UNIVERSITY OF CAPE COAST

EFFICIENCY OF INPUTS USE IN COCOA PRODUCTION IN TWIFO HEMANG LOWER DENKYIRA AREA OF THE CENTRAL REGION OF GHANA

BY

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DECLARATION

Candidate's Declaration

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

Name: Isaac Obeng Antwarko

Candidate's Signature...Date.................................

Supervisors' Declaration

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

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ABSTRACT

The most important cash crop in the agricultural production in Ghana remains cocoa due to its huge contributions to GDP, foreign exchange earnings, employment creation, poverty alleviation through the income generation etc. However, the continual expansion of land for crop production with low outputs and its concomitant low income is worrying and threatens the future sustainability of the sub-sector. The relevant issue is the efficiency with which the various inputs are combined in the production process to yield output. The study empirically examined the efficiency of inputs use in Twifo Hemang Lower Denkyira area of Central region of Ghana using farm level cross-sectional data. Results presented were based on data collected from a three-stage sampling of 400 cocoa farmers in twenty (20) communities using standardized structured interview guide.

The productivity and technical and cost efficiency of inputs in cocoa production were estimated through stochastic frontier production function analysis. The empirical result of summation of the partial elasticities exhibited positive increasing returns to scale for the inputs use in cocoa production in the area. All the inputs included in the study had significant effect on output and cost of cocoa production. The findings show that technical efficiency of inputs use is low in cocoa production but cost efficiency was fairly high. Hybrid varieties, level of education and age of tree, Farmer-based organization and extension contacts were found to be the main determinants of technical and cost efficiency. Among other things, review of the extension services in the study area was recommended.

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DEDICATION

To my son (Philip) and my wife (Rebecca Obeng).

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CHAPTER ONE

INTRODUCTION

Background to the Study

Cocoa production has been a chief support to Ghana's economy through mainly its foreign exchange earnings, employment to thousands of rural dwellers and its contribution to Gross Domestic Product (GDP). Ghana cannot be mentioned without talking about its cocoa. Likewise, one cannot think of cocoa without thinking about Ghana. Notwithstanding the tremendous contribution of cocoa to the rural and the entire economy at large, the cocoa sector faces several challenges that limit not only the full potential of the sub-sector but also raises concerns about future sustainability of the cocoa sub-sector and the competitiveness of Ghana's cocoa farmers in an ever changing global economy.

Research shows that efficiency score is globally quite low and technology gap plays an important part in explaining the ability of the cocoa sector in one country to compete with cocoa sectors in other regions in West and Central Africa (Nkamleu 2004b). Ahmad and Ahmad (1998) and Ahmad (2001) using district level data for Punjab, Pakistan, found similar results where negative growth rates in technical efficiencies partially or fully smoothed away the gains from technological progress. Ghana's cocoa sub-sector is battling with the problems of low yield per unit area, high yield gap, high knowledge gap and high inefficiency in production. Nkamleu (2004) stated that the current gap between observed and achievable yields in cocoa production lies in Ghana somewhere between 50 to 80 percent depending on different practices adopted by farmers (e.g. thin shading with or without fertilizer application).

Quantities of cocoa yields obtained may also differ on the farmers' fields having the same location, soil type, similar varieties and similar level of fertiliser. The major sources of yield variation are the differences in management practices employed at these farms, which in turn contributes to 'technical efficiency gap'. Citing few studies (Thirtle, Hadley, & Townsend,1995; Kalirajan, Pingali & Heisey, 1999) argued that the existence of higher technical inefficiencies could fully offset the potential gains of highly superior technologies. One of the main reasons for low productivity in agriculture all over the world is the inability of farmers to fully exploit the available technologies, resulting in lower efficiencies of production. This fact has been emphasized in many studies, particularly on cereals and pulses (Kalirajan, 1981; 1982; Battese, 1992; Battese & Coelli, 1988, 1992; Battese & Broca, 1997). Inefficiency in crop production is one of the major factors hindering the exploitation of full potential of the innovated technologies, particularly in the developing countries (Kalirajan & Shand, 1989). In order to accomplish sustained growth in agriculture, inefficiency and productivity differentials have to be reduced by improving the knowledge, education, management skills of the farming communities, and development of infrastructure (Pingali & Heisey, 1999; Ghura & Just 1992).

Belbase and Grabowski (1985) asserted that efforts to improve efficiency as a means of increasing agricultural output are more cost-effective than introducing new technologies if farmers are not optimizing the use of existing ones. Nkamleu (2004b) stated that cocoa productivity levels can be enhanced either by improving technical efficiency and/or by improving technological application. A relevant question for agricultural policymakers is whether to pursue a strategy directed towards technological change (bringing new technologies) or a strategy towards efficiency (improving the use of existing technologies). The presence of shortfalls in production efficiency means that output can be increased without requiring additional conventional inputs and without the need for new technology. If this is the case, then empirical measures of efficiency are necessary in order to determine the magnitude of the gain that could be obtained by improving performance with a given technology.

An improvement in the understanding of the level of cost efficiency and its relationship with the cocoa farmers can greatly aid policy makers in creating efficiency enhancing policies. The production efficiency of small holder farms has been reported to have an important implication for the development strategies in most developing countries (Ogundari, Ojo & Ajibefun, 2006). Realizing these, a central component of Ghana's development strategy has emphasized productivity-led and high-value-led agricultural growth as a means to transforming Ghana's agricultural sector in the next 10 to 20 years to help the country achieve middle-income country (MIC) status (National Development Planning Commission, NDPC, 2005).

Several researchers have found that Ghana's output growth in recent years in cocoa production has been as a result of increased land area frontier under cultivation. Ghana had an ambitious target of achieving one million metric tonnes of cocoa per cocoa season by 2012. The recent household studies suggest dramatic output increases in the cocoa sector, longer-term analysis using data from the Food and Agriculture Organization (FAO) of the United Nations suggests that productivity may have declined marginally in the country: between 1991 and 2005: Ghana's cocoa output increased by six percent while the area expanded by seven percent, suggesting a decline in productivity of about one percent over the 14-year period (Binam, Gockowski & Nkamleu, 2008). These reinforce that increment in output in the Ghana's cocoa sector is attributable mainly to farmers merely expanding the area frontier of production rather than improvement in the yield capacity of the plant.

Despite these major setbacks, Ghana set an ambitious target of obtaining one million metric tonnes of cocoa beans annually starting from the year 2012. The expansion of cocoa land under cultivation in a bid to achieving the set target in Ghana has come with environmental costs. The depletion of the forest reserves for agricultural production, mining and other human activities and the consequences of these activities cannot be underestimated. Nkamleu and Ndoye (2003) argued that the Western Region of Ghana in which cocoa production is growing at 8 percent annually, is one of 25 global hotspots containing rainforest remnants of global importance, and nearly 90 percent of which have disappeared.

Twifo Hemang Lower Denkyira area houses an important forest reserves in Ghana, that is, the Kakum forest reserves. The livelihood of many in this heavily depends on cocoa production. The recent encroachment issues being reported by the Game and Wildlife department of the Kakum Forest Reserve by some cocoa farmers in the area makes it more expedient for efforts to be devoted to improving productivity and efficiency of the inputs use in cocoa production in this area. Increasing productivity and efficiency requires a good knowledge of the current inherent efficiency or inefficiency and related factors. This work therefore deals with the efficiency of inputs use in Twifo Hemang Lower Denkyira area in the Central Region of Ghana.

Statement of the Problem

Efforts to improve cocoa productivity in Ghana will not only enhance the livelihood of the actors in the cocoa sub-sector but will have a colossal impact on the macro economy because of the myriads of the benefit the economy accrues from cocoa production. However, serious concerns arise over the future sustainability of the sector, as recent research findings clearly indicated that past and present cocoa output growth have been driven mainly by land expansion and by the intensive use of labour, rather than by rise in land productivity (Gockowski, 2007; Vigneri, 2005).

One of the major objectives of stakeholders in the Ghanaian cocoa industry is to increase production on a sustainable basis at the farm level. Proper farm maintenance through weeding and increased use of inputs like pesticides and fertilizers is considered to be the most effective way to increase production. This is because a greater part of cocoa produce is lost through diseases, pests and weeds on the farm (Binam *et al*., 2008; Dzene, 2010). For these reasons, efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of farmers are resource-poor (Amos, 2007; Binam *et al.;* Nkamleu *et al*, 2010). Bravo-Ureta B.E. and L. Rieger (1991) suggested that efficiency measurement is important because it leads to a substantial resource savings. Ogunjobi (1999) enumerated three major reasons why efficiency measurement is important: Firstly, the researcher reveals that it is a success indicator and performance measure by which production units are evaluated. Secondly, the exploring of hypothesis concerning the sources of efficiency differential can only be possible by measuring efficiency and separating its effects from the effects of the production environment. Thirdly, identification of sources of inefficiency is important to the institution of public and private policies designed to improve performance.

The production efficiency of small holder farms has been reported to have an important implication for the development strategies in most developing countries (Ogundari *et al*., 2006). However, very little study has been conducted so far to assess the efficiency of inputs use among cocoa farmers in Ghana. In Ghana, studies had concentrated on determining productivity with little attention given to efficiency levels; however it is possible to increase agricultural production significantly, simply by improving the level of producer technical efficiency without additional investments (Dzene, 2010). The findings of this research was intended to provide a sound understanding of current inherent efficiency and its related factors to serve as a base for productivity and efficiency enhancing policies.

Nkamleu *et al*. (2010) studied the "Technology Gap and Efficiency in Cocoa Production in West and Central Africa: Implications for Cocoa Sector Development". There have been a few studies on efficiency in the Ghanaian cocoa industry. Aneani, Anchirinah, Owusu-Ansah and Asamoah, 2011; Binam *et al*., 2008; Dzene, 2010; Kyei *et al*., 2011 are among the few researchers who have researched into the technical efficiency of cocoa production while publication on cost efficiency in cocoa production in Ghana is negligible.

However, findings from these studies are quite limited in terms of applicability in specific farmer locations due to their broad geographic scope. Farmers in different agro-ecological zones have different socio-economic backgrounds and resource endowments which might impact their resource use efficiency. Therefore, an empirical study to investigate technical or cost efficiency in different cocoa agro-ecologies is a necessary first step in our national effort to improve resource use efficiency in specific production areas/zones, boost production, and improve the overall contribution of the cocoa sector to local economic development and overall national development.

This research goes beyond much of published literature on efficiency and productivity analysis in Ghanaian agricultural sector which had focused exclusively on the measurement of technical efficiency only. This research work deals with in addition to technical efficiency, cost efficiency of inputs use in cocoa production. Also while this research concentrates on inputs use efficiency, other research works dwell on the technical efficiency of the entire cocoa production. In this study, the level of technical and cost inefficiencies of inputs use in cocoa production among different farmers were investigated along with the influence of various farm-specific socio-economic variables.

Objectives of the Study

The main objective of the study is to analyse the efficiency of inputs use in cocoa production. The specific objectives of the study include the following:

1. To describe the state of inputs use in cocoa production.
2. To determine the effect of inputs use on output and cost in cocoa production.
3. To estimate the efficiency of inputs use in cocoa production.
4. To identify the determinants of efficiency of inputs use in cocoa production.

Research Questions

The research questions formulated for the study were:

1. What is the state of inpus use cocoa in cocoa production in Ghana?
2. What are the effects of the inputs on output and cost of cocoa production?
3. What are the levels of efficiency of inputs use in cocoa production?
4. Which factors determine the efficiency of inputs use in cocoa production?

Research Hypothesis

The following hypotheses were considered for investigation in the study;

Technical and cost efficiencies hypothesis:

1. H_0: There are no inefficiency effects

H_1: There are inefficiency effects

2. H_0: Exogenous variables do not jointly explain the variation in technical and cost inefficiency effects in the data.

H_1: The exogenous variables jointly explain the variation in technical and cost inefficiency effects in the data.

Scope of the study

The study sought to analyse empirically, the efficiency of inputs use in cocoa production in Twifo Hemang Lower Denkyira in the Central region of Ghana. The study commenced with the background to the study, the research problem statement and the hypothesis of the study. Relevant literature and methodological issues were also reviewed.

The research commences with description of the state of inputs use in cocoa production in the study area. It must be stated that labour and cutlass/hoe inputs were not included in the description of the state of the inputs use in cocoa production. In this regard, the various inputs used in production were identified and their rates of use were also obtained. The description ends with emphasis on the direction of technical change.

In addition the Stochastic Frontier Analysis (SFA) was used to estimate the levels of technical and cost efficiency of inputs use in cocoa production of farmers. Based on the findings of Boahene, 1999; Edwin, *et a.l*, 2003; Gockowski and Sonwa 2007; Teal *et al.*, 2006; Vigneri *et al.*, 2004; Vigneri, 2008 that the major technical change that has taken place are in Ghana's cocoa sub-sector were increased use of fertiliser, the adoption of hybrid cocoa varieties, and greater control of pests and disease infested trees, the inputs considered for the efficiency analysis were fertilizer application, pesticides application, hybrid varieties, labour and farm size (land). The elasticities of the inputs were estimated in the cost and production functions to obtain the effects of the inputs on cost and outputs of cocoa production. A multiple regression was also used to identify the determinants of both technical and cost efficiency.

Relevant recommendations were also compiled to help further future research, policy-makers and all other actors involved in cocoa production. Due to limited financial resources and time constraints two districts were used for the study and therefore care must be taken when using this study to generalize for the whole nation or for all fields. It may however be useful in setting the stage for further research in these regard.

Significance of the Study

This study is of both a practical and theoretical importance. At the practical level, measuring the efficiency of inputs use of cocoa farmers, and identifying the factors that affect it, may provide useful information for the formulation of economic policies likely to improve producer cost and technical efficiencies. Secondly, the research findings will help Non Governmental Organisations (NGOs) in designing yield improvement package for farmers. The findings will aid Ghana Cocoa Board (COCOBOD) to fashion out the strategy necessary to increase per unit land output of cocoa by addressing factors which militate against cost and technical efficiencies of inputs use in production. Moreover, from the microeconomic standpoint, identifying the factors that may improve farm profitability is of major significance since, by using information derived from such studies, farms or plantations may become more efficient and hence more profitable.

At the theoretical level, the study aims to bring some contribution to the understanding of producer technical and cost performance in developing countries. The study provides an insight into the state of inputs use, the level of cost and technical efficiencies of inputs use in cocoa farming, the elasticities of the inputs use and identifies socio-economic variables that affect the cost and technical efficiency of farmers. The finding will alert researchers on the gap that exist between attainable and the observed outputs. The findings of the research is also expected to serve as a resource to other researchers, students, NGOs etc who would want to undertake research in this regard.

Limitations of the Study

The following were the limitations considered in the conducting and interpretation of the study;

1. Relevant variables such as the concept of opportunity costs and risk were not captured in the model.
2. The study did also not consider the spending preferences of the cocoa farmers, focused mainly on cocoa beans output, and not on other crops cultivated in the cocoa farm like yam as well as tree grown for timber.
3. Panel data cannot be obtained, hence the use of crossectional data.
4. Data collection mostly based on respondents own estimation.
5. Household consumption and use were not accounted for.

6. The translog model used for the estimation of technical efficiency has more parameters to estimate, which could give rise to econometric difficulties such as multicollineality.

Organisation of the Study

The study is structured into five major chapters. Chapter One (1) presents the background to the study and highlight also the problem statement, study objectives and research questions, statement of hypothesis and the scope, significance and limitations of the study. Chapter Two (2) begins with its overview, importance of cocoa to Ghana's economy, production trends in Ghana and across the world, and reviews literature on the theoretical and conceptual issues of cost and technical efficiency on technology use in cocoa production. The chapter also touches on other research work on efficiency. Major methodological approaches in efficiency measurement in production were reviewed which included both the parametric and non-parametric approach. Chapter Two (2) concludes with conceptual framework of the study.

Chapter Three (3) defines the population, research designs, data needs and sources, sampling procedure and sample size, instrumentation, data collection and analytical techniques as well as the statistical tools for approaching the problem. Also presentation and discussion of results are captured in Chapter Four (4) which addresses the hypothesis and the specific objectives of the study while Chapter Five (5) summarizes, concludes and make recommendations for policy makers, researchers, farmers and all relevant institutions.

CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter presents a review of relevant literature on the theoretical and conceptual issues of efficiency of inputs use in cocoa production. This is aimed at getting supporting theories and empirical evidence for the study. It provides the foundations upon which hypotheses can be formed and tested to get a clear focus of the particular aspect of the economy that is under observation. It also provides the basis upon which a model that will explain the behaviour of a variable is constructed with suitable modifications where necessary to focus on the topic.

The chapter consists of three sections; the first section focuses on the cocoa production around the world and Ghana; the second section concentrates on inputs use in agriculture; the third section deals with the efficiency concept, some methodological approaches in the measurement of efficiency and the final section handles conceptual framework of the study.

