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Analysis of production efficiency and the impact of extension services and policies on cocoa productivity in the western region of Ghana

MASTER'S THESIS

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Author:

Michael Amponsah Odei

Supervisor:

Dr. Miroslava Bavorova

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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Michael Amponsah Odei, BSc

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Thesis title

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Objectives of thesis

The main objective is to assess production efficiency and the impact of extension services on cocoa productivity in the western region of Ghana. Specifically the study seeks to:
i)Estimate the efficiency of resource utilisation in cocoa production.
ii)Analyse the effect of policies (e.g. fertiliser subsidy, mass spraying) and extension services on cocoa productivity.
iii)Suggest policy recommendations for improving productivity.

Methodology

The target population of the study are cocoa farmers in the western region of Ghana.A simple random and purposive sampling techniques will be used to select the required sample sizes among the farmers and study area respectively.

Again, the survey data collection technique will be adopted to collect wide range of primary data from the farmers using semi-structured questionnaires.

Secondary data will also be collected from articles, books,journals and the Internet. Data will however be analysed using Data Envelopment Analysis,Partial Least Squares (PLS) regression and the results will be presented in tables and charts (pie charts, bar charts, line graphs). This will be done using SPSS,Smart-PLS 3 , MaxDEA, and Excel.

The proposed extent of the thesis

60

Keywords

Productivity,Efficiency,Analysis,Agriculture policy,Output

Recommended information sources

Asare R, Asare RA, Asante WA, Markussen B, Ræbild A. 2017.Influences of shading and fertilization on on-farm yields of cocoa in Ghana.Experimental Agriculture 53: 416-431.

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Kyei L, Foli G, Ankoh J. 2011. Analysis of factors affecting the technical efficiency of cocoa farmers in the Offinso district-Ashanti region, Ghana.American journal of social and management sciences2: 208-216.

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Supervising department

Department of Economics and Development

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Ing. Vladimír Verner, Ph.D.

Head of department

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doc. Ing. Jan Banout, Ph.D.

Dean

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Declaration

I hereby declare that all contents of this thesis entitled "**Analysis of production efficiency and the impact of extension services and policies on cocoa productivity in the Western region of Ghana"** are my original work, and I have duly acknowledged all the sources used according to the citation rules of the Faculty of Tropical AgriSciences.

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27th April, 2018. ……………………………

In Prague Michael Amponsah Odei

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Abstract

In Ghana, cocoa production dominates the agriculture sector and plays a crucial role in the national economy. The crop has been country's backbone and the major agricultural export and foreign exchange earnings as well as the main source of livelihood for rural households since the 1960s**.** However, over the past decades, the sector has been experiencing a decline in production prompting successive governments and stakeholders to come up with policies and initiatives to improve productivity. Despite the numerous efforts, production has not seen appreciable increase. As a result, Ghana has dropped from its second position after Ivory Coast to third position in the world cocoa export ranking. In view of this, the study seeks to assess the efficiency of resource utilisation among cocoa farming households and examine the factors that influence cocoa productivity in the Western Region of Ghana. The study used the Data Envelopment Analysis (DEA) to analyse technical efficiency and resource used in cocoa production and the Structural Equation Model (SEM) to analyse the influence of policies on cocoa productivity. Farm-level data of 90 cocoa farmers was obtained using semi-structured questionnaires complemented by purposive sampling techniques. DEA results indicated that cocoa farmers were inefficient with a mean pure technical efficiency of 70 %. Factors that influenced cocoa productivity were established to be fertiliser subsidies offered by the government and the extension advisory and services. Addressing issues of productivity, it is recommended that extension advisory and services should be directed towards managerial efficiency of cocoa farmers. Also, government should strengthen and expand the CODAPEC spraying programme to cover greater mass of the rural farming households in order to improve the efficiency and productivity of the cocoa sector.

Keywords: Cacao, government policy, resource use, data envelopment, subsidies.

