic efficiency positively and that as mango farmers' ages they tend to accumulate a reservoir of experience in mango production, which turns to enhance their economic efficiency in production. This result is consistent with the findings of Bifarin *et al.,* (2010), Otieno, Hubbard and Ruto, (2012), Khan and Saeed, (2011), and Sajjad and Khan, (2010).

Table 18: Estimates for Determinants of Allocative Inefficiency in mango production derived from cost inefficiency model

Variables	Parameters	Coefficient	Std. Error	Z-value
Constant	δ_0	- 0.0343 ***	0.9997	-0.0343
AGE	δ_1	-0.2465 *	0.3211	-0.7679
SEX	δ_2	-0.0279 **	0.9998	-0.0279
HS	δ_3	-0.1009 **	0.9943	-0.1015
EXP	δ_4	-0.1341**	0.9812	-0.1366
NUP	δ_5	-0.0407 *	0.9994	-0.0407
GGAP	δ_6	-0.0103**	0.9998	-0.0103
EDU	δ_7	-0.5663 **	0.9518	-0.5950
CRD	δ_8	-0.0148**	0.9999	-0.0148
EXT	δ_9	-0.0690**	0.0024	-2.8277
GOV	δ_{10}	-0.0650	0.9999	-0.0065
APF	δ_{11}	-0.0388 **	0.9997	-0.0388

Note:, **,***; statistically significant at alpha levels of 10 %, 5 %, and 1 % respectively*

Source: Field Data, 2014

Sex was included in the technical and cost inefficiency models as a dummy variable to reflect the difference in perception and reaction to farming ideas and the resultant decisions making between male farmers and female farmers and how this influence their respective efficiency level in production. From the technical inefficiency model as shown in Table 17 and 18, sex had a negative relationship with both technical and cost inefficiencies, which was statistically significant at 5 percent significance level. This finding confirms the a prior expectation and hence it can be conclude that gender of the farmers tends to decrease technical inefficiency among mango farmers. Intuitively, it can be inferred that female farmers are less efficient than male farmers. These results from the technical and cost inefficiency models suggest that sex a farmer-specific variable affects economic efficiency positively. This finding is not consistent with the result of Mussa, (2011) in which sex had a positive relationship with technical inefficiency and allocative inefficiency.

Household of farmers has been identified in literature as an important factor that influences the efficiency level of farmers. Household size of farmers is often categorized into active members and inactive members in terms of level of participation in agricultural production activities. For this study, household size captured only members who participated actively in mango production. It was expected that household with large size of active participating individuals would have positive effects on labour supply, hence efficiency in mango production. As such, it was expected to have a negative relationship with inefficiency. From Table 16 and 18, household size was found to have a significant negative relationship with technical and cost inefficiency. This could imply that household with large household size were able to carry out timely agricultural activities as it pertains to mango production, hence increase in efficiency. From this result, it can be seen that household size is an important factor that can reduce technical and cost inefficiencies in mango production. From this account, it can be realized that household size is very important when it comes to improving the economic efficiency level of mango farmers in the study area. The finding from this study however disagrees with that reported by Mussa, (2011) who found a positive relationship between household size and economic inefficiency.

The Educational level of farmers was measured in number of years spent in school. From theory, it is believed that the higher the educational level of a farmer, the better his/her managerial capability. As such, it was assumed that farmers with more years of schooling would exhibit less technical and allocative inefficiency. The expected sign of the coefficient for educational level on inefficiency was negative and this was confirmed in the result as shown in Table 17 and 18. This result implies that mango farmers with higher educational level were more efficient than their counterpart with low educational level. The findings of this study is found consistent with that reported by Khan and Saeed (2011); Ike and Inoni, (2006); and Amaza, Bila and Iheanacho (2006) who reported a negative relationship between education and inefficiency.

As noted by Saeed and Khan (2007) credit is an important factor, which is expected to improve farmers' liquidity and as well as facilitates the purchase of inputs and encourage farmers to introduce improved and advance technology production to improve yield per acre. It assumed that access to credit help improve efficiency level of farmers, as such it was therefore expected to have a negative effect on inefficiency. The result as shown in Table 17 and 18 indicates that access to credit had a significant negative effect on both technical inefficiency and cost inefficiency respectively. This finding implies that receiving credit tends to increases farmers' economic efficiencies. This findings however does not agrees with the findings of Okike, Jabbor, Smith, Akinwumi and Ehui, (2001) who also reported a positive relationship between access to credit and economic inefficiency of farmers.