World Cocoa Market

Cocoa serves as an important crop around the world: a cash crop for growing countries and a key import for processing and consuming countries. Cocoa trades on two world exchanges: London (LIFFE - Pound) and New York (ICE - USD). In 2011, trading volume of cocoa futures on the Intercontinental

Exchange (ICE) was 4.95 million metric tonnes, outpacing production by 750,000 tonnes. Conversely, ICE traded 3.8 million tonnes in 2010, 390,000 tonnes less than total production. Comparatively, ICE traded 5.2 million metric tonnes of coffee futures in 2011 and 5.5 million metric tonnes in 2010. Africa (Cote d'Ivoire (40% global), Ghana, Nigeria, Cameroon) over the period produces about 73% of total global supply, 14% of total global supply by Asia and Oceania (Indonesia, Malaysia, Papua New Guinea) and the remaining 13% are produced by Americas (Brazil, Ecuador, Colombia), (ICE Market Data, 2012)

Total production has increased in absolute terms from 3.66 million metric tonnes in 2007- 2008 to 3.98 million metric tonnes in 2011 to 2012. Change in production has not been linear, however, and has fluctuated in various patterns among the different regions. Africa has been and is projected to remain the principal cocoa producer in the world. Since 2000/2001, Africa's production has expanded at an average annual rate of 2.7% according to the International Cocoa Organization [ICCO] (2010). Unlike larger, industrialized agribusinesses, the vast majority of cocoa still comes from small, family-run farms, who often confront outdated farming practices and limited organizational leverage (World Cocoa Foundation, 2012). Small cocoa farms provide more than 90% of world cocoa production. In Africa and Asia, a typical farm covers 2 to 5 hectares (4.9 -12.3 acres). Five to six (5-6) million cocoa farmers exist worldwide and 40-50 million people depend on cocoa for their livelihood (World Cocoa Foundation, 2012). In West Africa cocoa is essentially a smallholder crop, cultivated on 1.2–1.5 million farms ranging in size from 3 to 7 ha and employing 10 million people. The forecasts that annual global production will reach 4.5 million tons by 2013; this growth is expected to be primarily driven by West Africa (ICCO, 2010).

Conversely, the major importers of the beans and the major processors are dominated by the Europeans, the Americans and the Asian countries whiles African contributes a meagre 16.8% on the average from 2006 to June 2010 to the world total grinding of cocoa which is a sharp contrast to their gargantuan share of the total world supply (ICCO, 2010).

Cocoa Production in Ghana

Ghana as a country is almost synonymous with the cocoa crop. Since its introduction from Equatorial Guinea in 1879, cocoa has transformed the nature of agricultural activities and has occupied centre stage in the country's socio-economic development (CRIG, 2010). Records show that the Dutch missionaries planted cocoa in the coastal areas of Ghana as early as 1815 and in 1857 the Basel missionaries also planted cocoa at Aburi (COCOBOD, 2000). However, these did not result in the spread of cocoa cultivation until Tetteh Quashie, a native of Osu, Accra, who travelled to Fernando Po to work as a blacksmith, returned in 1879 with Amelonado cocoa pods and established a farm at Akuapem Mampong in the Eastern region of Ghana. It later spread to other parts of the Eastern, Western, Ashanti, Brong Ahafo and Volta Regions. The earliest cocoa farms were largely established in the southeast. Ever since, the epicenter of production has shifted to the west. By the early 80's Ashanti and Brong Ahafo regions dominated in the production and Western was fourth in the regional outputs to the total but the latter was the best in 2009/10 cocoa season, pulling more than half of total national output. Below are the contributions of the various regions to the total national output of cocoa.

Table 1: Cocoa productions by regions 1980/81 against 2009/10

Regions	1980/81	2009/10
Ashanti	91,540mt (35.5%)	97,310mt (15.4%)
Brong Ahafo	47,600mt (18.5%)	60,500mt (9.6%)
Western	45,150mt (17.5%)	173,110mt (56.5%)
Eastern	46,630mt (18.1%)	59,800mt (9.5%)
Central	25,560mt (9.9%)	56,510mt (8.9%)
Volta	1500mt (0.6%)	600mt (0.1%)

Source: COCOBOD, 2010

The Amelonado cocoa was the first cocoa type to be introduced in Ghana, commonly referred to as the 'Tetteh Quarshie'. It takes not less than five years to bear fruit. The Amazonian type which takes three to four years to mature was introduced into the country in the 1950's. Almost all the cocoa farms established in the 1960"s and 1970s were sown with the Amazonian type. Recently, the hybrid cocoa variety (called "akokora be di" in Akan) was introduced. This is high yielding and early maturing.

Aneani, Anchirinah, Owusu-Ansah and Asamoah, (2012) found that the mean farm size was 3.0 ha, implying that cocoa cultivation is dominated by small-scale farmers who on average had cocoa yield of 317kg/ha. A typical cocoa producing community consists of owner-occupiers, caretakers (abusa) and sharecroppers (abunu). Caretakers manage the cocoa farm and receive a third of the output while the owner takes two-thirds (abusa). The owner in an abusa farm management arrangement is expected to purchase inputs for the farm; however, this rarely occurs especially in the case of low yielding farms and absentee and aged farmers. The abunu contract is used in farm establishment where the landowner agrees with the tenant to share the cocoa farm into two when it begins to bear, the landowners' only contribution is only the piece of land, (CRIG, 2010. Page 2)

The COCOBOD was established by ordinance in 1947. The mission of the Board is to encourage and facilitate the production, processing and marketing of good quality cocoa, coffee and shea nut in all forms in the most efficient and cost effective manner, and maintain the best mutual industrial relation with its objectives. The cocoa sector combines element of privatization and strong government presence.

Contribution of the Cocoa Industry to Ghana's Economy

In Ghana, cocoa has been the backbone of the economy for a century and plays a major role in employment, foreign exchange earnings, government revenue, education, infrastructural development among others (Amoah, 2008). Agriculture sector accounted for 36.6% of GDP in 2004, 36% in 2005, 35.8% in 2006 and 31.7% in 2009 (Institute of Statistical Social and Economic Research [ISSER], (2005-2010)). The cocoa sub-sector alone contributed 16.4% of aggregate agricultural growth in 2003, 29.9% in 2005, 12.2% in 2006 and 7.8% in 2009, ISSER (2004, 2006-2010) thus making the single largest contributor to agricultural growth. In the 2009/2010 cocoa season, Ghana was the second world leading producer of cocoa, accounting for 21% of the total world supply. The value of processed cocoa-based exports in Ghana has gone up from US$83.6 million in 2004 to US$152.9 million in 2006. Ghana continues to levy an export tax on cocoa that contributes directly to government incomes even though the importance of this income source has declined (ISSER, 2001; BoG, 2007).

Besides the revenue to the state, cocoa cultivation supports the livelihoods of over 600,000 farmers and their dependents, working on over 1.2 million hectares of land (CRIG, 2010). Cocoa creates employment for these thousands of persons. Farmers obtain income from engaging in cocoa production and this is very essential for these farmers since job is very difficult to come by and the revenues most farmers generate from food crops production are not enough for the needs of the farmers as results of low productivity among other factor. Aneani *et al.* (2012) again found that the mean income from cocoa was GH¢ 717.68 with a high standard deviation of GH¢820.87, which was due to the high variation in cocoa output. Asamoah and Baah (2003) explains that cocoa contributes about 70 per cent of annual income of small-scale farmers and stakeholders like Licensed Buying Companies (LBC's) also depend largely on cocoa beans for their trading and marketing activities, employment and income generation.

In the Southern Forest Belt of Ghana, where cocoa is produced, aggregate figures suggest that through the 1990s, cocoa-farming households, along with those engaged in mining or timber (the other predominantly export-oriented activities) and other commercial activities, experienced improvements in their living conditions compared with food crop farmers (McKay & Coulombe, 2003).

Poverty reduction among cocoa farmers is clear. Household surveys indicate that poverty among cocoa-producing households dropped to 23.9 percent in 2005, down from 60.1 percent at the beginning of the 1990s (World Bank 2007b).

Cocoa is also of importance to consumers. To the consumers it is a food taken for pleasure, but with high nutritional value, making it a supplement to a balanced diet (Ojeh, 1979). Cocoa is a complete food high in energy value due to its high level of minerals and vitamins which are important for growth (Mossu, 1992).

Interventions in the Ghanaian Cocoa Industry (Cocoa Sector Support Programme Phase 2 (CSSP2)

The overall objective is to contribute to an improved livelihood of smallholder cocoa farmers in Ghana. Specifically this objective will lead to an improved sustainability of cocoa production in Ghana. The target group are cocoa farmers with potential for farm intensification/diversification in selected communities; emerging grassroots cocoa farmer organizations; Trainers from public and private sector institutions (All in Ashanti and Western Regions). The partners in the program were Ghana COCOBOD; Ministry of Food and Agriculture; District Assemblies; Cocoa Licensed Buying Companies; Beneficiary communities and their leadership; local consultants and relevant NGOs and private sector.

The main activities included: Intensify extension to cocoa farmers through participatory training methods and tools; Address the environmental and social aspects of cocoa production; Improve farmers' access to high quality hybrid cocoa planting material; Support replanting/planting of hybrid cocoa varieties including degraded forestlands; facilitate better self organization of cocoa farmers to access improved production services; organize cocoa farmers to contribute effectively towards cocoa sector development discussions and policy formulation processes; strengthen service provision capacity of cocoa farmers organizations; conduct evidence-based sector studies to provide information to policy makers and other sector stakeholders.

With the supporting action (action 1c) implemented through the Seed Production Unit (SPU) of Cocobod, STCP will demonstrate at the end of the four years a cocoa sub-sector where farmers are organized at the community level, adopt intensification technologies and possess requisite skills to apply the technologies. The intensified systems will ensure that farmers adopt the use of a set of technologies, acquire and use a set of skills within a supportive institutional arrangement that facilitates the technology adoption and application of appropriate skills. A set of evidence-based researched outcomes informing a set of policy strategies and choices recommended to government through participatory stakeholder discussions and consensus building. The specific set of technologies, skills, institutional frameworks and selected policy issues to be addressed are indicated in the bullets below:

A. Technologies Adopted

i. Improved planting material of cocoa

ii. Soil fertility management / fertilizer use in cocoa farms

iii. Integrated crop and pest and disease management techniques

iv. Food cropping in cocoa systems using improved food crop planting material (e.g. plantains and cassava)

v. Integration of valuable shade trees into existing and new cocoa farms

B. Farmer Skills

i. Integrated crop and pest management (ICPM) and quality management

ii. Replanting/new establishments

iii. Tree diversification

iv. Farm management and entrepreneurship

[All the above skills delivered through farmer field schools (FFS), video viewing clubs (VVC) and farmer business schools (FBS) type of approaches]

C. Institutional Arrangements

i. Training provision to farmers and their organizations

ii. Financing of training

iii. Access and linkage to credit

iv. Private sector input supply

v. Farmer associations access to services, inputs and saving/credit

vi. Policy dialogue and stakeholder input into sector policy formulation

D. Policies

i. Strategy and policies supporting farmer access to intensification packages

ii. Strategy or policies for cocoa cultivation in critical ecosystems or environmental hotspots (e.g. Western Region)

iii. Strategy to enhance the role and contribution of women in the cocoa sector

iv. Broader participatory sector policy formulation processes and engagement.

The above intensification approach was supposed to be implemented through the nine (9) inter-related key actions approved by the European Union (EU) in the CSSP2 financing proposal (FP). Below are the results' intended and their intended actions.

Result 1: Increased adoption of sustainable cocoa production methods

i. Intensify extension to cocoa farmers through participatory training methods and tools.
ii. Address the environmental and social impact of cocoa.
iii. Improved farmers' access to high quality hybrid cocoa varieties in former cocoa growing areas.
iv. Support replanting a large area with hybrid cocoa varieties in former cocoa growing areas.

Result 2: Improved cocoa sector governance through strengthened cocoa farmers organizations and their vertical integration in cocoa governance structures.

i. Strengthen governance and management capacities of existing and emergingfarmers and community-based organizations.
ii. Strengthen service provision capacity of cocoa farmers' organization.
iii. Foster vertical integration of cocoa farmer organizations in cocoa sector governance structures.

Result 3: Participatory Cocoa Sector Strategy Developed and Implemented

i. Support participatory cocoa sector strategy formulation.

ii. Carry out specific cocoa sector studies

Nevertheless, the need for alternative incomes for cocoa farmers and communities will be encouraged though synergies that the program will facilitate with other national level projects and programs that promote the development of alternative (i.e. non cocoa incomes). Examples of such national programs are the Millennium Village Project (MVP), President‘s Special Initiatives (PSI) on Oil Palm and Cassava. Target communities and farmers benefiting from CSSP2, through their community association formation will be supported to link-in with such programs'.

Furthermore, through skills developed in the FBS and through the community-based farmer organizations, farmers were supposed to be equipped with knowledge and skills to invest in income diversification option. A set of activities to be implemented were elaborated under each of the actions. The implementation of the activities under each action will contribute to achieving one of the three project results and ultimately achieve the project purpose - improved sustainability of cocoa production in Ghana. The expected outputs and anticipated outcomes for the actions are described below. The project calendar for the activities described below is defined as follows: Year one (July–December 2008); Year two (January–December 2009); Year three (January-December 2010) and Year four (January-December 2011). (International Institute of Tropical Agriculture (IITA)/Sustainable Tree Crops Program (STCP) Grant Agreement (EU-Cocoa Sector Support Programme – Phase 2-2008).

Agricultural Inputs

Olukosi and Erhabor (1980) characterize inputs/resources into variable and fixed resources. Variable resources include labour, seeds and fertilizers, which are normally used up in one production process. Fixed resources are more durable resources, which contribute to the production process over several production periods. They include land, machinery, farm building, and plantation plants. According to Klump and Cabrera (2008) agricultural technologies are classified into two types: (i) mechanical, which are labour-saving and aimed at substituting power and machinery for labour; and (ii) biological and/or chemical, designed to substitute labour-intensive techniques and industrial inputs (e.g. fertilizer) for land.

Kolavalli and Vigneri (2010) stated that "the effect of all these improved practices has been an increase in productivity of about 30 percent, which brought productivity to the levels achieved in the 1980s. Productivity was stagnant until the late 1980s, with production largely related to area harvested. The first big jump in productivity occurred in the 1980s, corresponding to the year of the Cocoa Rehabilitation Program rolled out under the Economic Recovery Programme (ERP), and the second more recently, with improved practices".

Empirical studies on inputs use

Since 1990, three noticeable changes have taken place in the use of inputs in cocoa production, in particular increased use of fertilizers; the adoption of hybrid cocoa varieties, and better control of pests and diseased trees (Boahene, Snijders, & Folmer 1999; Edwin & Masters 2003; Gockowski & Sonwa 2007;

Teal, Zeitlin, & Maamah 2006; Vigneri, Teal, & Maamah 2004; Vigneri 2008). Aneani *et al*. (2012) found that the adoption rates of the CRIG-recommended technologies such as control of capsids with insecticides, control of black pod disease with fungicides, weed control manually or with herbicides, planting hybrid cocoa varieties and fertilizer application were 10.3%, 7.5%, 3.7%, 44.0% and 33.0%, respectively. One way of increasing production by the small farmers is to efficiently use all the resources available in the production process. Olaide (1980) indicated that the most productive and efficiently used inputs are labour, seeds and farm equipment.

Land and labour inputs. Over time, cocoa farmers have changed the way they access land and labour in response to the changing production conditions of a constantly moving cocoa frontier. Until the early 1940s, when both land and labour were abundant, large farms were able to attract rural workers to establish new farms by selling them small plots of land, an arrangement that often also drew the workers' family members to establish and maintain new farms. By the second half of the1960s, when land became scarce, sharecropping arrangements increasingly replaced land sales. During times when the cost of hiring waged workers became too high, alternative forms of labour were used—mostly, either sharecropping arrangements or informal labour groups known as nnoboa (Berry 1993; Vigneri, Teal, & Maamah 2004).

A typical cocoa producing community consists of owner-occupier, caretakers (abusa) and sharecroppers (abunu). Caretakers manage the cocoa farm and receive a third of the output while the landowner takes two-thirds (abusa).

The owner of the abusa farm management arrangement is expected to purchase inputs on the farm; however this rarely occurs especially in the case of low yielding farms and absentee and aged farmers. The abunu contract is used in farm establishment where the landowner agrees with the tenant to share the cocoa farm into two when it begins to bear (the landowners contribution is only the piece of land). In recent times, the abunu arrangement has become less attractive due to the unwillingness of landowners to alienate family land (CRIG, 2010)

Esteban and Xinshen (2011) reveals that "labour, similar to land, is a necessary primary factor for crop production. Obviously, households provide most of the essential labour inputs throughout the various stages of smallholder crop production. As such, hired labour is mainly a seasonal phenomenon for these households intended to alleviate a bottleneck for certain time-constrained activities". According to Esteban and Xinshen, in the case of Ghana, hired labour primarily occurs for land preparation, which involves weeding, and ploughing (as well as weeding during crop growing season). The study by Esteban and Xinshen showed that 46% of rural household reported to have hired labours in the cropping season.

Land as a resource is efficiently used through shifting cultivation practices and other cropping systems (Okigbo, 1978), but the full potentials of land, capital and labour resources are yet to be efficiently husbanded for optimum production. On farm sizes, Heshmati and Mulugeta (1996); Mochebelele and Winter-Nelson (2000); Townsend *et al*. (1998) found no significant variation in technical efficiency, but Tadesse and Krishnamoorthy (1997) reported an inverse relationship while Helfand (2004) established a quadratic relationship. Wadud and White (2000) observed that inefficiency decreased with farm size.

Planting materials. Hybrid cocoa varieties were introduced in 1984 through the government's Cocoa Rehabilitation Project (CRP). Hybrid varieties outperform the older "Amazons" and "Amelonado" varieties in two ways—by producing trees that bear fruit in three years compared with at least five years for the older varieties, and by producing more cocoa pods per tree planted with traditional trees (Kolavalli & Vigneri, 2010). Edwin and Masters (2003) revealed that "new tree varieties yield approximately twice as much cocoa per hectare as similar-aged fields". But hybrid cocoa trees underperform older varieties in that they require optimal weather conditions and complementary farming practices such as the application of chemical inputs, adoption of new planting procedures, pruning, and spraying. Hybrids varieties also require that farmers make more harvest rounds at the beginning and the end of the season, something they are reluctant to do when it conflicts with other farming or trading activities (Boahene, Snijders, & Folmer 1999).

Despite the increased labour input for hybrid cocoa trees, farmers have increasingly adopted them. In the late 1980s only 10 percent of cocoa grown in Ghana was of the high-yielding type (Nyanteng 1993). By 2002, 57 percent of farmers in the three main cocoa-producing areas were growing hybrid trees (Vigneri 2005). Traditional varieties may have disappeared entirely from all fields planted after 1995 (Edwin & Masters 2003).