Contents

List of tables

List of figures

List of abbreviations

ADB	African Development Bank
ADF	African Development Foundation
AVE	Average Variance Extracted
BADEA	Banque Arabede Developpement Economique en Afrique
BCC	Banker, Chames and Cooper
BoG	Bank of Ghana
CCR	Charnes, Cooper and Rhodes
COCOBOD	Cocoa Marketing of Ghana
CODAPEC	Cocoa Diseases and Pests Control Committee
CR	Composite Reliability
CRP	Cocoa Rehabilitation Project
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DMU	Decision-Making Unit
EMS	Efficiency Measurement System
FSP	Fertiliser Subsidy Programme
GDP	Gross Domestic Product
GLSS	Ghana Living Standards Survey
GoG	Government of Ghana
GSS	Ghana Statistical Service

Ha	Hectares
ICCO	International Cocoa Organisation
IDA	International Development Agency
ISSER	Institute of Statistical, Social and Economic Research
JHS	Junior High School
ODA	Official Development Assistance
OEC	Observatory of Economic Complexity
OLS	Ordinary Least Square
PLS	Partial Least Square
SEM	Structural Equation Model
SHS	Senior High School
TE	Technical Efficiency
VRS	Variable Returns to Scale

1 INTRODUCTION

In Ghana, agriculture contributes significantly to growth and development in numerous ways. For instance, it plays essential function in provision of food, raw materials for industries, plants which have medicinal properties. All these products are useful resources that contribute to growth and development. Plantation crops which include cocoa, coffee, oil palm, and rubber, have championed the export and commodity market for many centuries. Among the perennial tree crops, cocoa has been a significant commodity for many West African countries, and for the global chocolate production. Africa alone contributes about 73.1 % of global cocoa production (ICCO 2016).

According to Bryce (2012), Ghana among other West African countries, contribute more than 70 % of world's cocoa production. Cocoa holds a unique position in Ghana's economy (Wessel & Quist-Wessel 2015) as it is a major contributor to Ghana's Gross Domestic Product (GDP) and is one of the most valuable agricultural export crop. It is the country's second important foreign exchange earner after gold. According to the Ghana Statistical Service the share of cocoa in Ghana's GDP is 8.2 % add the year and about 23 % of foreign exchange earnings (GSS 2015). Cocoa is also a major source of income for about 865,000 farming families (Monastyrnaya et al. 2016). It's estimated that the livelihood of more than 2 million people is directly derived from cocoa production (Gakpo 2012; Anang et al. 2013).

Most of Ghana' cocoa produce emanates primarily from small-holder cocoa farmers; however, their welfare is often side-lined or relegated to the background as majority of them lack the necessary capacity building. They have lower income levels and generally have lower standards of living (Anang et al. 2013). Over the last two decades, cocoa production in Ghana has decreased drastically and this has shifted the country's position from the second largest world producer and exporter after Cote d'Ivoire to third (Asante et al. 2017). Because of low production in cocoa sector, the research seeks to investigate the factors which affect the productivity and efficiency of cocoa production in Ghana. The emphasis will be on the role of policies and extension in bridging the gap between productivity and efficiency of Ghana’s cocoa production.

1.1 Problem statement

Ghana’s cocoa sector has continuously witness low productivity in the past decades due to the low credit facilities for farmers, prevalence of pests and diseases, fluctuating producer price, and low adoption of modern technology among others (Adu-Acheampong et al. 2017) and low technical efficiency. The increasing technical efficiency allows increased output without sourcing additional inputs and is thus of great interest to experts and development practitioners. Cross country researches have indicated that, there are rooms for expanding agricultural productivity through improving overall technical efficiency in agricultural production (Makombe et al. 2017).

Empirical studies on the role of extension services in the Ghanaian cocoa sector are of keen interest to the national government in order to increase productivity (Kolavalli & Vigneri 2011). Current investigations that analysed the effect of policy, extension advisory and services and resource use efficiency and determinants of productivity in the Ghanaian cocoa sector are limited. This study therefore seeks to analyse them and based on the results to suggest policy recommendations to improve cocoa efficiency and productivity in the cocoa sector.