It was also discovered that frequency of pruning had a significant negative relationship with both technical inefficiency and allocative inefficiency as indicated by the estimates from the technical inefficiency model and cost inefficiency model as presented in Table 17 and 18 respectively. It can therefore, be concluded that, the higher the frequency of standard pruning activity in mango production, the higher the efficiency level in production. Report from technical experts indicated that, if pruning is done to the required specification and standard, it helps to increase the output level per tree, hence productivity improvement. This according to them brings the farmer closer to or to the frontier output level, hence improvement in efficiency level in production.

Also, access to government support, access to GlobalGAP certification and as well as the establishment of a processing factory in the municipality were found to have a significant negative relationship with technical inefficiency and allocative inefficiency as indicated by the estimates from the technical and cost inefficiency models respectively. This suggests that if farmers get access to government support it would help increase their economic efficiency level in production. In addition, establishment of agro-processing factory in the municipality would reduce output losses due fruit rot and transportation cost incurred in transporting fruit to the buying centers. Accordingly, this would increase their profit level, which will thus serves as an incentive to farmers to increase their productivity as well as draw others into mango production given the economic prospect the industry presents. Access to GlobalGAP certificate gives farmers a better advantage in marketing their produce to local producing companies and as well as the international market. The certificate testifies to local and international buying companies that, farmers adopts and use best agricultural practices in their production. This help to reduces loses due to marketing constraints, hence improvement in their efficiency level.

Findings from the study also recorded a significant negative relationship between frequency of extension visits and technical inefficiency and allocative inefficiency as shown by the estimates from the technical and cost inefficiency models respectively. The implication of this result is that farmers who receive more extension visits in the production years were more efficient than their counterparts who receive fewer visits. This is because access to extension service strengthens farmers' knowledge level and guides them to exploit the available farm technology as well as taking advantage of new but improved technologies. This therefore demonstrates that extension visit is a very important factor in determining the technical, allocative, and economic efficiency level of mango farmers in the study area. Intuitively this means that provision of extension service will improve efficiency as better management and information utilization would yield greater benefits to mango farmers. This finding is consistent with the findings of Saeed and Khan (2007); Ike and Inoni, (2006); and Ajao et al., (2012).

Hypothesis Test for the Specification of Technical efficiency model and Allocative efficiency model (Derived from Cost efficiency Model)

The first null hypothesis that the Cobb-Douglas function is not an adequate representation of the data for mango production in the study area was rejected. The likelihood ratio test confirms that the Cobb-Douglas functionn fit the data well just as the translog function. The low p-value of 0.0004 and 0.000 obtain for the technical efficiency model and the cost efficiency model respectively justified that the translog functions does not significantly fit the data better than the Cobb-Douglas did and that there would be no significant difference between the two if used to represent the data. The Cobb-Douglas function was therefore, chosen to represent the data for mango production.

In addition, the second null hypothesis, which states that there was no inefficiency effect in the stochastic production and cost functions, was rejected given the high gamma values of 0.9182 in the technical inefficiency model, and gamma of 0.9546 in the cost inefficiency model. This was also confirmed by the low p-values of 0.0159 and 0.0001 obtain from the likelihood ratio test as shown in Table 19. This implies that the traditional average response function (OLS) is not an adequate representation for the mango production and that there is significant inefficiency.

The third null hypothesis specifies that the farm and farmer-specific characteristics are significant predictors of the technical and a cost inefficiencies effect in mango production was accepted. Hence, it can be concluded that the explanatory variables in the model contributed significantly to the explanation of technical, allocative, and economic inefficiencies in mango production as exhibited by mango farmers in the Yilo Krobo Municipality in the Eastern Region of Ghana.