Fertilizer use. CRIG (2010) defined fertilizer as any substances that contain nutrients and are applied to the soil or plants leaves to provide nourishment for plants. In Ghana, the common fertilizers applied on cocoa farms include Asaase Wura, Cocofeed, Sidalco liquid fertilizers (N:P:K 10:10:10 (balanced), N:P:K 20:2:4 (Nitrogen-rich) and N:P:K 6:0:20 (Potassium rich)) and more recently Nitrabor.

Due to constantly increasing pressure on available land as a result of high population densities, fallow periods have significantly reduced, and at present rarely exceed six years (Onyabinama, 2006). As a general rule, fallow shorter than ten years will not allow the soil to recover adequately and the quality of the soil decreases with more frequent exploitation (Ewe, 1978). In the same vein, the soil nutrients in cocoa plantation are being mined annually via cocoa harvest (Ogunlade, Oluyole & Aikpokpodion, 2009). Wessel (1971) reported that there is a steady decline in almost all the nutrients with lengthy cultivation. Omotoso (1975) revealed that a crop of 1000kg dry cocoa beans remove about 20Kg N, 4Kg P and 10Kg K and where the method of harvesting (as in Ghana) involves the removal of pod husks from the field, the amount of potassium removed increased more than five folds.

Adequate use of fertilizer has been found to increase agricultural output (Ogunlade *et al.*, 2009). According to Olson (1970), fertilizer could increase food production by at least 50%. Opeyemi, Fidelis, Ademola and Phillips (2005) reported that an effective use of fertilizer on cocoa would help not only improve yield but also has the advantages of profitability, product quality and environmental protection. Agbeniyi, Ogunlade and Oluyole (2010) observed that the majority of the respondents in Cross River State, Nigeria (98.13%) did not use fertilizer for cocoa production while just 1.87% of the respondents indicated that they were using fertilizer for cocoa production in the study area. The result is in line with the findings by Ogunlade *et al* which reported that 78.2% of cocoa farmers in Nigeria were not using fertilizer for cocoa production.

Kolavalli and Vigneri (2011) stated that fertilizer use in Ghana has increased significantly since the 1990s. According to Kolavalli and Vigneri, surveys of cocoa farmers in the three main cocoa-producing regions of Ghana show that fertilizer application rates increased from 9 percent in 1991 to 47 percent in 2003. Although the quantity of fertilizer used decreased between1991/92 and 1997/98, the proportion of farmers applying fertilizer increased, possibly from liberalization of input markets in 1996/97, which eliminated subsidies but improved private distribution (Vigneri & Teal, 2004).

Weeds, disease and pest control. CRIG (2010) revealed that annual global loss of cocoa to insect pest is estimated at 558,000mt and in Ghana; mirids alone may cause about 25% yield loss if their numbers on the crops are not effectively managed. Control of disease and pests, swollen shoot virus and capsid in particular has improved significantly in recent years. After COCOBOD initiated a free mass spraying program in 2001, 93 percent of cocoa farmers who participated in a survey conducted in 2002 linked their yield improvements to the effects of the program (Steedman, 2003).

CRIG (2010) again records in the "Cocoa Manual" version 1, page 27 that when "Glyphosate is used, weeds are controlled or suppressed over a longer period than manual weeding, much time is saved (1.5 mandays are required per hectare) and long-term saving in cost (about 30%) of weed control are achieved. The efficiency of herbicide application is very much improved when the cocoa is planted in lines". According to FAO report (1971), the control of diseases and pests of cocoa in the cocoa belt of Western Nigeria, is said to have increased cocoa output by about 40 to 50 percent in recent years. It has been suggested in the past that control of pests and diseases should be initiated when the pest population is low enough to cause damages whose cedis value is equal to the cost of control. Youdewei and Mike (1995) argues that the treatment of pests when population are already high is unreasonable, because considerable damage would have been done by the time control measure are undertaken.

Ayinde (2013) conducted a study to analyse pesticide use in cocoa production in Obafemi Owode local government area of Ogun State, Nigeria and found that pesticide use in cocoa production is a major productivity enhancing resource, although farmers used it below the recommended rate. The study therefore recommended among others, that it is necessary to sensitize cocoa farmers on the use of pesticide at a recommended rate and that there is need to make it available at subsidized rate with a view to enhancing their productivity. Paolletic, Stinnor and Lorenzoni (1995) reported that agricultural practices have adopted more and more, the use of chemical (fertilizers and pesticides) to produce crops since the 1940s. However, pesticides are required in agricultural production mainly for crop protection but pesticides are extremely hazardous to the health of workers, general public and environment (International Labour Organization, 1991). Amatobi (1995) also pointed out the health hazards resulting from the use of pesticides; such as high mammalian toxicity, persistence in the soil and pollution of the environment of some pesticides were identified as early as late 1970s. According to the estimate from World Health Organization (WHO) in 1973, 50% of poisoning cases, 75% of fatal poisonings and about 500,000 people in the world are accidentally poisoned annually by insecticides.

In Ghana Akate Master, Actara and Confidor are some of the insecticides approved by CRIG for the control of harmful insect in cocoa production while Ridomil Gold, Funguran-OH, Metalm 72 WP, Fungikill 50WP, Kocide 2000, Nordox 75WG and Champion are the current list of fungicides for cocoa and Round-up and Gramoxone are the list of currently approved herbicides for cocoa and its must be mentioned however that these list are subject to review over time (CRIG, 2010).

Biases in Inputs Needs in Agriculture

Direction of inputs needs and technical change in agriculture pursued by any economy or region in agriculture tend to have some biases toward a factor of production. The emergence of such biases had been pointed out by Hayami and Ruttan (1970) based on a study of long time series of agricultural inputs and technologies in Japan and in the US from 1880 to 1980. Land scarcity in Japan seems to have favoured land-saving technologies like new crop varieties and the use of resistant varieties, while land abundance in the US made technological change more labour-saving due to the use of tractors and machinery. Similar results were also documented by Klump and Cabrera (2008). Hayami and Ruttan's tests were ad hoc, and the most important limitation was the failure to distinguish between the technological change effects and the effects of factor substitution under the given technology (Oniki, 2000). In order to distinguish these two effects, Binswanger (1974) incorporated a time trend variable (proxy for technological change) in a translog cost function. Hayami & Ruttan (1970) and Binswanger (1974) found consistency with the induced innovation hypothesis.

A theoretical explanation for the relationship between factor-biases in technological change and relative factor proportions can be given in the framework of the model of directed technical change developed by Acemoglu (2000 and 2001). In this model the elasticity of substitution between factors of production is a key determinant of the direction of the technological bias. Acemoglu's (2000 and 2001) model on directed technical suggests that under a low elasticity of substitution among factors of production, country-specific factor proportions and factor prices may facilitate a substitution of technologies in order to save the relatively more scarce, and replace it with relatively more abundant and cheap factors. Given that most poor areas are characterized by scarce productive land and a large supply of landless and unskilled wage labourers, technical change may facilitate the use of land-saving or labour-intensive technologies rather than labour-saving technologies.

In the context of agriculture, Hayami (1969) and Hayami and Ruttan (1971), proposed a model of induced technical change for the agricultural sector, in which development and application of new technology is endogenous to the economic system. They stressed the role of changes in relative resource endowments and factor prices when explaining the induced bias of technical change. Alternative agricultural technologies are then developed to facilitate the substitution of relatively abundant (cheap) factors for relatively scarce (expensive) factors. Thirtle, Hardley and Townsend (1995), who followed Hayami-Ruttan approach and tested the so-called "induced innovation hypothesis" in South Africa between 1947 and 1992 by applying panel co integration techniques also affirms that factor prices mattered in the selection of production technology in the agricultural sector.

Within the Hayami and Ruttan framework, prices efficiently induce changes in the demand and supply of products and factors. While farmers are induced by shifts in relative prices to seek for technical alternatives that save the increasingly scarce factors of production, profit maximizing technology suppliers respond to demand by supplying new technical possibilities that facilitate profit-maximizing farmers to progressively substitute the increasingly abundant factors for increasingly scarce factors. Economically, Klump and Cabrera (2008) argues that agricultural technical change have to be also locally appropriate, so that it may suit properly to local conditions, increasing the use of relative abundant (hence cheap) factors of production rather than scarce (hence expensive) factors. From perspectives of efficiency and equity, technical change in the agricultural sector is expected to be more pro-poor the higher the bias towards land-saving technologies, in particular among the most poor and remote areas.

The Green Revolution is an example of how the increased use of land-saving (labour intensive) technologies could help to reduce poverty and generate pro-poor growth in the agricultural and rural sector. For instance, Lipton (2004) describes the process very clearly: "Total factor productivity far outpaced the fall in staples prices relative to the prices of inputs." The landless poor labourers found that larger harvest, more water control, and more fertilizer consumption all raised their productivity but the productivity of scarce land much more. The demand for labour increased significantly while their staples requirements became cheaper. The urban and rural non-farm poor gained also from increased staples output and decreased price of food staples.

Klump and Cabrera (2008) asserted that institutional commitment to develop the agricultural sector and good governance are pre-requisites and critical to encourage the private sector to progressively adapt technology to local conditions. This has been corroborated by Thirtle *et al*. (1995). Thirtle *et al.* found policy to be a major source of distortion, sustaining the bias towards labour-saving technical change, inappropriate for a labour-surplus economy in which small farmers face a chronic scarcity of land. This bias was found to be influenced by public spending on research and extension, and by favourable tax and interest rate policies.

Definitions and Concept of Efficiency

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 (Greene, 1997). Lovell (1993) defines the efficiency of a production unit in terms of a comparison between observed and optimal values of its output and input. The comparison can take the form of the ratio of observed to maximum potential output obtainable from the given input, or the ratio of minimum potential to observed input required to produce the given output. In these two comparisons the optimum is defined in terms of production possibilities, and efficiency is technical.

CRIG (2010) in “Cocoa Manual", page 57 stated that there are two levels of efficiency and they are technical efficiency and economic/cost efficiency. The cocoa manual defined technical efficiency “as the least input combination". That is choosing from the basket the combination of inputs that offer the least amount or quantity of inputs that will give the same level of output while economic/cost efficiency is also described as “the least cost combinations". That is choosing from the basket the combination of inputs that offer the least cost and will give the same level of output. Koopmans (1951) provided a definition of what we refer to as technical efficiency: 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 inputs. Farrell (1957) and much later Charnes, Cooper and Rodes (1985) go back over the empirical necessity of treating Koopmans’ definition of technical efficiency as a relative notion, a notion that is relative to best observed practice in the reference set or comparison group. This provides a way of differentiating efficient from inefficient production units, but it offers no guidance concerning either the degree of inefficiency of an inefficient vector or the identification of an efficient vector or combination of efficient vectors against which inefficient vector can be compared.

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. Radial measures focus on the maximum feasible equiproportionate reduction in all variable inputs, or the maximum feasible equiproportionate expansion of all outputs. They are independent of unit of measurement. Applying radial measures the achievement of the maximum feasible input contraction or output expansion suggests technical efficiency, even though there may remain slacks in inputs or surpluses in output.

In economics the notion of efficiency is related to the concept of Pareto optimality. An input-output bundle is not Pareto optimal if there remains the opportunity of any net increase in outputs or decrease in inputs. Pareto-Koopmans measures of efficiency (i.e., measures which call a vector efficient if and only if it satisfies the Koopmans definition reported above, coherent with the Pareto optimality concept) have been analysed in literature. Example, Fare (1975), Fare and Lovell (1978) among others. 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. Implicit in the notion of allocative efficiency is a specific behavioural assumption about the goal of the producer; Farrell considered cost-minimization in competitive inputs markets, although all the behavioural assumptions can be considered. Although the natural focus of most economists is on markets and their prices and thus on allocative rather than technical efficiency and its measurement, he expressed a concern about human ability to measure prices accurately enough to make good use of allocative efficiency measurement, and hence of overall economic efficiency measurement (Farrell, 1957).

Oleg, Fritsch and Stephan (2008) defined the measure of cost inefficiency (overall efficiency) as the ratio of potentially minimal cost to actual cost. The production technology can be represented in a form of cost function. The cost function represents the dual approach in that technology is seen as a constant towards the optimizing behaviour of firms (Chambers, 1983). In the context of cost function any error of optimization is taken to translate into higher cost for the producers. However, the stochastic nature of the production frontier would still imply that the theoretical minimum cost frontier would be stochastic. The cost function can be used to simultaneously predict both technical and allocative efficiency of a firm (Coelli, 1995). Also, it can be used to resurrect all the economically relevant information about farm level technology as it is generally positive, non-decreasing, concave, continuous and homogenous to degree one to one input prices (Chambers, 1983).

The concept of efficiency generally centres on the possibility of producing a certain level of output at lowest cost or of producing the optimal level of output from given resources. Conventionally, the performance of a firm is judged utilizing the concept of economic efficiency, which is made up of two components: technical efficiency and allocative efficiency (Kalarijan & Shand, 1989). According to Kalarijan and Shand, the willingness and ability of an economic unit to equate its specific marginal value product to its marginal cost is referred to as allocative efficiency. In effect, allocative efficiency refers to the adjustment of inputs and outputs to reflect relative prices (price efficiency) under a given technology (Ellis, 1998). Unlike technical efficiency concepts, which only consider the process of production, allocative efficiency concepts pertain to the idea that society is concerned with not only how an output is produced, but also with what outputs and balance of output are produced.

It is possible to distinguish different kind of efficiency, such as scale, allocative and structural efficiency. The scale efficiency has been developed in three different ways. Farrell (1957) used the most restrictive technology having constant returns to scale (CRS) and exhibiting strong disposability of inputs. This model has been developed in a linear programming framework by Charnes, Cooper and Rhodes (1978). Banker, Charnes and Cooper (1984) have shown that the CRS measure of efficiency can be expressed as the product of a technical efficiency measure and a scale efficiency measure. A third method of scale uses non-linear specification of the production function such as Cobb-Douglas or a translog function, from which the scale measure can be directly computed (Sengupta, 1994).

The allocative efficiency in economic theory measures a firm's success in choosing an optimal set of inputs with a given set of input prices; this is distinguished from the technical efficiency concept associated with the production frontier, which measures the firm's success in producing maximum output from a given set of inputs. The concept of structural efficiency is an industry level concept due to Farrell (1957), which broadly measures in what extent an industry keeps up with the performance of its own best practice firms; thus it is a measure at the industry level of the extent to which its firms are of optimum size i.e. the extent to which the industry production level is optimally allocated between the firms in the short run. 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.

Measurement of Efficiency

The two main methodologies for the estimation of efficiency are: the Data Envelopment Analysis (DEA) which involves mathematical programming (non-parametric approach) and the Stochastic Frontier Analysis (SFA) which uses econometric methods (parametric approach).

Non-parametric approach. The Data Envelopment Analysis (DEA) is a non-parametric linear programming approach to frontier estimation. DEA defines efficiency frontier based solely on the observed firm-level data, i.e., without assuming any specific functional form. The resulting production (cost) frontier is constructed by solving profit maximization (cost minimization) LP for every firm and represents a piece-wise set of production or cost vectors observed as best practices. Firm-level efficiency is computed by comparing the datum to the "best practice" defined by the frontier. This information is used for identifying characteristics of the most and the least efficient firms, as well as for recovering technological information and forecasting firm behaviour (Varian, 1984). According to Coelli (1996), large number of papers have extended and applied the DEA methodology. Charnes, Cooper and Rhodes (1978) proposed a model which had an input orientation and assumed constant return to scale (CRS). Subsequent papers have considered alternative sets of assumption such as Banker, Charnes and Cooper (1984) who considered a variable return to scale (VRS) model.

The main limitation of the DEA model is that any deviation from the frontier is interpreted as an indication of inefficiency. In the presence of random disturbances that affect farm operations, such as weather, farms may be erroneously labelled as inefficient. This inflexibility of deterministic DEA may lead to systematic overestimation of inefficiency (Cooper, Seiford, & Tone, 1999). However, since most farmers in the sample operate in similar geographical location, these effects could be attenuated.

Parametric approach. The stochastic frontier approach (SFA) is an alternative method of the frontier estimation that assumes a given functional form for the relationship between inputs and an output. When the functional form is specified then the unknown parameters of the function need to be estimated using econometric techniques (Battese & Coelli, 1995). The Stochastic Frontier Approach (SFA) specifies output variability by a non-negative random error term (u) to generate a measure of technical inefficiency as considered also by advocates of the deterministic approach (Afriat, 1972) and a symmetric random error (v) to account for effects of exogenous shocks beyond the control of the analysed units which embodies variation in weather conditions, diseases, poaching etc, measurement errors and any other statistical noise.

The stochastic frontier approach has gained popularity in farm-specific efficiency studies. In the frontier approach, the production function is estimated as the most efficient set of points in input-output space so that deviations from this frontier are used as the measure of technical inefficiency. An economically efficient input-output combination would be on both the frontier function and the expansion path (Xu & Jeffrey, 1998). Although several functional forms can be used to specify the stochastic frontier, desirable forms are those linear in parameters because they easily facilitate the calculation of technical efficiency (TE) or technical inefficiency (TI). Nevertheless, forms that are multiplicative in inputs and error terms are excellent candidates for the stochastic frontier (Kirkley, Squires & Strand, 1995).

A number of authors such as Aigner, Lovell, and Schidt (1977), and Meeusen and Van der Broeck (1977) developed the “stochastic composed error frontier methodology” following the inadequacies of the deterministic frontier estimation. The main principle of the model is to specify the error term as the sum of two parts, one normal and the other from the one sided normal distribution.