1.2 The objectives of the study

The main objective is to access the efficiency of resource utilisation and the factors which affect the productivity of cocoa production in the Western Region of Ghana. The emphasis will be on the effect of policies as well as extension services and their influence on productivity and efficiency of cocoa production.
The specific objectives are therefore to:

- Estimate the efficiency of resource utilisation in cocoa production.
- Examine the effect of policies (e.g. subsidies on fertiliser, CODAPEC mass spraying)

as well as extension services on cocoa productivity.

- Suggest policy recommendations for improving cocoa productivity.

1.3 Organization of the thesis

This study comprises of 6 chapters. Chapter one entails background of the study, problem statement, objectives. Chapter two comprises of the literature review. The third chapter contains the research methodology, sources of data, data collection tools and methods theoretical framework of DEA and SEM. Chapter four focuses on the description of the results. Chapter five is devoted to the discussions of the results. The Study concludes with chapter six, where research findings will be elaborated and some policy recommendations made.

2 LITERATURE REVIEW

This chapter contains the literature review to the topic of this study. First, the records on the origin and the spread of cocoa production is reviewed. Furthermore, the set of literature on the determinants of cocoa outputs in Ghana is well reviewed**.** Finally, the concept of resource use efficiency and some policies on Ghana's cocoa sector will be reviewed. This chapter is structured as follows

1. Origin and contribution of cocoa to Ghana's economy
2. Factors affecting cocoa production (labour and land factor market, extension services, cocoa policies, Abidjan declaration.
3. Efficiency- technical, allocative, economic, determinants of technical efficiency, efficiency measurement.
4. Extension services

2.1 The origin and contribution of cocoa to Ghana's economy.

"Ghana is cocoa" (Gakpo 2012). This implies that cocoa production cannot be completed without referring to Ghana (Kolavalli &Vigneri 2011). Cocoa, botanically known as *Theobroma cacao L*, originates from South America Amazon headwaters (Somarriba & Lachenaud 2013).

The cultivation of cocoa was started by the Spanish in the sixteenth century during their colonial era in the Americas (Vaast & Somarriba 2014). Later, the French, British and Dutch joined the cocoa cultivation business and spread their production to their colonies in the Western Indies (Jamaica, Martinique and Surinam) in the 17th century and subsequently to Brazil in the 18th century. From there, it disseminated to different parts of West Africa, and for that matter also to Ghana (formerly Gold Coast), Cote d'ivoire and Nigeria.

According to Kolavalli & Vigneri (2011), the introduction and exponential growth of cocoa production in Ghana was a missionary affair. The Dutch missionaries commenced cocoa growing in the coastal regions of the then Gold Coast as early as 1815, followed by the Basel missionaries in 1857. The missionaries' initiatives didn't yield results in the spread of cocoa cultivation until Tetteh Quashie returned from Fernando Po in 1879 with Amelonado cocoa pods and started a farm at Akuapem Mampong in Ghana' Eastern region.

Ghana's cocoa sector contributes significantly to its economic growth (Augustine & Asiedu 2017; Gunnarsson 2018). Between 1990 and 2014, cocoa has persistently contributed about 8.2 % to Gross Domestic Product (GDP), 23 % gross export receipts and 9 % to total export revenue annually (GSS 2015). It also contributes about two-thirds of the income and livelihoods of nearly 4 million cocoa farming households (GSS 2015).

Between 2013 and 2014 cropping period, export of cocoa beans earned the country as much as GH¢4,498,546,215 and $1.89 billion (COCOBOD 2014; OEC 2016). Proceeds from Cocoa exports increased by about 15.4 % in gross value, from US$2,267.39 million in 2013 to about US$2,612.87 million in 2014 (ISSER 2014). Cocoa constituted 63 % of the foreign export profits from the agricultural area (Adu-Acheampong et al. 2017). The country's main export destinations are Netherlands 21 %, France 4.5 %, Germany 7.4 %, Italy 2.8 %, Japan 8.0 %, United Kingdom 3.9 %, and United States 8.8 % (OEC 2016).