Table 19: Testing the Specification of the Efficiency Models

Technical efficiency Model				
Null Hypothesis	Log Likelihood Value	Test statistics χ^2	P-value	Decision
1.H_0: The Cobb-Douglas function is not an adequate representation of the data	119.41	38.188	0.0004	H_0 Rejected
2.H_0: Inefficiency effect are non-stochastic	100.31	4.6085	0.0159	H_0 Rejected
3.H_0: Farm and farmer specific characteristics are significant predictors of inefficiency	115.30	6.6349	0.8278	H_0 Accepted
Cost efficiency Model				
Null Hypothesis	Log Likelihood Value	Test statistics χ^2	P-value	Decision
1.H_0: The Cobb-Douglas function is not adequate representation of the data	386.64	295.51	0.0000	H_0 Rejected
2.H_0: Inefficiency effect are non-stochastic	38.233	-458.81	0.0001	H_0 Rejected
3.H_0: Farm and farmer specific characteristics are significant predictors of inefficiency	109.52	21.668	0.2707	H_0 Accepted

Source: Field Data, 2014 , *“significance level=0.05”*

CONSTRAINTS TO MANGO PRODUCTION IN THE STUDY AREA

Table 20 presents results from the identification and ranking of constraints associated with mango production by mango farmers in the Yilo Krobo Municipality. Farmers were asked to rank constraints in terms of magnitude given a scale of 1 to 10; where 1 means lowest and 10 means highest.

Table 20: Ranking of Constraints by Mango Farmers in terms of magnitude given a Scale of 1 to 10 (where 1 means lowest and 10 means highest)

Constraints	Mean	SD	Min	Max	Mean Ranks
Unavailability of skilled labour	9.92	0.33	8	10	15.56
Access to credit	9.74	0.57	7	10	14.86
Acquisition of land for production	9.60	0.59	8	10	14.29
Unavailability of government support	9.58	0.64	8	10	14.15
Pests and disease control	9.60	0.59	8	10	14.14
Fruit dropping	9.44	0.72	8	10	13.58
High inputs cost	9.19	0.74	8	10	12.69
Access to ready export market	9.00	0.79	8	10	12.05
Unavailability of agro-processing factory in the area	8.98	0.66	8	10	11.76
Fluctuation in output price	8.61	0.71	8	10	10.70
Unavailability of good storage facility in the area	6.68	1.99	1	10	9.04
Access to ready local market	3.10	0.78	2	5	6.15
Unavailability of good grading systems for fruits	3.13	0.86	1	5	6.12
Access to good transport facility	1.85	1.04	1	5	3.77
Acquisition of pesticides	1.56	0.82	1	5	3.31
Acquisition of fertilizers	1.53	0.67	1	5	3.30
Access to extension services	1.42	0.80	1	5	2.91

Source: Field Data, 2014

From the results, unavailability of skilled labour had the highest mean rank (15.56) and this implies that it is the most limiting constraint in the mango production in the study area. Farmers indicated that, access to skilled labour especially for pruning, harvesting, and other technical activity is very difficult as these personnel's are not many in the area. This they stated is affecting them seriously as controlling canopy size is very important to increase productivity. They also indicated that to avoid extensive bruise to fruit, harvesting procedure is very technical and needs skilled personnel to handle that. The finding is in agreement with the finding by Pervaiz, Khan, Javed and Zeb (2008) in which non-availability of skilled labour was identified to be a major constraint to guava production in the Kohat District of Pakistan. In addition, this finding is consistent with IFPRI (2010) in which labour was identified as one of the major constraint to agricultural production in Ghana.

Access to credit was ranked as the second highest constraints to mango production in the study area. It had a mean rank of 14.86. The respondents indicated that due to difficulty in accessing credit either from formal or informal source, they had to depend on their own saving to finance their production business. This they said was inadequate given the huge capital investment requirement, thus limiting their productivity level, profit level and farm investment. This finding is in agreement with the growing empirical literature which suggests that credits constraints have significant adverse effects on farm output (Sail and Carter, 1996; Petrick, 2004), farm profit (Carter, 1989; Foltz, 2004) and farm investment (Carter and Olinto, 2003) especially in developing countries as cited by Guirkinger and Boucher (2007). Farmers indicated that credit conditions in terms of interest rate, collaterals and loan processing procedures were not favourable making credit accessibility difficult. As indicated by Guirkinger and Boucher (2007), credits constraints negatively affect the efficiency of resource allocation of farmers. In addition, the World Bank (2007) reported lack of access to credit as a major constraint facing African countries.