The Stochastic Production Frontier models (SPF) developed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) is a parametric (econometric) approach to estimating efficiency. This approach assumes that the gap between actual and potential production levels may not be completely under the producer's control, and allows for the introduction of statistical noises resulting from random events (Greene, 1997). The stochastic frontier estimation involves the specification of the disturbance term that causes actual production to deviate from this frontier by decomposing it into two parts as follows:

$Y = f(X)e^{v-u}$.......................... (7)

This method focuses on the difference or distance from the efficient frontier (production curve) i.e. this distance reflects the inefficiency effect, *u*. The differences in estimation process are based on the treatment of the composite error components. The SFA is based on the assumption that the random error *v* is normally distributed and that the inefficiency term *u* follows an asymmetric (one sided) distribution (truncated normal distribution). The specification of the stochastic production frontier model, allows for a non-negative random component in the error term to generate a measure of technical inefficiency or the ratio of actual to expected maximum output, given inputs and the existing technology. Apart from allowing for the measure or assessment of technical inefficiency, stochastic frontier models also acknowledge the fact that random shocks outside the control of producers can affect the output level. This is due to the fact that stochastic effects such as weather conditions among others could cause variations in maximum output. The variation in output could also occur as a result of farms in a country operating at various levels of inefficiency due to poor incentives, mismanagement, inappropriate input levels or less perfectly competitive behaviour (Kumbhakar & Lovell, 2000).

The metafrontier approach is also a parametric approach. While technical efficiencies of units that are measured with respect to a given frontier are comparable, this is not normally the case among units that operate under different technologies. Such problems arise when comparisons of units from different countries are involved. The metafrontier production function concept is based on the hypothesis that all producers in different countries have potential access to the same technology. However, each producer may choose to operate on a different part of it depending on circumstances such as natural endowments, relative prices of inputs, and the economic environment (Lau & Youtopoulos, 1989). This implies that the metafrontier is more appropriate when the efficiencies of two or more producers in different countries and of different technology are to be compared.

The metaproduction function concept was first introduced by Hayami (1969) and Hayami and Ruttan (1970, 1971). As stated by Hayami and Ruttan (1971, p. 82): "The metaproduction function can be regarded as the envelope of commonly conceived neoclassical production functions." In their discussion of agricultural productivity across various countries, Ruttan *et al*. (1978, p. 46) state: "We now define the metaproduction function as the envelope of the production points of the most efficient countries." The concept of a metaproduction function is theoretically attractive because it is based on the simple hypothesis that all producers in different regions (countries, regions, etc.) have potential access to the same technology.

Inefficiency Effects

According to Battese and Coelli (1993), the stochastic frontier production function postulates the existence of technical inefficiencies of production of firms involved in producing a particular output. For a given combination of input levels, it is assumed that the realized production of a firm is bounded above by the sum of a parametric function of known inputs, involving unknown parameters, and a random error, associated with measurement error of the level of production or other factors, such as the effects of weather, strikes, damaged product. The greater the amount by which the realized production falls short of this stochastic frontier production, the greater the level of technical inefficiency.

Farrel (1957) observed that technical inefficiency arises when less than maximum output is obtained from a given bundle of factors while allocative inefficiency arises when factors are not used in proportions, which do not lead to profit maximization. Battese and Coelli (1993), again stated that a stochastic frontier production function is defined for panel data on firms, in which the non-negative technical inefficiency effects are assumed to be a function of firm-specific variables and vary over time. The inefficiency effects are assumed to be independently distributed as truncations of normal distributions with constant variance, but have means which are a linear function of observable firm-specific variables. Technical inefficiency error term has two components; one to account for random effects (e.g. measurement errors in the output variable, weather conditions, diseases and the combined effects of unobserved/uncontrollable inputs on production); and another to account for pure technical inefficiency in production (Dey, 2005).

Empirical Studies on Determinants of Efficiency

Factors that explain technical and cost inefficiency in a developing country's agriculture are many. An important characteristic is the prevalence of subsistence needs. Inefficiency can also result from socioeconomic, demographic or environmental factors. However, farm-specific efficiency or inefficiency can be related to farmer characteristics. These variables may measure information status and managerial skills, such as education, technical knowledge and extension contacts, as well as system effects exogenous to the farm, such as credit, input markets or tenancy (Ali & Byerlee, 1991).

Pudasaini (1983) documented that education contributed to agricultural production in Nepal through both worker and allocative effects. The author also found that even though education enhances agricultural production mainly by improving farmers' decision making ability, the way in which it is done differs from environment to environment. Thus, in a technologically dynamic agricultural system, education improves farmers' allocative ability, enabling them to select improved inputs and optimally allocate existing and new inputs among competing uses. On the other hand, in traditional agriculture, it enhances their decision making ability mainly by increasing their ability to better allocate existing farm resources.

However, Kalirajan and Shand (1985) argue that although schooling is a productive factor, farmers' education is not necessarily related significantly to their yield achievement. Illiterate farmers, without the training to read and write, can understand a modern production technology as well as their educated counterparts, provided the technology is communicated properly. Using Tamil Nadu rice farmers as a case study, Kalirajan and Shand conducted a quantitative analysis of various types of education in relation to productivity in order to determine whether schooling of farmers had a greater influence on yield than non-formal education (defined as a farmer's understanding of the technology). The findings revealed that schooling (education) of farmers had an independent effect on yield, but it was not significant. On the other hand, a farmer's non-formal education was found to have a significant and greater influence on yield. Kalirajan and Shand concluded that farmers' schooling and productive capacity need not be significantly related under all circumstances.

Further, Adesina and Djato (1996) investigated the extent to which education affects inefficiency in agriculture using a sample of 410 rice farmers in northern Côte d'Ivoire. The objective was to examine the relative differences in technical, allocative and economic efficiency between educated and non-educated rice farmers. The analysis was based on a duality method, using the normalized restricted profit function approach with factor share equations. The authors found that there is no difference in either relative technical, allocative or economic efficiencies between educated (defined as those who had at least one year of formal schooling) and non-educated farmers.

The analysis was repeated for an education threshold of six years of formal schooling, but this did not alter the results (considered as the minimum for literacy in Côte d'Ivoire). The conclusion was that educated farmers are not more efficient than non-educated farmers because the latter may have an empirical knowledge obtained from cumulative farming experience. Adesina and Djato (1996) recommended that rural development efforts should not be biased towards "educated" farmers as "non-educated" farmers are just as efficient.

For Weirs (1999), at least four years of primary schooling are required to have a significant effect upon farm productivity. The prior expectation is that cost efficiency should increase with the increase in the years of schooling since education is expected to be positively correlated with the adoption of the improved technology and techniques of production (Ojo & Ajibefun, 2000). In addition, Kumbhakar, Ghosh and McGuckin (1991) investigated the determinants of technical and allocative inefficiency in US dairy farms. The stochastic frontier approach was used involving a single-step maximum likelihood procedure and found that the levels of education of the farmer are important factors determining technical inefficiency. The conclusion was that both technical and allocative inefficiencies decrease with an increase in the level of education of the farmer. This is similar to the conclusion reached by Seidu (2008), Ajibefun and Daramola (2003) and Parikh and Shah (1995), that education is an important policy variable and could be used by policy makers to improve both technical and allocative efficiency.

Paudel and Matsuoka (2009) found significant positive correlation between maize area and inefficiency. Kumbhakar *et al.* (1991) again found that large farms are more efficient (technically) than small and medium-sized farms. The finding of frontier analysis by Ogundele and Okoruwa (2004) show that farm size significantly determines levels of technical efficiency in Nigeria. However, Murthy *et al* (2012) indicated that most of the farms irrespective of size of holding have shown technical inefficiency problems. Data Envelopment analysis (DEA) and log linear regression models were used for estimating the technical efficiency and its determining factors, respectively of tomato-producing farms in Karnataka, India, by Murthy *et al*. (2012).

The impact of agricultural extension on farm production has received considerable attention in the farm efficiency literature. Agricultural extension represents a mechanism by which information on new technologies, better farming practices and better management can be transmitted to farmers. Kalirajan (1981b) explained that extension workers' limited contact with the farmers and farmers' misunderstandings of the technology were responsible for the difference between the actual and maximum yields among the farmers. The researcher stressed the need for policy makers in a South Indian state to focus on extension work in order to increase rice production and reduce inefficiency. Seidu (2008) also found extension contacts as one of the main determinant of technical efficiency in rice production. Seidu argues that there is the need for training more qualified extension agents and motivating them to deliver.

Owen, Hoddinet and Kinsey (2001) investigated the impact of farmer contact with agricultural extension services on farm productivity using panel data obtained during the period 1993–1997 in Zimbabwe. The data were drawn from a sample of households resettled in three regions in Zimbabwe. The results showed that access to agricultural extension services, defined as receiving one or two visits per agricultural year, raises the value of crop production by about 15%. The results also show that the impact of agricultural extension services differed across individual crop years, with the impact being markedly different in drought and non-drought years.

Furthermore, Parikh and Shah (1995) also found that the estimated farm level technical efficiency was found to depend on levels of credit, farmers' ages, and the extent of land fragmentation. That is, restricted credit and fragmented holdings were found to be causes of inefficiency. Parikh and Shah concluded that policies to consolidate holdings and provide credit will tend to improve efficiency in agriculture.

Conceptual Framework

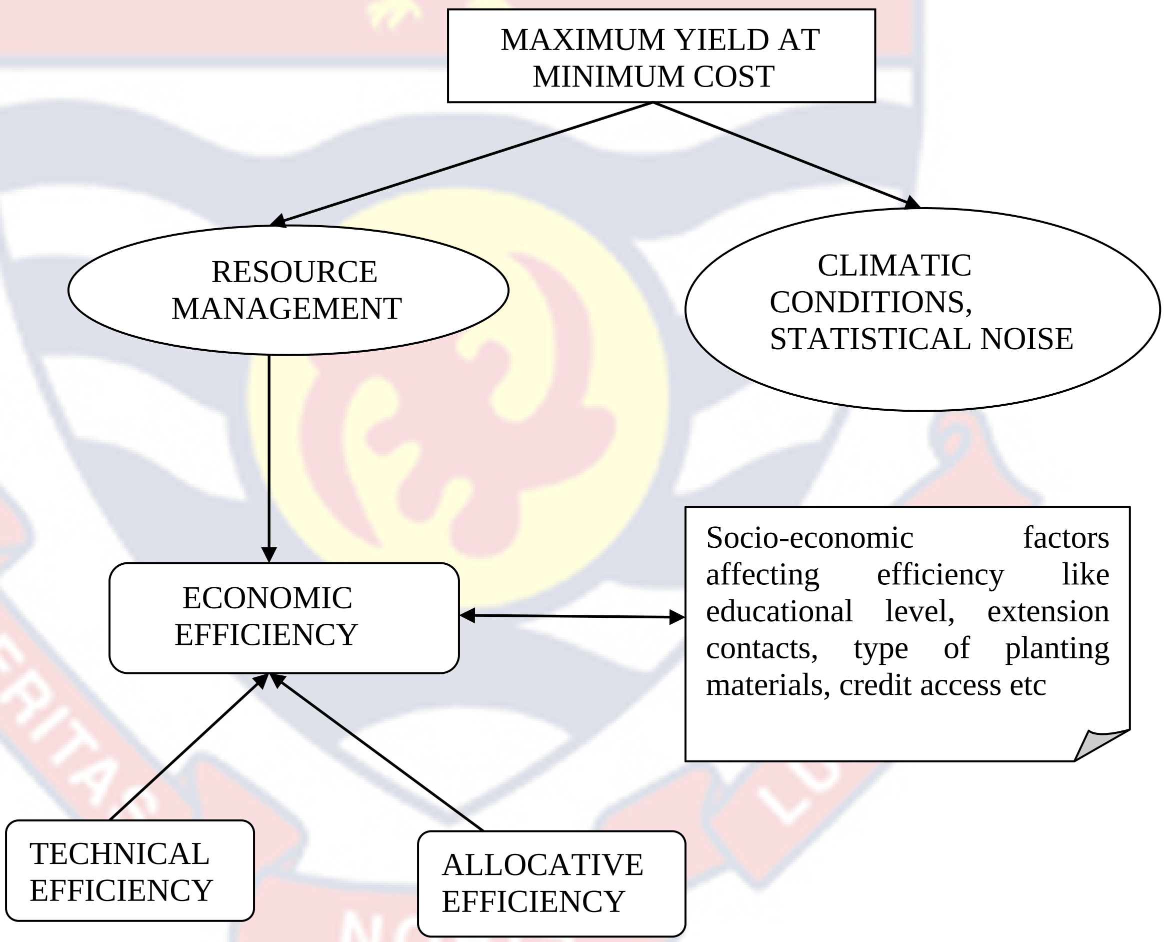
Production is the process of transforming inputs such as land, capital and labour into goods and services called output. These resources can be organised into a farm firm or production unit whose ultimate objectives may be profit maximisation, output maximisation, utility maximisation or cost minimisation or a combination of the four. In this production process, the manager or the entrepreneur is concerned with efficiency in the use of the inputs to achieve his aim. A farm manager, in his or her quest to attain these objectives faces many constraints. These include among others, especially in developing countries, imperfect information flow regarding the best husbandry practices, appropriate or optimal quantities of inputs to apply, prices of inputs employed in production etc, technological, financial constraints and climatic variation (important especially in agricultural sectors in developing countries). Given the financial constraints and the state of technological, a farmer or farm manager performance becomes heavily dependent on how effective and efficiently he/she utilises the resources available which are influenced by the knowledge available.

The basic theory of production is thus simply an application of constrained optimisation; the firm attempts to either minimise the cost of producing a given level of output or to maximise the output attainable at a given level of cost. The efficiency of resources allocated into the production, their quantities employed and price per unit are critical to obtaining the maximum yield at minimum cost referred to as economic/cost efficiency. The economic (cost) efficiency consists of technical and allocative efficiency. Some socio-economic variables also influence efficiency like education, credit access, extension contact, planting material used etc. The stochastic frontier approach is employed to analyse the cost and technical efficiencies of the technology use of cocoa farmers in the study.

The stochastic frontier approach assumes a composite error component. The errors are the noise components which are said to be beyond the control of the farmer. This includes omission of important variables by the researcher, data entry and approximation errors, climatic variations like drought, floods etc. This component is represented by ‘v’ in both the cost and technical efficiency models.

The other component of the composite error is the “inefficiency term” represented by ‘u’ in both the cost and technical efficiency models and is non-negative. However, the inefficiency term is considered to reduce total output and it increases cost and this accounts for the difference in the arithmetic signs in the cost and technical efficiency models. The figure below is a model that simplifies the concept.

Figure 1. Flowchart of Efficiency of Inputs Use of Cocoa Production



Source; Author’s construct

CHAPTER THREE

METHODOLOGY

Overview

This chapter defines the study design, data needs and sources, sampling procedure and sample size, instrumentation, data collection and analytical techniques as well as discusses the empirical model. Finally, the chapter outlines the a priori expectations of the coefficients of the variables included in the equation to be estimated.

Study Design

The study uses the cross-sectional survey design to analyse the efficiency of inputs use in cocoa production in the Twifo Hemang Lower in the Central Region of Ghana. A cross-sectional study involves data collection from a population, or a representative subset, at one specific point in time. A cross-sectional design provides a snapshot of the variables included in the study, at a particular point in time without manipulating the environment. The study is non experimental, because it deals with relationships among non-manipulated variables. The benefit of a cross-sectional study design is that it allows researchers to compare many variables at the same time.

According to Singleton, Straits and Straits (1993) a major strength of using a survey design is that, a survey work can be used for both exploratory and descriptive purposes and also allows for direct contact between the researcher and the respondents of the study during the process of data collection. It further helps in obtaining detailed and precise information from the respondents. The principal advantage of survey studies is that they provide information on large groups of people, with very little effort, and in a cost-effective manner. Surveys allow researchers to assess a wider variety of behaviours and other phenomena than can be studied in a typical naturalistic observation study.

However, cross-sectional studies may not provide definite information about cause-and-effect relationships. This is because such studies offer a snapshot of a single moment in time; they do not consider what happens before or after the snapshot is taken. Though the survey design comes with advantages, it has also got its weakness. Respondents might not give true responses to some or all of the questions posed. This is due to the fact that survey depends on reports of behaviour rather than observation of the behaviour. Sometimes respondents find it difficult to give answers to questions they find sensitive such as income, age and sexual behaviour. According to Singleton *et al.* (1993) the result of this problem is that of measurement error brought about by respondents lack of truthfulness, not understanding the questions or worse of all not able to recollect past events and situations accurately. The primary data were obtained from cocoa farmers directly involved in the cocoa production who may be a caretaker.

Data Types, Needs and Sources

Primarily, cross-sectional data were sourced for the empirical study of all the objectives set in the study. The cross sectional data collected were generally from primary sources. These data were centred on demographic features of cocoa farmers, socio-economic variables, and relevant data for the study area aimed at establishing the empirical means of achieving the objectives. This data were obtained from structured interview with cocoa farmers.

Due to lack of record keeping by cocoa farmers, panel data could not be obtained. According to Greene (1993), models relying on panel data are likely to yield more accurate efficiency estimates given that there are repeated observations on each unit. However, no a priori expectations regarding the impact of data type (i.e. cross sectional versus panel) on the magnitude of efficiency scores have been developed. Several researchers including Aneani, Anchirinah, Owusu-Ansah and Asamoah, 2011; Paudel and Matsuoka, 2009; Dzene, 2010; Kyei and Ankoh, 2011 among others have employed cross-sectional in both technical and cost efficiency studies. Secondary data, mainly from other research works were sourced for the review of relevant literatures which shed light in all stages of this important academic exercise.

Choice of Sample

The choice of sample of the study entails the study population, sample size and sampling procedure. Below are discussions on the various components of the choice of sample:

Study Population

The population includes all cocoa farmers within the Twifo Hemang Lower Denkyira area of Central Region of Ghana. Twifo Hemang Lower Denkyira area is currently made up of two districts namely Twifo Ati Mokwa district and Hemang Lower Denkyira districts in the central region of Ghana is the geographical area for the study.