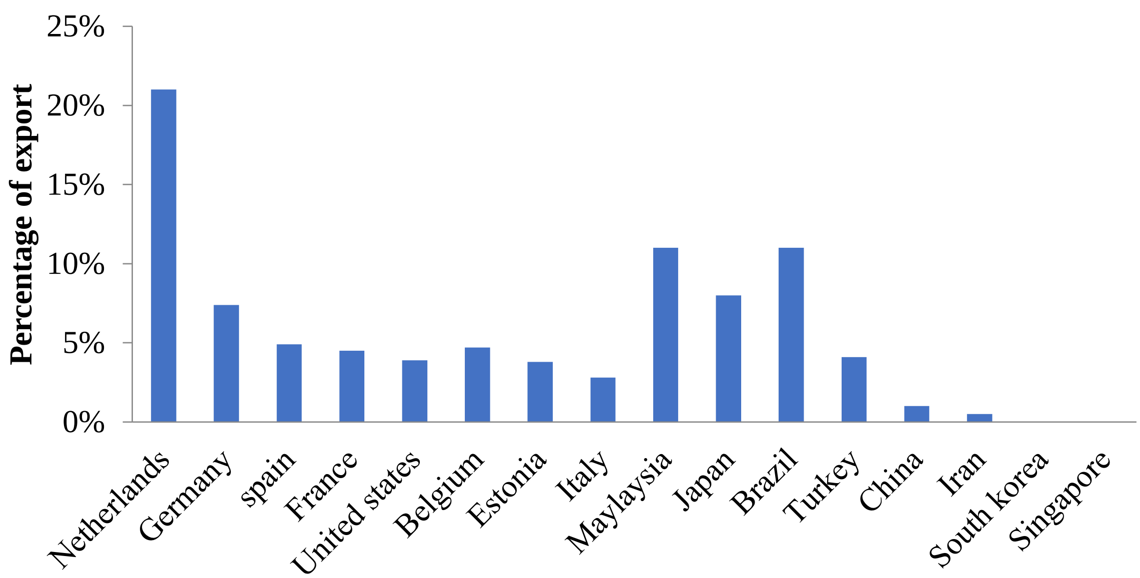

Figure 1: Ghana's cocoa export destinations

Source: own compilation with data from OEC

Many scholars and economists have argued that the persistent overdependence on export of raw cocoa beans will mean that the country will not derive the full economic benefit from this crop (Mitchell 2011). This is attributed to the continuous price fluctuations on the world market and the countries inability to add value to the cocoa beans before exporting. This has raised lots of concerns about the sustainability of benefitting fully from cocoa in the commodity market (Kalu & Kim 2014).

2.2 Factors affecting cocoa production

2.2.1 Land and labour

Labour is a vital input in the cocoa production. Cocoa production requires many agricultural practices that are labour intensive (Fadzim et al. 2017; Green 2017). In Ghana, a study conducted by Danso-Abbeam & Baiyegunhi (2017) revealed that labour significantly affect cocoa output and was also positively related to cocoa production. Kongor et al. (2017) studies also came to the conclusion that the amount of labour used greatly affected cocoa production. Similarly, Fadzim et al. (2017) studies also pointed out that cocoa output increases among Ghanaian cocoa households was mainly due to increases in labour productivity.

Land is one of the most vital of factors of production in cocoa production (Aneani et al. 2017). A study conducted by Wessel & Quist-Wessel (2015) have showed that farmers are likely to invest their resources and time on their own farms rather than farms where they don’t have complete ownership rights. According to Schroth et al. (2016), secured land tenancy rights directly affects cocoa resources management and usage.

The continuous use of farm land results in loss of soil fertility. Declining soil fertility is seen as one of the main reasons of decline in cocoa yields (Franzen & Mulder 2007). The solution to this problem is the use of fertiliser. The application of fertilisers is known to increase agricultural output (Baah et al. 2011). Fertiliser application is capable of increasing food production by at least 70 per cent (Somarriba et al. 2013). The effective and efficient use of fertilisers in cocoa production can increase profitability, improve yield and environmental protection (Jacobi et al. 2015). Boniphace et al. (2015) have revealed that the probability of cocoa farmers to use fertilizers depends on their farm size and if they belong to an association of farmers and if they desire to increase their output.

2.2.2 Extension services

The success of Ghana' cocoa production depends primarily on the role played by extension services. Agricultural extension or agricultural advisory services plays an essential role in improving rural livelihoods, facilitating increased productivity, food security and enhancing pro-poor economic growth (Dorward et al. 2004; Pingali 2007; Walo 2017).