The third constraint to mango production was acquisition of land for production with a mean rank of 14.29. Farmers' indicated the land tenure system and insecurity and as well as land litigation as major cause to difficulty in accessing land for agricultural production. Also respondents gave competition by estate developers for land as one of the cause to limited access to agricultural lands. This finding is consistent with the annual report of MoFA, (2009) in which land was identified as a major constraint to rice production in Ghana in term of access and security. Land is known to play a fundamental role in facilitating agricultural revolution, growth and development and as such limited access to land for agricultural production becomes a major concern to any economy to which agriculture is a major contributor to its GDP. Duncan and Brants, (2004) indicated that access to land determines one's access to income-generating activities as well as access to food. As such, this finding indicates that farmers' access to productive activities is limited given that agriculture according to MoFA (2012) is the major economic activity in the study area and specifically mango is the major tree crop cultivated in the municipality. The finding is also in concordance with the finding by Nabbumba and Bahiigwa (2003) in which they identified access to land as an increasing constraint to agricultural productivity in Uganda.

The fourth major constraint to mango production was unavailability of government support directed to mango industries and it had a mean rank of 14.15. Most (91.9%) of the respondents indicated that there are not aware of any direct government support or intervention for the sector. The few individuals (8.1%) who indicated they had received some government support said accessing the support facility was very difficult and thus discouraging. Information from key informant indicated that public investments in institution like MoFA and major infrastructures that accelerate agricultural productivity were very low. Government as a key stakeholder in the agricultural growth is expected to provide agricultural support services as well as formulating and implementing macroeconomics and sectoral policies to promote agricultural production. There are concerns among researchers and policy analyst on the role of institutional constraint on agricultural growth and development. Since availability of government support is an institutional constraint, the finding of this study agrees with that of Bategeka, Kiiza and Kasirye (2013) who identified institutional constraints as a major limiting factor to agricultural development in Uganda. The finding also agrees with Philip, Nkonya, Pender and Oni (2009) who identified poor agricultural pricing policies, poor funding and coordination of agricultural extension, low and unstable public investment in agricultural research, low public investment in infrastructure such transportation, storage facility and communication as some of the constraints to increasing agricultural productivity in Nigeria.

The result also showed that the least constraint to mango production in the study area was access to extension. It had a mean rank of 2.91 as indicated in Table 20.0. From the survey it was discovered that there are many approved nursery establishment that provides quality mango seedlings for sales to farmers. It was also realized the monitoring by MoFA in ensuring these commercial nursery establishment adopt recommended techniques and procedures in producing quality and disease free seedlings to farmers was very intensive. And that regular training was often given to nursery producers both by government and private agency.

Testing for the degree of Agreement among mango farmers

The Kendall's coefficient of concordance was use to test the degree of agreement among mango farmers on the ranking of constraints facing mango production in the study area. From the result as shown in the Table 21, there was a high degree of agreement among farmers given the high value of Kendall's W of 0.864. As such, the fourth null hypothesis that there is a strong degree of agreement among mango farmers regarding the constraints limiting their productivity was accepted. This implies that there is strong agreement among farmers concerning the constraints that limit the output level of mango in the YiloKrobo Municipality in the Eastern Region of Ghana.

Table 21: Kendall's W Statistics

N	62
Kendall's W	.864
Chi-Square	911.108
Df	17
Asymp. Sig.	.000
Hypothesis testing of degree of agreement among judges	
Null hypothesis	Decision
$H_0 : W \neq 0;$	Accepted

Source: Field Data, 2014

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter presents the key findings of the study. It presents the conclusions based on the key findings from the study. It also suggests recommendations to mango farmers and major actors in mango production. Finally, the chapter gives some suggestions for further studies on mango production.