The Twifo-Hemang Lower Denkyira area was one of the 17 District Assemblies in the Central Region of Ghana. It is located between latitudes 5.50ºN and 5.1ºN and Longitudes 1.50ºW and 1.10ºW. It is bounded on the north by the Upper Denkyira East Municipal on the south by the Abura Asebu Kwamankese, Cape Coast and Komenda-Edina-Eguafo-Abirem, on the west by the Mpohor Wassa District and the East by the Assin North Municipal. It has a total land area of 1199 km^2 and 1,510 settlements. The population of the study is estimated as at 2010 to be 166,224 composed of 50.1 percent male and 49.9 percent female and the current Population growth rate is 4.1 percent. This is higher than the corresponding regional growth rate of 1.8 percent. The alarming situation is that the district growth rate is far higher than the national growth rate of 2.7 percent. The relatively high population growth rate is attributed to the fertile soil which support crops like oil palm, cocoa, plantain, cassava and others, which has resulted in many settler/migrant farmers living in District (Ministry of Food and Agriculture, [MOFA] (2007)). The District's vegetation consists basically of semi-deciduous forest. Portions of which have been largely disturbed by the activities of man through farming, logging and mining among others.

An analysis of the poverty situation revealed that as many as 51 percent of households had annual consumption aggregates, which fell below the higher poverty line, based on the 2000 Ghana Population Census. That is 55,433 persons were found to be living below the poverty line. These constitute the hardcore poor or those living in extreme poverty whose conditions call for urgent attention. The poverty gap for the district is 41 percent which is a high figure. The aggregate poverty gap amounted to 24,377,545,786.00 cedis. On saving, it has been identified that there is a low proportion of household who had made some little savings. Only 21 percent of household save part of their incomes. This falls below the national figure of 28 percent and is also below the 47 percent household who were engaged in saving as at 1995 when the previous medium term plan was prepared.

Agriculture and its related activities constitute the most important economic activities in the district. It provides employment for about 46.0 per cent of the active working population. The predominant farm practice is mixed cropping. The main crops grown are sometimes inter-cropped with vegetables and other crops cultivated for both home consumption and for sale

Farmland therefore becomes an important ingredient in agricultural production and its ownership and use have a significant effect on total output. The district farmlands are acquired in several ways including individual ownership or inheritance from landowners and mortgage. The land tenure arrangements include owner occupancy where the farmer is the owner of the land on which he/she works and provides all the necessary inputs for production and the other is the share tenancy where a land owner engages a farmer to work on his land and the proceeds shared. There are six major ways of acquiring land for farming purposes. There are allocation by chiefs or by family heads, lease, inheritance, private ownership and hiring. One feature identified in the district is the multiplicity of plots of land per farmer. These plots of land are usually small in size and are scattered over the area, often at considerable distance away from one another. Apart from the main reason cited in the background for the choice of the study area, the proximity of the area to the researcher was also considered.

Sample Size

For populations estimated to be large but the exact figure of the population is not known, Cochran (1963) developed an equation to yield a representative sample for proportions:

$$n_0 = \frac{Z^2 pg}{e^2}$$

which is valid where n_0 is the sample size, Z^2 is the abscissa of the normal curve that cuts off an area α at the tails (1 - α equals the desired confidence level), e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p. The value for Z is found in statistical tables which contain the area under the normal curve.

The disadvantage of the sample size based on the mean is that a "good" estimate of the population variance is necessary. Often, an estimate is not available. Furthermore, the sample size can vary widely from one attribute to another because each is likely to have a different variance. Because of these problems, the sample size for the proportion is frequently preferred (Glenn, 2013).

Though the population is likely to be large but that we do not know the variability in the proportion that had adopted the inputs; therefore, assume p=0.5 (maximum variability), 95% confidence level and ±5% precision is also assumed.

$$n_0 = \frac{Z^2 pq}{e^2} = \frac{(1.96)^2 (0.5)(0.5)}{(0.05)^2} = 385 \text{ farmers}$$

The sample size of 385 was rounded up to 400 to take care of maximum error. According to a series by Glenn (2013), a good size sample, e.g., 200-500, is needed for multiple regressions, analysis of covariance, or log-linear analysis, which might be performed for more rigorous state impact evaluations.

Method of Sampling

A sample of 400 cocoa farmers was randomly selected using the multi-stage sampling approach for individual personal interview. A list of names of farmers of the Licensed Buying Companies (LBC) served as the sampling frame from which the sample of farmers was selected. A three-stage sampling technique was used for the selection of sample of 400 farmers. With multistage sampling technique, the researcher combines two or more sampling techniques to address sampling needs in the most effective way possible. This involved using a mixture of probability and non probability sampling procedures at different stages in order to select the final sample.

First of all, stratified sampling technique was used to divide the study area into two strata based on the demarcations of the two newly created districts, the Twifo Atti Mokwaa district and Hemang Lower Denkyira district from the study area. The two (2) districts were considered in the first stage sampling in the study to ensure generalization of the conclusions over inputs use in cocoa production in the study area.

In the second stage, simple random sampling was employed to obtain ten (10) cocoa communities from each district and finally twenty (20) farmers were identified randomly using, again, simple random sampling technique in each of the communities. The sample size per stratum was the same because the two zones had similar population strengths in terms of cocoa farmers. However, due to some irregularities in the data, 326 respondents were used for the efficiency analysis in the study.

Method of Data Collection

Interview schedule were administered to cocoa farmer for the primary data. Purchasing clerks were consulted for the farmers list and also to verify price of output (cocoa beans). Various literatures were used and necessary information from the internet was accessed to shed more light on the study.

Instrumentation and Techniques

This survey involved individual interviews with selected farmers using an interview schedule which covered issues such as socio-economic data of cocoa farmers, farm management practices, farm characteristic like the age and size of farm etc, quantities and prices of inputs used, inputs adoption, cost of undertaking some husbandry practices, labour type and price, constraints to cocoa production and extension. The interviewer had a standard set or sequence of questions that were asked of all candidates. Interviewers read the questions exactly as they appear on the survey questionnaire. The interview schedule was structured with both open and closed ended questions. This was to ensure that sufficient responses were obtained. The aim of this approach is to ensure that each interviewee is presented with exactly the same questions in the same order. This ensures that answers can be reliably aggregated and that comparisons can be made with confidence between sample subgroups.

Furthermore, due to time constraint, the researcher was helped by three (3) extension agents in the data collection. The extension agents were taken through the process and mechanism of interviewing to obtain the right response from the respondents in order to achieve the objective of the study. The extension agents who were involved in the data collection were chosen based on their educational background, proficiency in the Twi language and their ability to translate from English to Twi. Interviews were conducted in local language in order to break any communication barrier. The interview guide was pre-tested with a group of farmers to correct fundamental problems in the survey design such as difficulties in question wording, problems with leading questions and bias due to question order. Twenty farmers from two communities, namely Mbem and Bremang were used in the pre-test. The two communities were not included in the list of communities from which the final list of communities was sampled

Method of Data Analysis

The method of data analysis describes data processing and analysis, model specification, variables of the study, definitions and measurements of variables and the a priori expectation. The descriptions are as follow:

Data Processing and Analysis

The raw data obtained from administering the interview guide were coded and entered into SPSS software. The data were exported into STATA 11.0 software for data cleaning to ensure coherence and for the descriptive analysis needed for objective one. The cleaned data was further exported into FRONTIER 4.1 software for the efficiency (stochastic frontier) and the regression analysis. The research concentrated on efficiency of inputs use in cocoa production. Both statistical and econometric techniques were employed to analyse the data obtained and as such both qualitative and quantitative mode of analysis were deployed. The STATA 11.0 software was used to analyse and obtain the frequency table and its corresponding percentage of the various inputs identified in the study which excludes the inevitable cutlass, land and labour to provide insight into the state of inputs use in the area. All the inputs considered were man-made tools or equipment and chemicals used in the production of cocoa in the season.

The data were exported into FRONTIER 4.1 software for analysis of stochastic production frontier and stochastic cost frontier models and the estimated scores of technical and cost efficiencies were obtained. The stochastic frontier function models were estimated using the maximum likelihood estimation (MLE) procedure. The stochastic frontier approach was used to obtain the elasticities of the various inputs included in both the cost and production models and the analysis provided the effects of the various inputs to cost of production and output per cocoa season. A two-stage estimation procedure was followed in this study. After the Translog production function and Cobb-Douglas cost function were estimated, their inefficiency models were also estimated in the second stage by using the residuals in the initial models and socio-economic variables.

Variables of the study

The study sought to assess the state of inputs use in production of cocoa, the efficiency of the use of these inputs, its contribution to output and its effects on cost and the determinants of inputs use efficiency of cocoa production. Two major dependent variables were dealt with, that is, output and total cost in the technical and cost efficiency models respectively while in the inefficiency models the dependent variables were the farmer's cost and technical inefficiency scores.

The independent variables for the dependent variable 'total output' in the production function include the quantity of pesticide (herbicide, insecticide and fungicide) used in litres; farm size (land), which is the total area of matured cocoa *i*-th farm in hectares; estimated number of hybrid varieties; and the quantity of fertilizer used in Kilogram. On the other hand, the independent variables for dependent variable 'total cost' in the cost function were cost of fertilizer for the cocoa season used by i-th farmer also in Ghana cedis (GH₵); cost of labour.; cost of pesticide which include the cost of herbicide, fungicide and insecticides used by i-th farmer for the cocoa season measured in Ghana cedis (GH₵); and Y_i is the price of total yield obtained by i-th farmer for the cocoa season also measured in kg.

In addition, the independent variables for the dependent 'technical inefficiency' include gender as a dummy variable; the i-th farmer experience in cocoa farming in years; hybrid plants only; combinations of hybrid and local breed on farm; levels of education; number of direct contact with Extension agents for the cocoa season; age of cocoa trees of i-farm in years; farmer based organization; and access to credit. In addition, the independent variables for dependent variable for the ‘cost inefficiency included farmer experience in cocoa farming in years; the number of direct contact the i-th farmer had with extension for the cocoa season; farmer based organization; the age of cocoa trees of i-farm in years; various level of formal education; hybrid plants only; combinations of hybrid and local breed on farm.

Model Specification

The models for the study are specified below;

Production function. Battese and Coelli (1992) proposed a stochastic frontier production for (unbalanced) panel data that has firm effects, which are assumed to be distributed as truncated normal random variables, and are also permitted to vary systematically with time. However, estimation of the stochastic production frontier requires a particular functional form of the production function to be imposed. A range of functional forms for the production frontier are available. The model may be expressed as:

$$Y_{it} = X_{it}\beta + (V_{it} - U_{it}),\ i=1,\ldots, N;\ t=1,\ldots, T \qquad (1)$$

Where Y_{it} is (the logarithm of) the production of the i-th firm in the t-th time period; X_{it} is a k×1 vector of (transformation of the) input quantities of the i-th firm in the t-th time period; β is a vector of unknown parameters; μ is a parameter to be estimated (determining whether the inefficiencies are time varying or time invariant. A value that is significantly different from zero indicates time varying inefficiencies)

The error term has a double component typical of stochastic frontiers. The noise component V_{it} is a classical disturbance term, i.e. identically and independently normally distributed Vit~i.i.dN (0, σ^2_v). The inefficiency component U_i is, in this particular model, independently (but not identically) distributed according to a truncated normal distribution with truncation at 0, whereby assuring non-negativity $U_{it} \sim (U_{it}, \sigma^2_u)$. A higher value for U implies an increase in technical inefficiency. If U is zero, the farm is perfectly technically efficient, Battese and Coelli (1995).

$U_{it}=\delta_0+z_{it}\delta$ (2)

(2) defines an inefficiency distribution parameter for z_{it} a vector of firm-specific effects that determine technical inefficiency, and δ is a vector of parameters to be estimated.

The technical efficiency (TE) of the i-th firm in the period can be defined as: $TE_{it} = \frac{E(Y_{it} / U_{it}, \ X_{it})}{E(Y_{it} / U_{it}=0, X_{it})}$=exp (-$U_{it}$) ...(3) where E is the usual expectation operator. The measure of technical efficiency is thus based on the conditional expectation of Equation 3, given the values of (V_{it}-U_{it},) evaluated at the maximum likelihood estimates of the parameters in the model, where the expected maximum value of Y_{it} is conditional on U_{it} = 0 (Battese & Coelli, 1988). All estimates are obtained through maximum likelihood procedures, where the maximum likelihood function is based on a joint density function for the composite error term (V_{it} -U_{it}). In this case, efficiency shall be calculated for each farm per year as;

$$E= [\exp (U_i)| (V_i + U_i) (\frac{1-\emptyset(\sigma_a+\gamma(V_i+U_i)/\sigma_a}{1-\emptyset(\gamma(V_i+U_i)/\sigma_a}) \exp [\gamma+ (V_i + U_i) + \sigma_a^2/2]...(4)$$

Where $\sigma_a = \gamma\ (1-\gamma)\ \sigma^2$, $\sigma^2 \equiv \sigma^2_u + \sigma^2_v$, $\gamma \equiv \sigma^2_u/\sigma^2$, $\varepsilon_j \equiv (V_i + U_i)$, and φ and φ represent the density and the distribution function of a standard normal random variable (Battese & Coelli, 1988). A value of gamma closer to zero implies that much of the variation is due to random stochastic effects, whereas a value of gamma closer to one implies mainly cross-farm differences in technical efficiency. The output elasticity with respect to this inputs variable is a function of the value of the input in both the frontier and the inefficiency models. Assuming a transcendental logarithm function (translog), the stochastic frontier model is specified as:

$$y_i = \exp(\chi_i\beta) + \mathcal{E}_i \text{.................equation (5)}$$

where $\mathcal{E}_i$ is the composite error defined as

$$\mathcal{E}_i = \exp(v_i - u_i) \text{..............equation (6)}$$

For the purposes of this study the stochastic frontier (linearized) model is specified as equation 7.

$$LnY_{it} = \beta_0 + \Sigma_{j=1}^{4} \beta_j LnX_{itj} + \Sigma_{j=1}^{4}\Sigma_{i=1}^{4} \beta_j LnX_{ijt} LnX_{it} + V_{it} - U_{it} \ \ldots\ldots (7)$$

$$LnY_{it} = \beta_0 + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \beta_4 LnX_{4i} + 0.5\beta_5 LnX_{1i}LnX_{1i} + 0.5\beta_6 LnX_{2i}LnX_{2i} + 0.5\beta_7 LnX_{3i}LnX_{3i} + 0.5\beta_8 LnX_{4i}LnX_{4i} + \beta_9 LnX_{1i}LnX_{2i} + \beta_{10} LnX_{1i}LnX_{3i} + \beta_{11} LnX_{1i}LnX_{4i} + \beta_{12} LnX_{2i}LnX_{3i} + \beta_{13} LnX_{2i}LnX_{4i} + \beta_{14} LnX_{3i}LnX_{4i} + V_{it} - U_{it} \text{..} (8)$$

where j represents the j-th input (j = 1, 2 …4) of the i-th farm (1, 2…326) in the t-th time period (t = 1); β_0 is the unknown parameter or constant and is equal to output when the explanatory variable(s) is zero, Yi represents the physical output of cocoa production. This output also excludes the portion used as planting or given out to other farmers for planting. The output was measured in kilogram; X_{1i} is the quantity of pesticide (herbicide, insecticide and fungicide) used in litres by i-th farmer; X_{2i} represents the total area of matured cocoa of *i*-th farmer; X_{3i} is the estimated number of hybrid variety per farm; X_{4i} represent the quantity of fertilizer used in Kilogram; Yit(k) and all Xit(k)s are mean-corrected to zero in the translog functional form, which implies that the first-order coefficient estimates of the model represent the corresponding elasticities. $U_{it} = \Sigma$ (exp [$-\eta$ (t – T)]) U_i and U_i is defined by the non-negative truncation of the N (μ, $\sigma 2$)-distribution and U_i represents the technical inefficiency in production of *i-th* farm. It is assumed to be independently and identically distributed between observations, and is obtained by truncation at point zero of the normal distribution with mean u_i, and variance $ó^2{}_u$, where the mean is defined by the multiple regression equation:

$$U_{it} = \delta_0 + \delta_1 Gen_i + \delta_2 Exp_i + \delta_3 Hyb_i + \delta_4 Hyb\text{-}loc_i + \delta_5 Pri_i + \delta_6 M/JS_i + \delta_7 Sec/Voc_i + \delta_8 Ter_i + \delta_9 Ext_i + \delta_{10} Age_i + \delta_{11} FBO_i + \delta_{12} Cred_i \ldots\ldots\ldots\ldots\ldots \quad (9)$$

where $\delta_i s$ are the unknown parameters to be estimated, and all these variables are expected to explain the technical efficiency levels of inputs use in cocoa production in the study area and were fitted into a multiple regression equation.

Cost function. The traditional production efficiency against a cost frontier is evaluated by the extent to which a farm's actual cost deviates from the efficient cost frontier. To analyze the data, both the statistical and tabular methods were employed. For the purpose of the statistical analysis, Battese and Coelli (1995) model was used to specify a stochastic frontier cost function with the behaviour inefficiency component and to estimate all parameters together in maximum likelihood estimation. If we wish to specify a stochastic frontier cost function, we simply alter the error term specification from (V_i - U_i) of the production function to ($V_i + U_i$). This model is implicitly expressed as:

$$In\ C_i = g\ (P_i, Y_i; \alpha) + (V_i + U_i) \qquad (10)$$

where C_i represents the total cost of production, g is a suitable functional form such as the Cobb-Douglas; P_i is the vector variable of input prices,. Y_i is the value of output, α is the parameter to be estimated. The systematic component V_i represents the random disturbance costs due to the factors outside the scope of farmers. It is assumed to be identically and normally distributed mean zero and constant variance as N $(0, \sigma^2 v)$. Ui is the one-sided disturbance form used to represent cost inefficiency and is independent of Vi. Thus, $U_i = 0$ for a farm whose costs lie on the frontier, $U_i > 0$ for farms whose cost is above the frontier, $U_i < 0$ for farm identically and independently distributed as N $(0, \sigma^2 v)$. The two error terms are proceeded by positive signs because inefficiencies are always assumed to increase cost.