Extension agents provide farmers with new technologies and information leading to innovative farming. Improved agricultural productivity predominantly rest on how farmers approve new technologies as well as how swiftly they get rid of cultural changes (Fadzim et al. 2017).

Increased cocoa productivity means that cocoa farmers should be abreast with adopting recommended scientific farming methods instead of relying on the traditional farming. Cocoa farmers need to positively respond to technological innovations (new ways of doing things). For cocoa farmers to accept these new ideas positively, they need be well educated on best farming practices. This is because innovative ideas are complicated, and in most cases these farmers are uneducated so they can hardly understand (Fosu-Mensah et al. 2012; Tetteh & Asase 2017).

What then is agricultural extension service? According to Asiabaka (2002) extension services refers to the periodic education offered to both the urban and rural clientele on how to find corrective measures to agriculture using farmers limited own resources. He further expounded that agricultural extension has three main dimensions, the first comprises of the educational component, which entails behavioural changes in the attitudes and beliefs of the people, secondly the economic dimension entails increase in income of farmers through improved crop yield as well as better financial management, better food preservation techniques, and lastly the social dimension also includes enhanced health of the farmers, farmers cooperation development, leadership development, better mentoring and increased enthusiasm for personal development.

Ghana's cocoa extension services are aimed at promoting increased production through institutional support for cocoa farmers. This support enables them to circumvent their production and marketing problems leading to sustainable production (Rogers 2003; Ruifa et al. 2009).

These cocoa extension services are anticipated to address the numerous socio-economic and environmental problems via linkages between the extension personnel. These services usually involve smallholder farmers in the decision making and problem-solving and process thus ensuring the disseminating valuable knowledge and information (Quisumbing & Pandolfelli 2010; Lukuyu et al. 2012).

The government of Ghana (GoG) has taken drastic measures to modernize traditional cocoa farming practices, disseminating technology and resources and training personnel to address extension needs of cocoa farmers (Okorley 2007).

Furthermore, extension services are mediums of research and technology transfers between science and farmers (Adesina & Baidu-Forson 1995). Cocoa research institutions liaise with extension agents by developing recommended packages for farmers and then extension agents transferring to smallholder farmers, through farm demonstrations and farm visits. They also offer advisory services to farmers through gathering and farm visits.

In Ghana, the commonest medium of technology transfer is focused groups. This entails discussions groups where the extension officer interacts with farmers to exchange knowledge (Hennessy et al. 2017). Cocoa farmers willingly join these groups primarily for educational reasons (to learn and gain knowledge and information).

2.2.3 The cocoa rehabilitation policy

The Cocoa Rehabilitation Project (CRP) was the first initiated by the African Development Bank (ADB). According to Agriculture Development Bank report in 2002, the CRP had the following objectives (i) intensify cocoa production to an annual output of at about 300,000 tons per year by the year 1995; (ii) increase foreign exchange earnings through the export of cocoa and (iii) reduce rural poverty and improve quality of life in the cocoa growing areas.

According to Kolavalli & Vigneri (2011) the CRP was jointly funded by the Ghana Cocoa Board (17.4 %), African Development Bank, ADB (19.2 %), African Development Foundation (ADF) (6.6 % the Ghana Cocoa Board (17.4 %), International Development Agency (IDA) (31.6 %), Banque Arabede Developpement Economique en Afrique (BADEA) (7.8 %), Official development assistance (ODA) (9.3 %) and the Government of Ghana (8.4 %).

According to Suglo (2012), CRP led to an increase in annual production from 110,000 – 115,000 tons. The CRP had also contributed to improved rural well-being as well as rural poverty reduction an improvement from 2.4 – 4.9 times better than when the project was implemented. This was corroborated by the results of the Ghana Living Standards Survey (GLSS 2005) which revealed that rural poverty (absolute) had reduced from 43 % to 34 % between 1989 and 1999, cocoa farmers experienced a sharp decline in poverty level (Coulombe 2005).