Summary of Results

Objective one focused on the state of mango production in the study area. The results showed that mango production in the municipality was highly profitable as farmers were able to obtain more than seventy percent returns on their investment. In addition, there was no significant difference in mango output level between the major and minor season. Most of the farmers did not have access to credit and as such depends on their own saving to finance their farming business. Majority of the farmers used slashing, burning and ploughing with machines as the main land preparation method. It was also realized that the majority of the farmers acquired their land for production through own ownership either by direct purchase or inheritance. It was also noted that most of the farmers had regular access to extension services and technical training on mango production. Chemical control was the main method adopted by farmers in controlling weeds, pests, and diseases. The results also revealed that majority of the mango farmers had some level of education and the average age of the interviewed was fifty-six years. Finally, majority of the farmers had GolbalGAP certification and that they produce for both the local market women, local processing companies and the export market.

Objective two of this study centered on the estimation of economic efficiency of mango production. Results revealed that the mean technical, allocative and economic efficiency scores were 94 percent, 95 percent and 89 percent in that order. In addition, the results showed that majority of the farmers (64.5 percent) had an economic efficiency scores above 90 percent. Furthermore, it was noted that the most economically efficient mango farmer was 2 percent away from the frontier output whiles the least economically efficient farmer was 30 percent away from the frontier output. Furthermore, the technical efficiency model revealed that all the inputs variables were significant predictors of the technical efficiency level in mango production. From the cost efficiency, models it also revealed that with exception of cost of equipment, all the explanatory variables were significant predictors of the cost efficiency level in mango production. Finally, analysis confirmed the presence of technical and allocative inefficiency in mango production.

Results reflecting objective three on the determinants of economic efficiency revealed that, the most important and statistically significant variables that influence economic efficiency. Results from the technical inefficiency model revealed with the exception of GlobalGAP certification all the explanatory variables were significant predictors of technical inefficiency level in mango production. On the other hand, in the cost inefficiency model all the explanatory variables were found to be significant predictors of cost inefficiency levels in mango production.

For Objective four, results indicated that unavailability of skilled labour was the most pressing constraining factor that limits farmers' ability to achieve optimum output level. Also access to reliable credit facility, acquisition of land for production, availability of governments support, pest and disease control and fruit dropping were the next top five most pressing constraints to mango production. The Kendall's coefficient of concordance test revealed an independent and a strong degree of agreement among the farmers on the constraints. As a result, the null hypothesis that there was strong degree of agreement among mango farmers on the factors limiting mango output level was accepted.

Conclusions

1. The results showed that mango production in the municipality was highly profitable with farmers realizing more than seventy percent returns on their investment
2. The results also showed that there was no significant difference in the output levels between the first and second production season. Thus, farmers were cushioned against output risk of seasonal loses in productivity
3. Results from the study revealed that mango farmers were technically, allocativelly and economically inefficient in production.

4. The results also revealed that with the exception of GlobalGAP certification, all the farm and farmer-specific characteristics included in the technical inefficiency model were significant predictors of the level of technical inefficiency exhibited by the mango farmers.
5. In addition, results from the cost inefficiency model revealed that all the farm and farmer-specific variables included in the model were significant predictors of the cost inefficiency level exhibited by the mango farmers
6. Finally, the results revealed a strong degree of agreement among mango farmers concerning the constraints facing mango production in the study. Farmers ranked the unavailability of skilled labour, access to credit, access to productive land, high input cost, and pest and disease infestations as some of the major constraints limiting their productive capacity.

Recommendations

1. Mango Farmers should reorganize and restructure their production activities to timely carried out the various agronomic practices in both production seasons in order to optimize or maximize their farm profit.
2. Giving the profitable nature of mango production, government through its micro-enterprise policies should use an integrated and holistic approach to replicate the pineapple value chain and agribusiness development framework in the mango industry on a regional and sub-regional basis in the municipality.

3. To address the issue of economic inefficiency in mango production it is recommended that extension strategies should be focused on providing farmers with training, information, and access to inputs and services. In this regard, the Ministry of Food and Agriculture through the District Department of Agriculture should organize regular capacity building workshops and field demonstration on resource use efficiency for mango farmers in the Yilo Krobo Municipality.
4. Since farm-specific characteristic like access to extension, service and access to credit were found to be significant predictors of farm efficiency level, governments' agricultural supports policies should address ways of liberalizing access to extension service and credit through increasing the farmer-extension agents ratio and micro credit facilities.
5. In addition, as factors such as pruning, fertilizer application, and agrochemical applications were found to be significant determinants of farm efficiency level, the Ministry of Food and Agriculture through its District Department of Agricultural should organize regular training for farmers on effective and appropriate method of pruning, fertilizer, and agrochemical application to enhance farmers' productivity level.
6. Lastly, government should use its public private partnership policy on agro-industrial development framework to promote and encourage direct investment in agro-processing factories within the municipality.