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. If this assumption is not made, the interpretation of the U_i in a cost function is less clear, with both technical and allocative inefficiencies possibly involved. Thus we shall refer to efficiencies measured relative to a cost frontier as "cost" efficiencies in the remainder of this document. The exact interpretation of these cost efficiencies will depend upon the particular application.

Furthermore, the cost efficiency of an individual cocoa farm is defined in the terms of the ratio of the observed cost (C^b) to the corresponding minimum cost (C^{min}) given the available technology is expressed as:

$$\text{Cost Efficiency } (C_{EE}) = \frac{c^b}{C^{min}} = \frac{g\,(Pi, Yi;\, \alpha) + (Vi + Ui)}{g\,(Pi, Yi;\, \alpha) + (Vi\,)} = \exp\,(U_i) \quad \text{............... (11)}$$

where the observed cost (C^b) represents the actual production cost whereas the minimum cost (C^{min}) represents the frontier total production cost or the least total production cost level. C_{EE} takes the values between 1 or higher with 1 defining cost efficient farm (Ogundari *et al*.2006). The stochastic cost frontier model focused on the average performance, optimal and extreme performances of firm. The zone below the cost frontier is unattainable; therefore, all productive units are either on or above the frontier. Those on the frontier have the lowest or minimum cost of factors of production for a given level of output. The Cobb-Douglas cost frontier function for the cocoa farmers was specified and defined as follows:

$$C_i = \alpha_0 .\, P_1^{\alpha 1} .\, P_2^{\alpha 2} .\, P_3^{\alpha 3} .\, Y_i^{\alpha 4} .\, \varepsilon_i \quad \text{...(12)}$$

But $\varepsilon_i = V_i + U_i$

The linear transformation of (11) is achieved by taking the natural logarithm of both sides of the equation to obtain (12)

$$\text{In } C_i = \alpha_0 + \alpha_1 \text{InP}_1 + \alpha_2 \text{InP}_2 + \alpha_3 \text{InP}_3 + \alpha_4 \text{In } Y_i + V_i + U_i \quad \text{.......................... (13)}$$

The choice of the Cobb-Douglas is based on the fact that the methodology requires that the function be self dual as in the case of cost function which this analysis is based on. The cost inefficiency model for the study is specified as:

$$U_{it} = \chi_0 + \chi_1 Exp_i + \chi_2 Ext_i + \chi_3 FBO_i + \chi_4 Age_i + \chi_5 Pri_i + \chi_6 M/JS_i + \chi_7 SVT_i + \chi_8 Ter_i + \chi_9 Hyb_i + \chi_{10} Hyb\text{-}loc_i \quad \ldots\ldots (14)$$

where U*it* represents the cost inefficiency of i-th farmer; All these variables are expected to explain the technical efficiency levels in technology use in cocoa production in the study area and were fitted into a multiple regression equation.

These socioeconomic variables were included in the equations 9 and 14 because they impact on the efficiency with which farmers produce cocoa beans. Many past studies on cost and technical efficiency and in agricultural production (e.g. Chirwa, 2007; Ogundari, 2008; Paudal & Matsuoka, 2009; Aneani *et al*, 2011) have tested the effects of these variables on technical inefficiency. Considering them in this study was not only appropriate from theoretical stand point; it also afforded the opportunity for comparison of the study results with previous findings.

Definition and Measurement of Variables

The variables included in the study are further summarised in the Tables 2, 3 and 4 below:

Table 2: Definition and measurement of variables (production function)

Variable	Definition	Unit
Dependent Variable		
Y_{it}	Quantity of cocoa harvested in the previous season	Kilograms (Kg)
Independent Variables		
X_{1i}	Quantities of pesticides applied in the previous season.	Litres
X_{2i}	Size of matured cocoa farm i^{th} farmer	Hectares
X_{3i}	Estimated number of hybrid variety in the farm	
X_{4i}	Quantities of fertilizer applied in the previous season	Kilograms (Kg)

Source: Author's construct, 2014

Table 3: Definition and measurement of variables (cost function)

Variable	Definition	Units
Dependent variable		
C_i	Cost incurred in the cocoa production previous season by i-th farmer	Ghana cedis (GH₵)
Independent variables		
P_{1i}	Cost incurred on fertilizer (GH₵) applied in the previous season i-th farmer	Ghana cedis (GH₵)
P_{2i}	Cost incurred by i-th farmer labour for the season (A woman day is 0.75man day And child day is equivalent to 0.50 man day)	Ghana cedis (GH₵)
P_{3i}	Cost incurred on pesticide by i-th farmer on fertilizer per season	Ghana cedis (GH₵)
Y_i	Value of cocoa yields per season obtained by i-th farmer kilograms in the previous season.	Ghana cedis (GH₵)

Source: Author's construct, 2014

Table 4: Definition and measurement of variables (technical and cost inefficiency)

Variable	Definition	Model type	Unit
Dependent Variables			
Technical inefficiency	Technical inefficiency Score obtained by i-th Farmer	Technical inefficiency(TI) Model	
Cost inefficiency	Cost inefficiency Score obtained by i-th Farmer	Cost inefficiency(CI) Model	
Independent Variables			
Age	Age of cocoa tree of i-th farm	Both	Years

Table 4 (continued)

Gen (male dummy)	Sex of the cocoa farmer	TI model	0 = female 1 = male
Ext_i	Number of extension contact had by i-th farmer per previous season.	Both	
FBO	Farmer being a member of farmer-based organisation	Both	0= not member 1 = member
Edu	Level of schooling of cocoa farmer	Both	0=no schooling 1=primary sch 2=JSS/JHS/Middle school 3=SSS/SHS/Tec/Voc 4 =tertiary
Hyb (dummy)	Farm entirely planted with hybrid variety	Both	0= not hybrid only 1= hybrid only
Hyb-loc (dummy)	Farm planted with both hybrid and local varieties	Both	0=not both varieties 1=both Varieties
Exp	Number of years of cocoa farming by farmer	Both	Years
Cred	Farmer receiving credit for cocoa production in the previous year	TI models	0=not receiving 1=receiving credit

Source: Author’s construct, 2014

Expected Output (A priori Assumption)

From the literature review done in this research work, the researcher anticipates that quantities of pesticides, hybrid varieties, farm size and quantities of fertilizer to have significant positive effects on cocoa output while the cost of labour, fertilizer and pesticides are also anticipated to have significant positive impact on total cost of cocoa production per season. The positive and negative signs (+ and -) indicate the direction of influence of the variables based on a priori expectations. Positive (+) indicates movement in the same direction (i.e. positive influence on the dependent variable) and negative sign (-) indicates movement in opposite direction (i.e. negative influence on dependent variable). Further a priori-assumption of the variables included in the inefficiency models is presented in the tables 5 below:

Table 5: Summary of a priori assumptions of the variables included in the inefficiency models

Variables	Effect on technical efficiency	Effect on cost efficiency
Gender	(+) positive	Not included
Experience	(+) positive	(+) positive
Farmer based organisation	(+) positive	(+) positive
Access to credit	(+) positive	Not included
Extension contact	(+) positive	(+) positive
Levels of education Primary MSL/JSS Sec/Voc/tech Tertiary	(+) positive	(+) positive
Hybrid	(+) positive	(+) positive
Hybrid-local	(+/-) positive/negative	(+/-) posi/negative

Source; Author’s construct, 2014

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

The chapter deals with the empirical analysis of inputs use in cocoa production in Twifo Hemang Lower Denkyira. The chapter is composed of four sections and each section cover one objective of the study. The chapter begins with the presentation and discussion of state of inputs use in cocoa production in the study area. Subsequently, the other objectives were empirically estimated and discussed from primary data obtained through the administration of the questionnaire.

State of Inputs Use in Cocoa Production

The inputs identified in the study were fertilizers, weedicides or herbicides, pruning tool, fungicides, insecticides and hybrid cocoa varieties. The description of the state of inputs use in the study concentrated basically on the degree of usage of the various inputs. The table 6 below provides the specifics of the degree of usage of the inputs identified in the study.

From Table 6, it is observed that the noticeable changes in inputs use in cocoa production were in line with the findings by other researchers. Boahene, Snijders, and Folmer 1999; Edwin and Masters 2003; Gockowski and Sonwa 2007; Teal, Zeitlin, and Maamah 2006; Vigneri, Teal, and Maamah 2004; and

Vigneri 2008 stated that "since 1990, three noticeable changes have taken place in the use of inputs in cocoa production, in particular, increased use of fertilizers; the adoption of hybrid cocoa varieties, and better control of pests and diseased trees." Table 6 below provide the specifics of the usage rate of inputs by the respondents.

Table 6: Degree of inputs use among respondents

Inputs	Frequency of use	Percent
Weedicides	348	87.00
Fertilizer	333	83.33
Insecticides	324	81.00
Fungicides	308	77.00
Hybrid cocoa variety	299	74.67
Prunner	116	29.00
	400	

Source: Field data, 2014

First and foremost, a massive usage of herbicide or weedicides among respondents was observed. From the research, it was observed that the farmers preferred the use of herbicide/weedicides for weed control because it saved cost, relatively faster and easier to apply and takes much longer time for weeds to re-grow. This conforms to the reasons cited in the cocoa manual by CRIG (2010), for the usage of herbicides for weed control, and this explains why the herbicide is the most utilised input in the study area.

It can be reasoned that due to continual increase in rural-urban migration, farmers are trying to employ less labour intensive techniques like herbicide weed control, which substitutes labour for capital. Acemoglu's (2000, 2001) model on directed technical suggested that under a low elasticity of substitution among factors of production, country-specific factor proportions and factor prices may facilitate a substitution of technologies in order to save the relatively more scarce, and replace it with relatively more abundant and cheap factors.

Secondly, in sharp contrast to the reports by Ogunlade *et al.* (2009) and Agbenyini, Ogunlade and Oluyole (2010) that the percentage of fertilizer usage in cocoa production in Nigeria were low, the percentage of farmers in the study applying fertilizer (83.33% of respondents) in the study area was encouraging. Kolavalli and Vigneri (2010) observed that fertilizer use in Ghana has increased significantly since the 1990s. A survey by Kolavalli and Vigneri of cocoa farmers in the three main cocoa-producing regions of Ghana show that fertilizer application rates increased from 9 percent in 1991 to 47 percent in 2003.

Omotoso (1975) revealed that a crop of 1000kg dry cocoa beans remove about 20Kg N, 4Kg P and 10Kg K and where the method of harvesting (as in Ghana) involves the removal of pod husks from the field, the amount of potassium removed increased more than five folds. Since cocoa is a perennial crop and has high nutrients consumption, it is encouraging to observe such rate of fertilizer application among farmers in the study area. Opeyemi *et al.* (2005) reported that an effective use of fertilizer on cocoa would help not only to improve yield but also has the advantages of profitability, product quality and environmental protection.

Furthermore, it was observed that the use of insecticides to control insects was very prevalent among cocoa farmers in the study area. From the table above, 81% of the respondents had applied various kinds of insecticides to control insects like mirids/capsids, termites, caterpillars. As revealed in the Cocoa Manual, version 1, by CRIG (2010), the annual global loss of cocoa to insect pest is estimated at 558,000mt and in Ghana; mirids alone may cause about 25 percent yield loss if their numbers on the crops are not effectively managed; it is worthwhile to encourage continual application. It should however be noted that the 81 percent of the respondents reported in the study were farmers who had applied the insecticides on their own irrespective of the National Mass Spraying exercise. Also noteworthy, was the fact that none of the respondents had applied DDT for insects control in the cocoa farm.

In addition, seventy-seven (77) percent of the respondents, as seen in Table 6 above, were farmers who had applied fungicides on their farms irrespective of National Mass Spraying exercise. The fungicides were used by the respondents to control fungi causing the Blackpod disease in cocoa.

Furthermore, the use of hybrid cocoa variety has become popular among the farmers in the study area. 74.76 percent of the respondents had grown the hybrid varieties. The majority respondents sourced the hybrid cocoa variety pods from the Seed Production Unit (SPU) of the Ghana Cocoa Board for nursery while some other respondents also bought the nursed seedlings from other farmers or the Seed Production Unit (SPU). However, some respondents also claimed that they obtained their hybrid cocoa variety from the farms of other farmer who had grown the hybrid variety. The increased use of the hybrid cocoa variety were as result of higher yielding ability and better resistance to pest and diseases. Edwin and Masters (2003) revealed that “new tree varieties yield approximately twice as much cocoa per hectare as similar-aged fields". Kolavalli and Vigneri (2010) observed that hybrid varieties outperform the older "Amazons" and "Amelonado" varieties in two ways by producing trees that bear fruit in three years compared with at least five years for the older varieties and by producing more cocoa pods per tree planted with traditional trees.

Lastly and equally worth mentioning is the pruning tool. A lot of the farmers pruned their cocoa plants using the cutlass; however, the 29 percent of the respondents used a special equipment to carry out pruning operation on the farm. Few of these respondents owned this kind of equipment while some claim to rent them from the Cocoa Rehabilitation of the Cocoa Swollen Shoot Virus Control Unit of the Ghana Cocoa Board. This equipment provided the advantage of slanting the surfaces of pruned branches, thus helping to prevent decay of the left over part, less laborious and faster.

According to Klump and Cabrera (2008), technologies are classified into two types: (i) mechanical, which are labour-saving and aimed at substituting power and machinery for labour; and (ii) biological and/or chemical, designed to substitute labour-intensive techniques and industrial inputs (e.g. fertilizer) for land. In conclusion, apart from the pruning equipment and the herbicide application which were labour-saving technologies or inputs, the rest of the inputs, which were fertilizers, insecticides, fungicides applications and hybrid cocoa variety increased more, the productivity of the scarce land and were more of land-saving inputs/technology than labour-saving. This is in line with Acemoglu's (2000, 2001) model on directed technical change.

Effect of the Inputs on Output and Cost

The elasticities of the inputs included in each model were estimated in this study to obtained effect of the various inputs to total output and cost. The elasticities were maximum likelihood estimates obtain from the frontier output. Considering that some individual coefficients of the variables of the translog stochastic frontier production function are not directly interpretable because of the presence of second order coefficients, partial elasticities of output with respect to inputs were estimated because they permit the evaluation of the effect of changes in the amount of an input on output. Results are as presented in Table 8 and 9.

Hypothesis test. To begin with the null hypothesis which states that there is no inefficiency effects was tested for the production function and cost function. The results of the test is as presented in table 7.

Table 7: Hypothesis test for no inefficiency effect

Null Hypothesis	Loglikeli-hood Value	Test statistic (λ)	Critical Value	Decision
Technical Efficiency				
1. $H_0 : \gamma = \delta_0 = \delta_1 = \delta_2 = ...\delta_{12} = 0,$	-	112.56***	35.42	Reject H_0
Cost Efficiency				
1. $H_0 : \gamma = \delta_0 = \delta_1 = \delta_2 = ...\delta_{10} = 0,$	-	87.81[a]***	35.42	Reject H_0

Values of test of one sided error from the FRONTIER 4.1 Output file. The correct critical value for the hypothesis of the one sided error is obtained from table 1 of Kodde and Palm (1986, p. 1246). *** and ** Significant at 1% and 5% level of significance respectively.
Source: Field data, 2014.

The null hypotheses of the Table 7 were rejected at 1% level of significance for both the technical and cost efficiencies models. It means that there were inefficiencies at all levels of the production process. The estimated gammas were 0.9998 and 0.8570 for technical and cost efficiency models respectively and were significantly greater than zero. This implies that the 99 percent of variations in the observed outputs (efficiency) from the frontier output were mainly due to technical inefficiency whilst very insignificant amount was explained by random effect like climatic variations, measurement errors etc whiles 85.7 percent of the variation in the observed cost from the frontier cost were mainly due to allocative inefficiency whilst small percentage (14.30%) was explained by random effects. If the coefficient of gamma was not significant, an OLS function would have been sufficient; as the component technical inefficiency is small (Battese & Coelli, 1995). Therefore, the traditional average (OLS) function is not an adequate representation for the data. Since the inefficiencies were present and significant, it implies that it is justifiable to employ the stochastic frontier approach.

Effect of the inputs on cocoa output. The maximum likelihood estimates of the stochastic frontier production function given in Table 8 reveals that all the inputs considered in the study were statistical significant and that they had positive effects on output of cocoa production in this study area. The output elasticity was highest for quantity of fertilizer use (0.4606), followed by estimated quantity of hybrid variety (0.3388), quantity of pesticide usage (0.2403) and farm size (0.1712). The partial elasticity values obtained indicate the relative importance of every factor used in cocoa production. The maximum likelihood estimates of the translog stochastic frontier production function are presented in Table 8.