2.2.4 Fertiliser subsidisation policies

In Ghana the government has taken the initiative to provide cocoa farmers with subsidized cocoa fertilizers aimed at increasing productivity to about 75 % from ten bags of cocoa per hectare to about 19 bags per hectare (Bates 2014; Houssou et al. 2017). The fertiliser subsidies policies are tools adopted by most governments to maximize incomes for rural households as a means to alleviating their poverty (Oduro & Omane-Adjepong 2012).

Proponents of the fertiliser subsidies believe they are the only solution to increasing agriculture productivity to ensure food security and sustainable income for rural folks (Anang et al. 2013). The subsidies are encouraged as a way of reversing depleting soil nutrients because of continuous farming without fallowing (Obeng & Opoku 2008).

Re-introduced in 2008 the Fertiliser Subsidy Programme (FSP) was in response to hikes in prices of fertilisers and its resultant rise in food prices. The government of Ghana introduced a country-wide subsidy on 50 Kg bags of fertiliser as a means to alleviate the effect of increasing energy and food prices (Yawson et al. 2010). The program heavily subsidised fertiliser up to 50 per cent of prices (Obeng & Opoku 2008).

Ghana has one of the lowest fertiliser usages in the world (Martey et al. 2013). The fertilizer application rate is 8 kg per hectare compared to 20 kg/ha in sub-Saharan Africa (Okebalama et al. 2016). The low rate of application was attributed to the high cost of fertilisers; many farmers are therefore unable to afford the product, thereby translating into low productivity. The introduction of the FSP aims to address these challenges and surge agricultural production and productivity (Fearon et al. 2015).

The Government of Ghana allocated an estimated GH¢200 million in fertiliser subsidies in the 2017 farming season, making it the highest subsidy tranche since the programme was instituted in 2008 (Ghanaweb 2017). This is expected to cover about 180,000 metric tonnes, comparable to about 3.6 million bags of fertilisers (Ghanaweb 2017). This is aimed at motivating farmers to increase their yields. However, Álvarez-Carrillo et al. (2015) have suggested that for this policy to be effective, cocoa farmers need to be educated by extension officers as to the best ways of applying these fertilizers.

2.2.5 Pests and diseases in cocoa production

Pests and diseases pose big problems to cocoa production and it require intensive pest management to control them to increase cocoa yields (Asante et al. 2017). The high incidence of pest and diseases infestation is considered by many farmers to be the major cause for low cocoa yields (Ntiamoah & Afrane 2008). Three major diseases and pests of economic significance include; (i) swollen shoot caused by virus, (ii) black pod caused by fungus and (iii) capsid, which consumes plant tissues (shoot and pods), finally killing them.

Black pod disease probably appeared as soon as cocoa was introduced in Ghana and it is the most destructive among all cocoa diseases which attack the developing cocoa pod. It is caused by soil-borne fungus *phytophora* and is most prevalent during the rainy season (Hanada et al. 2010). The disease is worse in the areas of heavy rainfall (Melnick et al. 2008).

The disease can cause severe damage, to both small and matured pods. The leaves of coupons and seedlings (in the nursery) can be attacked and destroyed under conditions of long periods of cool and rainy weather. Losses of cocoa yields due to black pod disease differ from place to place and from variety to variety. The recommended method of control was to remove the affected pods and also to harvest the matured pods at short intervals (Mbarga et al. 2014).

Mirids and capsids are widely used terms which refers to the numerous species of pests found in cocoa growing regions (Sarfo et al. 2018). Capsids which cause the swollen shoot disease were first identified as serious cocoa pests in the early part of the cocoa industry since 1910 (Farrell et al., 2018). Insect pests such as capsids and moths cause lots of destructions to young cocoa trees by piercing young shoots and sucking out liquid food and inject toxic saliva that eventually lead young trees dying (Sonwa et al. 2017). A country-wide mass spraying campaign was planned and implemented in all the cocoa growing areas to curb theses pest and diseases since the 1970s when they first broke out (Awudzi et al. 2017; Aneani et al. 2017).