Suggestions for further studies

The stochastic frontier model used in estimating economic efficiency of mango production in this study assumes that production technologies are homogeneous across farms. This restrain imposed on the stochastic frontier model could lead to incorrect conclusions about the opportunity for mango farmers to enhance their efficiency by adopting better production practices. Also the type of mango variety grown can influence difference in efficiency level of farmers.

It is therefore suggests that a further study using metafrontier approach which account for technological difference to estimate the economic efficiency of mango production in the municipality. It is also recommended that a further study on a comparative study be carried out on economic efficiency covering the whole country in order to find out the comparative advantage in mango production in the major mango growing area in the Ghana.

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APPENDICES

APPENDIX A

A Structured interview Schedule for Mango Farmers

This instrument is designed to collect data on mango production to estimate economic efficiency of mango production in the Yilo Krobo Municipality in the Eastern Region of Ghana. Information given by each respondent shall be treated with great confidentiality. I shall be grateful if you would respond to the following items on the structured interview schedule. Thank you

BASIC INFORMATION

Nam of interviewer................................. Date of interview............................

Name of mango farmer............................ Contact Number..............................

Name of community...

PART ONE: FARMER-SPECIFIC CHARACTERISTICS OF MANGO FARMERS

1. What is the age of the farmer at last birthday................................?
2. What is the sex of the farmer? i) Male [ ] ii) Female [ ]
3. What is the marital status of the farmer i) Single [ ] ii) Married [ ] iii) Divorced [ ] iv)widowed [ ]
4. What is the educational background of the farmer? i) No formal education [ ] ii) Primary [ ] iii) JSS/Middle School Leaving Certificate [ ] iv) SSS/technical education [ ] v) Tertiary [ ]
5. Number of years spent in school…………………………………………..

6. What is the household size of the farmer? .... (indicate number)

7. How many years have you been actively engaged in mango production?..

8. Is mango production your main occupation? i) Yes [ ] ii) No [ ]

9. If no, can you indicate the other occupation that you have?........................

………………………………………………………………………………

PART TWO: FARM-SPECIFIC CHARACTERISTICS AND PRODUCTION TECHNIQUES

10. How did you acquire your land for mango production........?

 i) Own land [ ] ii) family land [ ] iii) lease land [ ] iv) Share cropping [ ] v) Rent [ ] vi) other (specify).......................

11. What main land preparation method(s) do you use?..i) slash and burn [ ] ii) ploughing with(machines and implements) [ ] iii) animal drought [ ] iv) Weedicide application [ ] v)other (specify)……………………

12. What main varieties of mango do you produce? i) Kent [ ] ii) keitt [ ] iii) Palmer [ ] vi) other (specify)......................

13. What planting techniques to you practice?........ i) Mono cropping [ ] ii) Mixed cropping [ ] ii) intercropping [ ]

 iv) Other (specify)........................

14. How old is your plantation?...

15. How do you control weeds on your farm? i) Slashing with Cutlass [ ] ii) Use of chemicals [ ] iii) Use of tractor [ ] iv) Other (specify)............

16. Do you prune your mango plant? i) Yes [ ] ii)No [ ]

17. If yes, how many times do you prune in the production year........................

18. What main method(s) do you use in controlling pests and diseases on your farm? i) cultural only [ ] ii) mechanical/physical techniques [ ] iii) pesticides use [ ] v) biological methods [ ] vi) other (specify)..........

19. How do you harvest your mango fruits? i) Allow fruit to drop on the ground [ ] ii) use harvesting knife / Sickle [ ] iii) shaking the branches [ ] iv) climb and pluck fruit into sacks [ ] v) Fruit picking pole [ ] vi) other (specify)...................................