Table 8: Estimated parameters (MLE) of the translogarithmic Stochastic Frontier production function

Variables	Parameters	Coefficient	Standard-error	t-ratio
Constant	B_0	0.7338***	0.0359	20.4250
Lnpesticide	B_1	0.2403***	0.0623	3.8580
Lnfarmsize	B_2	0.1712***	0.0420	4.0787
Lnhybrid	B_3	0.3388***	0.0724	4.6814
Lnfertilizer	B_4	0.4606***	0.1260	3.6558
0.5[Ln(pesticide)]^2	B_7	0.1004***	0.0320	3.1423
0.5[Ln(farmsize)]^2	B_8	0.0879	0.0892	0.9855
0.5[Ln(hybrid)]^2	B_9	-0.0040	0.2451	-0.0165
0.5[Ln(fertilizer)]^2	B_{10}	-0.4717	0.3849	-1.2257
Ln pest. x Ln fsize	B_{15}	0.0625**	0.0302	2.0682
Ln pest. x Ln hybrid	B_{16}	0.0082	0.0373	0.2202
Ln pest x Ln fert	B_{17}	0.2035***	0.0557	3.6537
Ln fsize x Ln hybrid	B_{18}	0.2401***	0.0802	2.9919
Ln fsize x Ln fert	B_{19}	0.0017	0.1352	0.0124
Ln hybrid x Ln fert	B_{20}	-0.0198	0.1330	-0.1486
Sigma-squared	Σ^2	0.2072	0.0277	7.4846
Gamma	γ	0.9999	0.278E-06	0.358E+07
Log-likelihood		-85.1155		

Note: *, **, *** indicate significance at 10 per cent, 5 per cent and 1 per cent levels, respectively
Source: Field data, 2014.

The return to scale was revealed to be 1.2109. The return to scale, defined as the percentage change in output from 1 percent change of all input factors is equal to 1.2109, implying that cocoa farming in study area were characterised by inputs with increasing return to scale. This means that a percentage increase in all the inputs of production considered in the study will elicit more than a proportionate increase in cocoa output under the current technology. To be more specific, a percentage increase in all the inputs will results in 1.2109 percentage increases in yield under the existing technology. The implication is that cocoa farmers in the study area are operating in the irrational zone of production (stage I) where decreasing average costs (AC) of production is being experienced and this stage represents an underutilization of production. This shows that there is more room for improvement in terms of cost reduction and efficiency improvement in cocoa production. From Table 8 and 9, one percent (1%) increase in any one of the variables (which are fertilizer usage, pesticide usage, farm size and number of hybrid plants) holding constant the other variables, elicited 0.4606 percent, 0.2403 percent, 0.1712 percent and 0.3388 percent increase in output respectively. Output of cocoa in the study area can be further improved by increasing the quantities of these inputs. Partial elasticities for the production model are presented in table 9:

Table 9: Partial elasticity and Returns to Scale of production (production model)

Variables	Partial elasticities
Pesticide	0.2403
Farm size	0.1712
number of hybrid plants	0.3388
Fertilizer	0.4606
Returns to scale	1.2109

Source: Field data, 2014

Kyei *et al.* (2011) also found that greater yield can be obtained from intensification of fertilizer and this conforms to the finding of the study. Aneani *et al*. (2011) further buttresses the point on the effect of quantity of fertilizer usage on cocoa output. The researchers established that the quantity of fertilizer applied to the cocoa farm "had the highest marginal physical product (133.11 kg/ bag)" and that "a 10 percent increase in quantity of fertilizer applied elicited 3.25 percent increases in cocoa output". Omotoso (1975) showed that a crop of 1000kg dry cocoa beans removes about 20KgN, 4kgP and 10kgK. As a perennial crop and heavy feeder, cocoa productivity is surely affected by fertilizer nourishment to replenish lost nutrients. This explains the relatively large effect of fertilizer on cocoa output.

In addition, the significantly positive effect of farm size (land) on cocoa output obtained in the study is collaborated by findings of other researchers. Nkamleu and Ndoye (2003) reported that in Africa, cocoa output has been achieved by increasing the area cultivated rather than by improving yield. Aneani *et al* (2011) again pointed out that a 10 percent increase in farm size resulted in 5.14 percent increase in output. The result obtained from the study is however contrary to the study by Berry and Cline (1979) and Lau and Yotopoulos (1971). Berry and Cline (1979) and Lau and Yotopoulos (1971) however showed that there is a negative relationship between output and farm size in developing economies.

As expected, an increase in the number of hybrid variety plants on the farm increased output. The result is in line with other research finding by Kolavalli and Vigneri (2010) and Edwin and Masters (2003). For instance, Edwin and Masters (2003) report that new tree varieties yield approximately twice as much cocoa per hectare as similar-aged fields.

From Tables 8 and 9, increasing the quantity of pesticide usage by one percent (1%) resulted in 0.2403 percent (0.2403%) increase in output. Kyei *et al* (2011) found a similar result. According to FAO report (1971), the control of diseases and pests of cocoa in the cocoa belt of Western Nigeria, is said to have increased cocoa output by about 40 to 50 percent in recent years. CRIG (2010) expressed the need for employing these pesticides. It reveals that mirids alone may cause about 25 percent yield loss if their numbers on the crops are not effectively managed in Ghana.

Effect of the inputs on cost of production. All the variables included in the cost function have a positive correlation on total cost. With the exception of coefficient of the price of yield, the coefficients of all the other variables were statistically significant. This means that an increase in the cost of fertilizer, cost of pesticides and cost of labour will result in a significant increase in total cost. Maximum likelihood estimates (MLE) of the cost model is presented in Table 10.

Table 10: Cost efficiency model estimation

Variables	Parameters	Coefficients	Standard error	t-ratio
Constant	α_0	-0.0677***	0.0148	-4.5774
InFertilizer cost	α_1	0.1452***	0.0231	6.2927
InLabour cost	α_2	0.7192***	0.0384	18.7451
InChemicals cost	α_3	0.1660***	0.0223	7.4370
InYield price	α_4	0.0139	0.0238	0.5848
Sigma-squared	Σ^2	0.1263	0.0268	4.7048
Gamma	γ	0.8571	0.0227	37.7577

*** represents one percent (1%) level of significance
Source; Field data, 2014

The computed value of the scale return to scale is 1.0443 as exhibited in Table 11. This indicates increasing return to scale and it means that increasing cost of all the variables by one percent (1%) caused 1.044 percent (1.044) in the total cost. Increasing any of the variables, that is, the cost of labour, cost of pesticide, cost of fertilizer or price of yield by one percent (1%) result in 0.7192 percent, 0.1660 percent, 0.1452 percent or 0.0139 percent in total cost respectively. It is worthwhile to reiterate that an increase in yield by one percent (1%) resulted in 0.0139% increase in total cost. In Paudel *et al.* (2009) research, increasing the yields of maize by one percent (1%) was found to elicit a 0.21 percent increase in total cost and is greater than the percentage increment in total cost when yield is increased by one percent (1%) in this study. Paudel *et al.* likewise obtained higher cost of labour to the total cost than the cost of fertilizer. Paudel *et al.* stated that the elasticities or coefficients of costs of labour and fertilizer were significant and also were positively correlated to the total cost. However, Paudel *et al.* found the coefficient of cost of pesticide to have insignificant effect on total cost.

The huge effect of cost of labour on total cost of cocoa production to a large extent explains why a lot of the respondents in the study area are adopting labour serving technologies or inputs like herbicide weed control (87%) and use of prunners for pruning. These inputs greatly enhance labour productivity. The supply of labour may be less than labour demanded and this might be causing the rise in cost of labour. Also, it can be argued tentatively that other sectors of the rural economy (like in constructions to carry concrete, assisting in commercial cars etc) may pay higher for labour services than farming and arguably less laborious, and so individual prefer offering the labour services to the other sectors. As a result, farmers may be forced to pay higher price for the labour supply. Table 11 provides the results of the partial elasticities and return to scale of the cost model discussed in Table 10.

Table 11: Partial elasticity and Returns to Scale of production (cost model)

Variables	Elasticities
Fertilizer cost	0.1452
Labour cost	0.7192
pesticide cost	0.1660
Yield price	0.0139
Returns to scale	1.0443

Source: Field data, 2014

Levels of Efficiency of Inputs Use in Cocoa Production

The efficiency estimates obtained from the frontier analysis for both production and cost models are further grouped into distributions and discussed below.

Technical efficiency. The technical efficiency indexes of farmers varied from 0.116 (11.6%) to 0.9998 (99.98%), with mean of 0.54 (54%) and this suggest the prevalence of technical (managerial) inefficiency and little random shocks (climatic changes, production risks etc) since the estimated gamma was 0.999. The coefficient of gamma of 0.999 implies that, about 99 per cent of the difference between the observed and the frontier value productivity was mainly due to inefficient use of resources, which was under the control of sampled farmers. From the result, 46 percent of cocoa output on the average is lost due to inefficiencies or managerial ineptitude and there was a scope to increase the value productivity of cocoa production under the existing condition and technology. Thus, in the short run, there is a scope for increasing cocoa production by about

46% by adopting new technologies, practices and efficient combination/allocation of production factors.

Sekhon *et al.* (2010) also had a similar high value of gamma (0.9999) which indicated the presence of significant inefficiency in the production of crop from a research in south-western region of Punjab state in India. Dzene (2010) used a balanced panel data for three years to show that mean technical efficiencies for cocoa farmers in the Western region of Ghana were 48.6 percent, 48.3 percent and 47.2 percent in 2002, 2004 and 2006 respectively. Binam *et al.* (2008) estimated the mean efficiency of cocoa farmers in Ghana to be 44 percent. Binam *et al*. and Dzene results are not too different from the result obtained in this study considering the time variance and as such slight improvement in the technical efficiency estimate is expected.

However, all the empirical estimates of technical efficiency for Ghanaian cocoa farmers are lower than those estimated for cocoa farmers in other West African countries. For instance, Amos (2007) showed that cocoa farmers in Nigeria were 72 percent technically efficient whiles Binam *et al.* (2008) estimated 74 percent and 65 percent as technical efficiency figures for cocoa farmers in Nigeria and Cameroun respectively.

From the table in page 92, 92.3 percent of the sampled farmers were at most 90 percent technically efficient and about half of the respondents had technical efficiency level less than the mean value. Only 7.7 percent of respondents achieved 91 percent to 100 percent of the frontier output while about 12 percent of farmers were operating near the potential output, i.e. 91-100 per cent of technical efficiency in Sekhon *et al.* 2010 results. This suggest that technical efficiency level of the respondent were generally low and therefore with the application of the appropriate agronomic and management practices, output of farmers in the study area can be substantially improved by 46 percent on the average. The distribution of level of technical efficiency estimate of inputs use obtained from the study is presented in Table 12.

Table 12: Frequency distribution of levels of technical efficiency estimates

Efficiencies level (%)	Frequency	Percent	Cumulative percent
11 - 20	8	2.4	2.4
21 – 30	49	15.0	17.5
31 – 40	53	16.3	33.7
41 – 50	42	13.0	46.7
51 – 60	56	17.1	63.8
61 – 70	40	12.2	76.0
71 – 80	16	4.9	80.9
81 – 90	37	11.4	92.3
91 – 100	25	7.7	100.0
Total	**326**	**100.0**	

Source: Field data, 2014

Sekhon *et al.* (2010) findings from the research on "Technical efficiency in crop production" in the Sub-mountainous region in Punjab state of India was that the estimated technical efficiency of individual farm varied between 45 and 98 per cent, with mean technical efficiency of about 66 per cent, implying that on average, the sample farmers realised only 66 percent of their technical abilities.

Hence, on an average, approximately 34 per cent of their technical potential was not being realized by the sample farms in crop production in the sub-mountainous region of Punjab. Contrary to the 99 percent obtained, Sekhon *et al* found that 52 per cent of the difference between the observed and frontier output was primarily due to the factors which are under the control of farmers.

The result is reinforced by research work by Nkamleu (2004). The researcher stated that "technical efficiency score is globally quite low" and technology gap plays an important part in explaining the ability of the cocoa sector in one country to compete with cocoa sectors in other regions in West and Central Africa (Nkamleu 2004b). However, Nkamleu, again stated that the current gap between observed and achievable yields in cocoa production lies in Ghana somewhere between 50 to 80 percent depending on different practices adopted by farmers".

Cost efficiency. The coefficient of gamma was high (0.8570) and significant, indicating the appropriateness of the model. The coefficient of gamma of 0.8750 means that 85.71 percent variations in the observed cost from the frontier cost are mainly due to cost inefficiency whilst a 14.29 percent is explained by factors beyond the control of the farmer like weather conditions, statistical errors, data collection errors. The cost efficiency score of the respondents ranges from 1.03 to 1.45. The mean cost efficiency was 1.10 meaning that an average cocoa farms in the study area incurred costs that were about 10 percent above the minimum cost defined by the frontier. That is, over 10 percent of the cocoa farms costs were wasted in comparison to the best practice firms producing the same output and facing the same technology.

Table 13: Frequency distribution of levels of cost efficiency estimates

Efficiencies level (%)	Frequency	Percent	Cumulative Percent
1.01-1.05	94	28.9	28.9
1.06-1.10	135	41.5	70.3
1.11-1.15	48	14.6	85.0
1.16-1.20	21	6.5	91.5
1.21-1.25	12	3.7	95.1
1.26-1.30	8	2.4	97.6
>1.30	8	2.4	100.0
Total	326	100.0	

Source: Field data, 2014

The frequency distribution of results of the data analysis of the level of cost efficiency of inputs use by respondents is presented in Table 13 above. The results show that the vast majority of the cocoa farmers were fairly cost efficient. From the above table, 70.3 percent of the respondents incurred at most 10 percent more than the minimum cost defined by the frontier. The research by Ojo *et al.* (2008) in Niger state, Nigeria on cost efficiency in small scale irrigated tomato production had a similar mean cost efficiency estimate. The researchers revealed that the mean cost efficiency of the respondents is 1.09 indicating that they were relatively efficient in allocating their scarce resources. Ogundari *et al*. (2006), while analyzing the small scale maize production in Nigeria, obtained the result that a relatively larger proportion of farms were fairly efficient to minimize the resource wastage associated with the production process.

In contrast, Paudel *et al*. 2009 research in cost efficiency estimate in maize production in Nepal found cost efficiency estimates ranging from 1.0 to 7.1 with mean cost efficiency of 1.634 which is higher than the results obtained in this study. Again, only about 11 percent of the respondents in Paudel *et al.'*s research had efficiency estimates equal or less than 1.10.

Determinants of Efficiency of Inputs Use in Cocoa production

Hypotheses test. As the gamma estimated for both the technical and cost efficiencies were significantly greater than zero (0), it's abundantly clear that inefficiency existed in the use of inputs in cocoa production in the study area. To identify the socio-economic variables that influence the efficiency of inputs use, it was further hypothesised exogenous variables (socio-economic variables) do not jointly explain the variation in technical inefficiency. The results of the hypothesis are presented in Tables 14 further discussed below:

Table 14: Test for null hypothesis that exogenous variables do not jointly explain the variation in technical inefficiency

Null Hypothesis	Loglikeli-hood Value	Test statistic (λ)	Critical Value	Decision
Technical Efficiency				
$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \ldots \delta_{12} = 0$	110.21	50.18***	26.75	Reject H_0
Cost Efficiency				
$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \ldots \delta_{10} = 0$	92.65	19.26**	18.31	Reject H_0

FRONTIER 4.1 Output file. The correct critical value for the hypothesis was obtained from the chi-square table. *** and ** Significant at 1% and 5% level of significance respectively.
Source: Field data, 2014.

Again, both technical and cost efficiency null hypotheses that exogenous variables do not jointly explain the variation in allocative inefficiency effects in the data were rejected and therefore the alternative hypotheses were accepted that the exogenous variables jointly explain the variation in cost inefficiency to inform policy making. This reveals that the combined effects of factors involved in the cost inefficiency model were important in explaining the variation in production of cocoa farming in the study area, although individual effects of some variables may not be significant.

Determinants of technical efficiency. Table 15 shows that the tertiary educational level, use of hybrid seedlings and age of tree were the main variables that significantly affected the technical inefficiency of farmers and were the important determinants of technical efficiency of inputs use in cocoa production in the study area. The coefficients of gender, years of cocoa farming, use of hybrid-local seedlings, levels of educational attainment below tertiary (primary, MLS/JSS and Secondary/Vocational), extension contacts per year, farmer based organisation/association and access to credit were not statistically significantly different from zero at the various statistical levels (1%, 5% and 10%) as indicated in Table 17. It is worth noting however that the signs of coefficients of variables such as years of cocoa farming, use of hybrid varieties, use of hybrid and local varieties, levels of educational attainment below tertiary (primary, MLS/JSS and Secondary/Vocational), Farmer based organisation/association and access to credit were in accordance with the a priori expectation.

Firstly, the coefficients of the variables of levels of formal education below tertiary had a negative and insignificant effect on technical inefficiency except primary education which was positive. From Table 15 the coefficient estimates gradually increases through the various levels. It shows that technical efficiency is enhanced with increasing formal education. The result is similar to the conclusion reached by Ajibefun and Daramola (2003) that education is an important policy variable and could be used by policy makers to improve both technical and allocative efficiency.

This is because farmers with formal education can read labels on agro-chemical, read or understand advertisement and best agricultural practices from newspapers, bulletins, literature, mass media etc, and may have also acquired relevant knowledge that can aid in production in school. Farmers can learn faster and have access to other sources of income which the farmer can acquire to buy other inputs. Pudasaini (1983) documented that education contributed to agricultural production in Nepal through both worker and allocative effects. Pudasaini reasons that even though education enhances agricultural production mainly by improving farmers' decision making ability, the way in which it is done differs from environment to environment. Kumbhakar *et al.'s* (1991) research also agrees with the research findings. Kumbhakar reveals that the levels of education of the farmer are important factors determining technical inefficiency.

The research finding conforms to the findings of Battese and Coelli (1996). Battese and Coelli reported a positive relationship between maximum years of formal schooling for a member of household and technical efficiency.

Battese and Coelli reasoned that educated farmers usually have better access to information about prices, and the state of technology and its use. Better-educated people also have higher tendency to adopt and use modern inputs more optimally and efficiently, (Ghura & Just, 1992).

Age of tree has a positive significant influence on technical inefficiencies and hence an important determinant of technical efficiency of inputs use in cocoa production. This means that as the cocoa trees gets older beyond certain years, it output decreases and this increases inefficiency. In a study on technical efficiency in cocoa production, Kyei *et al.* (2011) found -0.249 as coefficient for age of cocoa trees to output and this corroborate with the finding in this study. The researchers added that the years of cocoa trees affect general output and should be given prior attention.