Numerous recommendations and suggestions have been made towards how fungicides can be applied against the black pod disease and other insecticides such as swollen shoot disease. Emile et al. (2017) recommended early spraying at the beginning of the season and its continuous application every three weeks until rains stop. Cocoa Research Institute of Ghana also recommends an average of seven to eight times of spraying fungicides per season and three to four times of insecticides spraying per cocoa season (Aneani et al. 2017).

The above mentioned presupposes that the chemical control of cocoa diseases (mainly black pod and swollen shoot diseases) is feasible, acceptable and desirable, that’s technically possible, practically feasible, environmentally acceptable, economically desirable and politically advantageous (Nyadanu et al. 2017). However, maintain pest and disease control is becoming a high cost venture for cocoa farmers due to escalating costs of insecticides and fungicides (Danso-Abbeam & Baiyegunhi 2017).

2.2.6 Policies to tackle pest and diseases

Economic losses due to infestation in cocoa are 30 % worldwide. (Ntiamoah & Afrane 2008). The Ghana COCOBOD implemented the mass cocoa spraying exercise where they provided insecticides and machines for the spraying of cocoa farms for at least six times within a year.

The cocoa mass spraying program has been implemented since 2001 to improve production to about 1000,000 tons by 2012 (Obeng & Opoku 2008).

The Cocoa Diseases and Pests Control Committee (CODAPEC), was subsequently established by the government of Ghana in the year 2001 to coordinate and implement the program. The initiative also intended to train farmers and extension personnel on pests and diseases control, safe use of pesticides, create jobs for the unemployed in rural communities and increase farmers' incomes (Obeng & Opoku 2008).

On the success of the mass cocoa spraying exercise, a study by Naminse et al. (2011) have showed that cocoa output has been boosted tremendously from 13.68 to 23.80 bags per farmer per season, representing about 73.98 % increase in mean output. This was based on the fact that the mass spraying had a positive impact on cocoa production in Ghana (Asuming-Brempong et al. 2008). This was also corroborated by Abankwa et al. (2010), who revealed that the policy has rejuvenated cocoa production in Ghana as well as increasing output levels.

Although the increased yield cannot be solely credited to the mass spraying policy but by other contributory factors such as improved technology, favourable weather, improved producer price and elimination of market restrictions (Vigneri & Santos 2009).

According to Obeng & Opoku (2008), the mass cocoa spraying policy had the following constraints

1. Pilfering and diversion of chemicals, that is most of the chemicals were smuggled to neighbouring country especially Ivory Coast,

2. There was also the lack of reliable data on farm sizes due to poor farm record keeping leading to speculations and manipulations by spraying officials.

3. There was also the problem of political discrimination in the selection of beneficiary farms and areas, and finally inappropriate spraying methods and bad timing of the spraying activities.

2.2.7 Abidjan Declaration

As at the time of finalizing this dissertation, an interesting development happened in the cocoa sector. On 26th March 2018, the two top cocoa producers Ghana and Cote d'Ivoire signed the Abidjan Declaration. The Abidjan Declaration is a Strategic Partnership Agreement between the two countries aimed at resolving and addressing the numerous challenges facing the cocoa sector in both countries.

The Abidjan Declaration also has the objective of defending the interests of cocoa farmers and marketers, as well as the economies of both countries (Daily Guide 2018). This represents a collective strategy and a viable solution for improving cocoa prices for producers in both countries.

Ghana and Cote d'Ivoire have committed to harmonizing cocoa marketing policies, which will be reviewed annually in a concomitant manner, to peg the prices of cocoa and collectively bargain for better prices for cocoa producers before the production and harvesting even commences (Daily Guide 2018). Additionally, Ghana and Cote d'Ivoire also decided to intensify scientific research collaboration that will provide improvement in cocoa varieties and carry out regional programs to fight cocoa diseases especially swollen shoot.

Revenues from the sale of cocoa in both countries fell to around 20 % in 2017 due to the export of unprocessed cocoa beans (Daily Guide 2018). Both countries also made a commitment to add value to the raw cocoa beans by processing a major part of cocoa this is to be done by invitation the African private sector to massively invest in cocoa processing.