20. Do you produce for any mango buying company? i) Yes [ ] ii) No [ ]

21. Do you have Global GAP certification to produce mango? i) Yes [ ] ii) No [ ]

22. Which market do you produce for? i) Export market [ ] ii) local market [ ] iii) Both [ ]

23. Did you export any of your produce, in the last production season? i) Yes [ ] ii) No [ ]

24. Did you receive a good price for your product? i) Yes [ ] ii) No [ ]

25. If no, can you indicate the reason..

26. What proportion did you export and what proportion did you send to local market? Please indicate; i) export ....% ii) local market .... %

27. Is the export market easily and readily accessible… i) Yes [ ] ii)No [ ]

28. If no, what is the reason?...

29. Do you have regular local market at satisfactory price for your product? i) Yes [ ] ii) No [ ]

30. Do you have access to storage facility for your produce? i) Yes [ ] ii) No [ ]

31. Do you have access to good transportation system to transport farm inputs and farm output? i) Yes [ ] ii) No [ ]

32. How do you transport your produce to the market? i) own vehicle [ ] ii) commercial vehicle [ ] iii) By head [ ] iv) other (specify).........................

33. How do you package your mango fruit for transport to market centers? i) in boxes/crates [ ] ii) in sacks [ ] iii) packed them directly into the vehicle [ ] iv) Other (specify)...

34. How much did you spend on transportation in the last production season

    i) For transporting Inputs to the farm (Gh¢).......................

    ii) For transporting Output to market (Gh¢).........................

35. Do you often receive any extension service? (i.e. education, training and information delivery) i)Yes [ ] ii)No [ ]

36. If yes, indicate the number of times within the production year...................................

37. Have you ever received any technical training relating to mango production before?........ i) Yes [ ] ii) No [ ]

38. If Yes, who provided the training...... i) AEAs [ ] ii) NGOs [ ] iii) FBOs (mango based) [ ] iv) Fellow farmers [ ] v) others (specify)..................

39. What are the main sources of finance for your mango production i) own saving [ ] ii)family and relatives [ ] iii) friends [ ] iv) money lenders [ ] v) bank loans [ ]

40. Have you ever received any credit facility for mango production? i) Yes [ ] ii)No[ ]

41. If yes, is the credit easily available to access? .... i) Yes [ ] ii) No[ ]

42. In what form was the credit provided?.... i) input supply [ ] ii) Cash [ ]

iii) others (specify)........................

43. Are there any government policies to boost output growth in the mango industry? i) Yes[ ] ii) No [ ]

44. If yes, can you give some of them that you know................ i) input subsidy [ ] ii) output price policy [ ] iii) export levy [ ] iv) Other (specify)..........................

45. Is the absence of processing facility or company in the production area affecting your output level i) Yes [ ] ii)No [ ]

PART THREE: PRODUCTION INFORMATION

46. Input variables:

a. Land

Item	Size (acres)	Cost/acre (Gh¢)	Total cost (Gh¢)
Land acquisition	Total Land size:		
Land preparation	Land under cultivation:		

b. Labour

Types	Source	No of persons	Hrs worked / day	Days worked/ week	Days worked/production year	Wage/person/day (Gh¢)
Family:	Men					
	women					
	children					
Hired:	Permanent					
	Casual					

i.Weeding:……………………………………………………………..
ii. Fertilizer application:…………………………………………………
iii. agrochemical application:……………………………………………
iv. Pruning:…………………………………………………………….
vi. harvesting:………………………………………………………….

c. Equipment

Type	No	Unit cost (Gh¢)	Maintenance/hiring cost (Gh¢)	Year of purchase	Economic life	Usage share of mango (%)	Total cost (Gh¢)
Tractor							
Cutlass							
sprayer							
Harvesting knife/sickle							
Harvesting basket /crates							
Others........							

d. Plant Population

Plant Age	Mango tree/hectare of land	Total

e. Fertilizers

Type	Quantity (Kg)	Unit cost (Gh¢)	Total cost (Gh¢)
NPK			
Ammonium Sulphate			
Potassium nitrate			
Organic			
Others(specify)			

f. Agro-Chemicals

Type	Quantity (litres)	Unit cost (Gh¢)	Total cost (Gh¢)
Fungicide			
Weedicide			
Insecticide			
Others specify			