Again, the coefficient estimated for the variable indicating use of hybrid varieties has a significant negative sign on technical inefficiency implying that the technical inefficiency diminishes with the use of hybrid variety. The use of both hybrid and local varieties in farm also enhanced the efficiency level of cocoa production as it has a negative correlation but insignificant correlation with technical inefficiencies. The finding is in line with Chirwa (2007) who suggested that efficiency rises with hybrid seed. Contrary to the finding of this study, Dzene (2010) found evidence that there is no significant difference in technical efficiency across seed type. Table 15 highlights the estimated determinants of the technical inefficiency of inputs use in cocoa production. The other variables that were not statistically significant are also discussed in respect to the direction of their coefficient signs below:

Table 15: Estimated parameters of the technical inefficiency effects model

Variables	Parameter	Coefficient	Standard-error	t-ratio
Constant	δ_0	0.3487*	0.1975	1.7658
Gender	δ_1	-0.0249	0.1089	-0.2285
Years of farming	δ_2	-0.0082	0.0052	-1.5912
Hybrid-local	δ_3	-0.1372	0.1076	-1.2750
Hybrid	δ_4	-0.2814**	0.1237	-2.2741
Primary	δ_5	-0.1654	0.1467	-1.1279
MSL/JSS	δ_6	-0.1680	0.1148	-1.4630
Sec/Voc	δ_7	-0.2858	0.2302	-1.2413
Tertiary	δ_8	-0.1135**	0.5798	-1.9576
Extension cont. per yr.	δ_9	0.0481	0.0320	1.5028
Age of tree	δ_{10}	0.0372***	0.0083	4.4773
Farmer based org.	δ_{11}	-0.1914	0.1646	-1.1631
Credit access	δ_{12}	-0.0028	0.1575	-0.0178

Note:*, **, *** indicate significance at 10 per cent, 5 per cent and 1per cent levels, respectively
Source: Field data, 2014

Access to credit also has a negative influence on technical inefficiency and hence increases the efficiency of farmers insignificantly. Actually, it reduces the financial difficulties farmers face at the beginning of the crop year, thus enabling them to buy inputs. Abdullai and Huffman (2000) reasoned that the adoption and use intensity of purchased inputs usually depends on the adequacy of the working capital. The credit availability eases these financial constraints and helps in buying inputs and thus their application at the proper time. Therefore, in order to reduce the farm inefficiencies the farmers have to be provided with easy excess on favourable terms to credit particularly through formal institutional channels. Access to credits in the study was not limited to the farmer receiving liquid cash but also provision of inputs to farmer to pay by an agreed deadline.

The coefficient estimated for the variable indicating contact with farmer based organisation or association in the technical inefficiency model had a negative sign, implying that technical inefficiency diminishes insignificantly with the farmer being a member of farmer association or farmer based organisation. Contacts with farmer based organisation or association facilitate the practical use of modern techniques and adoption of agronomic norms of production as some of these association or organisation provide inputs to its members and provide different forms of training. Members in farmer association or organisation also teach themselves with some relevant farming skills.

Also, there was insignificantly, negative correlation between technical inefficiency and the years of farming. This implies that farming experience does not have a significant impact on enhancement of technical efficiency of inputs use in cocoa production. However, farmers had acquired some relevant knowledge through years of farming which tend to improve the technical efficiency of inputs use in cocoa farming a little bit.

Finally, the impact of agricultural extension on farm production has received considerable attention in the farm efficiency literature. Agricultural extension represents a mechanism by which information on new technologies, better farming practices and better management can be transmitted to farmers. However, contrary to the a priori expectations, the coefficient estimate of farmers contact with extension personnel per cocoa season is insignificantly positive to technical inefficiency. This means that farmers who had higher extension contacts in the cocoa season were more technically inefficient though statistically insignificantly. Kalirajan (1981b) explained that "…. and farmers' misunderstandings of the technology were responsible for the difference between the actual and maximum yields" among farmers. Hussain (1989) also found no significant relationship between agricultural extension and wheat production inefficiency. There is the likelihood that extension teaching has not been carried-out well thereby having a reduction effect on technical efficiency of inputs use in cocoa production in the study area.

Determinants of cost efficiency. The results of the analysis of the determinants of cost inefficiency are as shown in Table 16. Except the variables; experience of farmer and planting of mixture of hybrid and local; all the other variables had significant effects on cost efficiency of inputs use in cocoa production in the study area. The other variables that were not statistically significant were also discussed in respect to the direction of their coefficient signs.

Table 16: Estimated Parameters of the Cost Inefficiency Effects model

Variables	Parameter	Coefficient	Standard-error	t-ratio
Constant	χ_0	-0.9452***	0.2915	-3.2429
Experience	χ_1	-0.0032	0.0036	-0.8820
Extension contacts per yr	χ_2	0.0715**	0.0290	2.4610
Farmer based org.	χ_3	-1.3254***	0.4160	-3.1863
Age of tree	χ_4	0.0219***	0.0052	4.2478
Primary	χ_5	0.3251**	0.1112	2.9228
MSL/JSS	χ_6	-0.3765**	0.1320	-2.8514
Sec/Voc	χ_7	-0.8674**	0.3311	-2.6201
Tertiary	χ_8	-0.5095**	0.2324	-2.1928
Hybrid	χ_9	-0.4039**	0.1490	-2.7114
Hybrid-local	χ_{10}	-0.0296	0.0789	-0.3757

Note:*, **, *** indicate significance at 10 per cent, 5 per cent and 1 per cent levels, respectively
Source: Field data, 2014

Farmer based organisation had the highest significant impact on cost efficiency. There was negative correlation between farmer based organisation and cost inefficiency. Farmer-based-organisation significantly enhanced the cost efficiency of inputs use in cocoa production in the study area. In other words, farmers that were members of farmer-based-organisation were much more efficient in the management of the cost of production. Most of the farmer based organisations took advantage of the number of inputs they can purchase for its members to bargain for cheaper prices of inputs for their members and also organises training services for their members. Again members of farmer-based-organisation help themselves to undertake farm operations popularly referred to in 'nnoboa' in Twi. These forms of assistance the farmers enjoy from farmer-based-organisation enhanced their cost efficient of inputs use.

Furthermore, as expected, the age of tree was positively related to cost inefficiency of production. This implies that as the age of trees increases, the cost inefficiency of production of the farmer increases. This may be due to the reduction in yield of the plant as the plants grow beyond some years of production. Age of trees also had negative effect on technical efficiency of inputs use in cocoa production in the study.

Kalirajan (1981b) stressed the need for policy makers in a South Indian state to focus on extension work in order to increase rice production and reduce inefficiency. Owen *et al*. (2001) showed that access to agricultural extension services, defined as receiving one or two visits per agricultural year, raises the value of crop production by about 15 percent . Contrary to these and other literatures, the result of the empirical analysis showed that there was positive correlation between cost inefficiency and the number of contact made with extension agents per cocoa season. This implies that farmers who had more contacts with extension agents were rather more cost inefficient.

On education, the coefficient estimate of primary education was positively related to cost inefficiency while the coefficients of middle school/junior secondary school leavers, secondary/vocational leavers and tertiary institution were negatively related to cost inefficiency. However, all the variables were significant. This means that formal education above primary level improved cost efficiency. Pudasaini (1983) documented that education contributed to agricultural production in Nepal through both worker and allocative effects. The author also found that even though education enhances agricultural production mainly by improving farmers' decision making ability, the way in which it is done differs from environment to environment.

Interestingly, the coefficient estimate of secondary/technical/vocational level of education is greater than that of tertiary level of education though the latter is positive and significantly correlated to technical efficiency. Kumbhakar *et al.* (2000) argues that a producer may be technically efficient, but yet cost inefficient because he fails to choose correct input combination. For Weirs (1999), at least four years of primary schooling are required to have a significant effect upon farm productivity.

On the contrary, Kalirajan and Shand (1989) argued that although schooling is a productive factor, farmers' education is not necessarily related significantly to their yield achievement. The researchers argued that illiterate farmers, without the training to read and write, can understand a modern production technology as well as their educated counterparts, provided the technology is communicated properly. Adesina and Djato (1996), also found that there is no difference in either relative technical, allocative or economic efficiencies between educated (defined as those who had at least one year of formal schooling) and non-educated farmers and recommended that rural development efforts should not be biased towards "educated" farmers as "non-educated" farmers are just as efficient.

The number of years of farming or farming experience had negative effect on cost inefficiency. Farming experience improved the cost efficiency of inputs use in cocoa production insignificantly. This may be because increased years of farming establishes important acquaintance and acquire relevant skill which helps reduce cost and increases cost efficiency. For instance, because farmers operate in market of imperfect information, farmers over time can establish acquaintance with inputs seller who may sell inputs to these farmers at relatively low cost and learn over time the right quantities of inputs to use. This reduces cost inefficiency of production since the cost of a factor is a product of quantities of the input used and the price per unit of the input.

Lastly, the planting of mixture of hybrid and local cocoa varieties on the cocoa farm had a negative correlation with the cost inefficiency and this implies that cost efficiency of farmer increases though insignificantly by planting a mixture of hybrid and local varieties. However, growing hybrid varieties only significantly improved cost efficiency of inputs use in cocoa production in the study area. This can be ascribed to the fact that the hybrid varieties respond more positively to application of inputs because the hybrids had been genetic improved.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview

This final chapter summarizes the major findings of the empirical study undertaken on efficiency of inputs use in cocoa production in Twifo Hemang Lower Denkyira District in central Region of Ghana. The chapter is divided into three sections. Section one has summary of the findings of the empirical study, section two presents the conclusions of the empirical analysis of the study while in section three, recommendations were derived from the analysis.

Summary

Below are the summary of the empirical study of the efficiency of inputs use in cocoa production in Twifo Hemang Lower Denkyira. Each paragraph of the summary emphasizes on one objective of the study.

Description of the state of inputs use in the study area. The inputs identified in the study were fertilizers, weedicides or herbicides, special pruning tool or prunner, fungicides, insecticides and hybrid cocoa varieties among which weedicide usage (87% of the respondents) and the use of special pruning tool (29% of the respondents) were the most and least prevalent inputs in the study respectively. Four out of the six inputs were land-saving inputs, which means they maximise the productivity of the land more than the other factors of production and tend to save land while the remainder are labour-saving which saves labour more for other factors of production.

Effect of inputs on outputs and cost of cocoa production. The coefficient of all the variables included in the both the production and cost models were positive and significantly affected both output and cost in cocoa production in the study area. Fertilizer usage, pesticide usage, land (farm size) and estimated number of hybrid variety were included in the production model while costs of fertilizer usage, pesticide usage, use of hybrid variety and value of yield were included in the cost model. Return to scale (RTS) was estimated to be 1.2109 in production function while 1.0443 was estimated for the cost function.

Estimation of the level of efficiency of inputs use in cocoa production. The estimated technical efficiency levels ranged between 0.11- 0.99 with mean of 0.54 while the estimated cost efficiency levels ranged between 1.03 - 1.45 with mean of 1.10. Furthermore, 99.9 percent of the variation between the observed output and the frontier output were as results of inefficiency while inefficiency accounted for 85.71 percent of the difference of the observed cost from the frontier cost.

Determinants of efficiency of inputs use in cocoa production. Lastly, the coefficient estimates of number of hybrid varieties and tertiary level of education were significantly positive while that of 'age of tree' was significantly negative determinants of technical efficiency of inputs use in cocoa production in the study area. Meanwhile, the coefficient estimate of 'extension contacts' had an insignificant negative effect on technical efficiency of inputs use in cocoa production in the study area. The coefficient estimates of farmer-based organisation, formal education above primary school and planting of hybrid varieties were positive and significantly correlated to cost efficiency while age of cocoa trees and extension contacts correlated significantly positive to cost inefficiency. However, the coefficient estimates of farming experience and combination of hybrid and local varieties on a farm were positive but insignificantly related to cost efficiency.

Conclusions

From the analysis and findings of this study, the following conclusions were made:

1. The majority of the respondents had employed five of the six inputs identified in the study. The inputs identified were biased toward land-saving than labour-saving.
2. Quantities of fertilizer application, pesticide usage, hybrid varieties and farm size significantly affected the output of cocoa production in the study area. Cocoa output in the study area can be enhanced by increasing the quantities of fertilizer application, pesticide usage, hybrid varieties and farm size.
3. Cost of fertilizer, cost of pesticide, cost of labour and the value of yield also affected significantly the cost of cocoa production. Labour cost affected total cost more than all the other variables included in the cost function of the study.

4. The study further showed that cocoa farmers in Twifo Hemang Lower Denkyira exhibited increasing returns to scale, indicating that cocoa production was in the irrational zone (i.e. stage I of the production function).
5. Technical efficiency of inputs use in cocoa production was low but cost efficiency of inputs use in cocoa production was fairly high.
6. Hybrid varieties, tertiary level of education and age of tree were found to be the main determinants of technical efficiency of inputs use in cocoa production in the study area.
7. Farmer-based organisation, MSL/JSS, Secondary/technical/Vocational levels and tertiary of formal education, planting of hybrid, age of cocoa trees and extension contacts were also the major determinants of cost efficiency of inputs use in cocoa production in the study area.

Recommendations

From the results and findings, the following recommendations were made for policy makers, farmers and other stakeholders;

1. Cocoa output can be improved by increasing the quantities of fertiliser application to replenish the soil of lost nutrient, increasing pesticides applications and use hybrid varieties in the study. Knowing the great benefit the country derives from cocoa, Government should subsidise the cost of inputs and make them readily available to farmers. Non-Governmental Agencies and Farmer association should complement the effort of Government to make inputs readily availabe to farmers.

2. The Cocoa Rehabilitation Unit of the Cocobod should help farmers to rejuvinate and or re-plant the aged cocoa farms with hybrid varieties. The Extension unit of the Cocoa Swollen Shoot Virus Control Division of COCOBOD should intensify the education on the effects of aged trees on output to farmers to make it easier for farmers to accept this change. This will make farmers more technical and cost efficient.
3. The coefficient estimates of variable, farmer-based-organisation, correlates positively to cost and technical efficiency, Farmers should be encouraged to join farmer-based organization. The Extension unit of the Cocoa Swollen Shoot Virus Control Division (CSSVCD) of COCOBOD should use their medinm to organise farmers into association to access input. The unit can provide the association with the requisite technical training.
4. Due to empirical results obtained for the effect of extension contact on cost and tehnical efficiency, further research work is encouraged to study or review the activities of the extension agents in the study area. COCOBOD should make it a necessicity to undertake an annual research to review the activities of the extension unit through Cocoa Research Institute of Ghana, the Universities or by creating a research team to work with the Monitoring and Evaluation unit of the CSSVCD of COCOBOD.
5. Cocoa Research Institute of Ghana and the Universities should be funded by the Ministry of Food and Agriculture (Government) to undertake research aimed at reducing the cost of labour in cocoa production by

looking out for efficient and cost effective labour saving technologies. Research to reduce labour cost will have an important impact on cocoa production. Labour cost takes a chunk of total cost of cocoa production per cocoa season and effort to reduce the cost of labour will make farmers much more cost efficient and increase the net profit of cocoa farmers.

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APPENDIX

Appendix A: Farmers' Interview schedule

Research Topic: Efficiency of Inputs Use in Cocoa Production in Twifo Hemang Lower Denkyira of Ghana

Introduction

This questionnaire is purely for academic purposes and all information given shall be recognized as such. The information provided shall be handled with the highest confidentiality.

Thank you for your warm reception

District; ……………………………………………………………

Community; ……………………………………… Date; ………………………

Please, kindly respond to the questions by marking or writing the appropriate option.

Section A

Demographic features of respondents (socio-economic variables)

1. Gender of farmer Male [ ] Female [ ]
2. Age of farmer as at the last birthday (years) …...
3. Marital status

Single [ ] Married [ ] Divorced [ ]

Separated [ ] Widowed [ ]

4. Size of farm (hectares) ....
5. Number of years of cocoa farming..

6. Age of cocoa farm ……………………………………………………

7. Type of cocoa grown by farmers

Hybrid [ ] Amelonado [ ] Amazonian [ ] Others [ ]

8. Proportion of the cocoa plantation grown with

Hybrid (……...) Amelonado (…….) Amazonian (…….) Others (……)

9. Highest level of formal education attained by farmer

No formal education [ ] Primary edu. [ ] MSL/JSS [ ]

Secondary/Technical/Vocational [ ] Tertiary [ ]

10. Is farmer a member of a farmers association? Yes [ ] No [ ]

11. If no, why? ....

19. If yes, what are the reasons for joining the farmer association?

....

20. Does the farmer have access to extension agent? Yes ( ) No ( )

21. Number of extension contact per year………………………………………

22. Origin of extension agent Public ( ) Private ( )

23. Does the farmer have access to credit Yes ( ) No ( )

24. If yes, then, what are the sources of credit to the farmer …………………

Section B

State of Inputs use in the Study Area

Tick appropriately the inputs used on your farm for the previous cocoa season and specify the source of information on the each specified input in the table below;

Inputs	**Yes**	**No**	**Why yes or no**
Fertilizer			

Insecticides			
Fungicides			
Herbicides			
Hybrid cocoa varieties			
Pruner			
Others (specify)			

SECTION C

Measurement of Quantities and Cost of Inputs used in the previous cocoa season.

Please state the quantities and cost of inputs used in the just ended cocoa season.

Inputs	**Quantity used per season**	**Cost per unit (GH₵)**	**Total cost per season (GH₵)**
Fertilizer (Kg)			
Pesticides (litres) Insecticides Fungicides Herbicides			
hybrid cocoa varieties			

Labour (Mandays); Men Women Child			
Total cost			

Section D

OUTPUT COMPONENT

1. Yields obtained per farmer for the previous cocoa season (Kg) ....
2. Price per unit (GH₵) ....