47. Output variable:

Quantity of mango harvested in the last production year

Season	Quantity (Kg)	Unit Price (Gh¢)	Total Price (Gh¢)
Major (1st)			
Minor (2nd)			

Part four: Constraints to mango production

Constraints variables	On a scale of 1 to 10 indicate how much you think each of the factors provided is a constraint in terms of magnitude									
	1	2	3	4	5	6	7	8	9	10
Access to reliable credit										
Access to extension service										
Unavailability of government support										
Access to good transport facility										
Unavailability of skilled labour										
Unavailability of good storage facility										
Acquisition of fertilizers										
Acquisition of pesticides										
Acquisition of land for production										
Access to ready export market										
Access to ready local market										
Unavailability of good grading system for fruit										
Unavailability of agro- processing factory										
Pest and disease control										
Fluctuation in output price										
High input cost										
Fruit dropping										

NOTE: Where 1 means lowest and 10 means highest

APPENDIX B

Interview Guide for Key Informant Interview

This instrument is designed to collect data on mango production to estimate economic efficiency of mango production in the Yilo Krobo Municipality in the Eastern Region of Ghana. Information given by you shall be treated with great confidentiality. I shall be grateful if you would respond to the following items on the interview schedule. Thank you

Name of respondents............................... Contact Number........................

1. How many years has mango production been a major agricultural activity in the municipality?..
2. What mango varieties are commonly grown by mango farmers in the municipality?...
3. On a scale of 1 to 10 (1=lowest, 10= highest) how would you rate the economic viability and importance of mango production in the municipality?..
4. On a scale of 1 to 10 (1=lowest, 10=highest) how would you assess the performance of extension service delivery on the production level of farmers for the past five years?...
5. In what way has the formation of mango farmers association affected production performance of the individual farmers?................................
6. In what way has the training and other assistance given to mango farmers by MoFA and NGOs like ADRA affected farmers performance?...

7. How has pests and diseases situation affected mango production in the municipality?..

8. How is the absence of good storage facility for mango fruit affecting production level?..

9. Do you know of any government support in terms of policy framework to boost production of mango ....

10. How has output price fluctuation affected mango production in the municipality...

11. On a scale of 1 to 10 (1=lowest, 10=highest), how would you rate the performance of the mango industry in the municipality for the past five years in terms of output size? ....

12. How do you see the state of mango export?..

13. On a scale of 1 to 10 (1=lowest, 10=highest), what is your assessment of farmers in their efficiency in resource utilization given their respective prices...

14. What are some of the constraints facing mango production in the municipality...

15. What are some of the current strategies being implemented by your organization to help farmers improve on their productivity...................

16. Any recommendation to boost production..

....

APPENDIX C

Survey Guide for focus Group Discussion

This instrument is designed to collect data on mango production to estimate economic efficiency of mango production in the Yilo Krobo Municipality in the Eastern Region of Ghana. Information given by each respondent shall be treated with great confidentiality. I shall be grateful if you would respond to the following items on the interview schedule. Thank you

Name of community..

1. On a scale of 1 to 10 (where 1=lowest and 10=highest) how important is mango production in the municipality?
2. What varieties of mango are produced in the municipality?
3. Which of them are the major ones?
4. Is there any societal and cultural norm that hinders commercial mango production?
5. How is land acquired for production in the municipality
6. What land preparations methods are used in getting the land ready for planting?
7. What is the Market price for mango fruit per unit quantity?
8. In what unit are mango fruit marketed?
9. How do you control the incidence of pest and diseases on your farms?
10. On a scale of 1 to 10 (1=lowest and 10=highest) how has pests and diseases situation affected mango production in the municipality
11. Do you know of any government policy targeted to support the mango industries

12. In your view how has the unavailability of storage and agro-processing facility impacted on mango production in the municipality
13. What are some of the production constraints faced by farmers in the municipality?
14. What is the trend of production level for the past five years?
15. On a scale of 1 to 10 which of the two production seasons, (major and minor) is more profitable given the margin of production costs and revenue obtained?