2.3 The concept of efficiency in agricultural production

In agriculture, efficiency refers to the index of the relationship between all the aggregates of farm' outputs to all the total inputs used in farm production (Manning & Taylor 2015). Efficiency refers to how well a production unit performs in utilising resources to produce a given output, with an existing technology (Fried 2008). Efficiency therefore deals with farmers' ability to produce with least resources and time.

The efficiency of a production unit such as cocoa farms involves the comparison among all the observed and best quantity of its input and output (Färe et al. 2013). Agriculturalists are interested in resource use efficiency because it enables them to determine agricultural productivity growth and the efficient allocation of agricultural resources (Ogundari 2014). Three main types of efficiency are identified for a decision-making unit (DMU): technical, allocative and economic efficiencies (Ogundari 2014; Pastor & Zofio 2017).

2.3.1 Technical efficiency

Technical efficiency is the most important constituent in economic profitability and it measures the capability of entities such as firms or agricultural units to produce topmost output from a given array of inputs (Atici & Podinovski 2015). In agriculture technical efficiency refers to the capability of a farm unit to utilize minimum amount of inputs combined with a given technology to produce a desired level of output (Tiedemann & Latacz-Lohmann 2013).

Agricultural units can be referred as technically efficient if they can tower their production with least inputs and time (Briec et al. 2006). The continuous adoption of cocoa farm mechanization is an essential step towards increasing technical efficiency of the cocoa production sector (Abdulai et al. 2013). According to Kumbhakar et al. (2014), technically efficient farms do not waste resources such as labour in farm production process.

2.3.2 Allocative efficiency

Allocative efficiency is defined as a firm's ability to achieve the best combination of diverse inputs in producing specified levels of outputs considering the relative prices of these inputs. Talks about allocative efficiency will not be complete without referring to Farrell (1957).

According to him allocative efficiency talks about the extent to which farmers make efficient production decisions by utilizing inputs to the point at which their marginal production value is on par the factor cost.

Allocative efficiency is essential when firms maximize their profits simultaneously by minimizing costs of production (Decker et al. 2017). Allocative efficiency therefore measures farms capability to obtain greater profits at the prevailing market prices for all inputs and outputs. Allocative efficiency demonstrates farmer's flexibility and capability to evolve production with feedback from the market.

2.3.3 Economic efficiency

Economic efficiency is the synergy of allocative and technical efficiency (Coelli et al. 2005). Economic efficiency refers to the maximum possible profit made by Decision Making Unit (DMU) comparative to the lowest profit, given the most advantageous combination of factor prices and output (Ogundari 2014).

Farmers are economic efficient if they are successful in producing the largest quantities of output as possible with given sets of inputs. Firms achieve maximum efficiency when it becomes impossible to reorganize a given resource combination without decreasing its total output. Economic efficiency simply measures the general economic performance of DMU, that is, their propensity to make their operations more profitable (Ouattara 2012).

2.4 Determinants of technical efficiency

Numerous studies have been carried out on the determinants of technical efficiency across major cocoa producing regions in Ghana (see Kyei et al. 2011; Aneani et al. 2011; Danso-Abbeam et al. 2012; Besseah & Kim 2014).

2.4.1 Socio-economic characteristics of households

Gender is known to be a key determinant that influences cocoa production efficiency. A study conducted by Fadzim et al. (2017) in cocoa production in Malaysia established that gender has a positive influence on technical efficiency, male farmers were more technically efficient than their female counterparts. Similar studies by Mishra et al. (2017) also concluded that women farmers were more technically efficient than their male counterparts. On the other hand, Kongor et al. (2017) studies conducted in Ghana found contrasting results that male cocoa farmers were more technically efficient than their female counterparts. Ogunniyi et al. (2012) revealed that there were no significant variations in efficiency among male and female farmers in the Nigerian cocoa industry.

It is believed that more *educated* farmers will adopt best farming practices and innovative technologies to enhance their efficiency (Djoumessi et al. 2018). A study conducted by Besseah & Kim (2014) in Ghana found a positive and significant relationship between farmer's educational level and technical efficiency. This means that whenever farmers education increases, their corresponding technical efficiency significantly increases. Etwire et al. (2013) also found education to have a positive impact on technical efficiency in the Nigerian cocoa production.

The productivity and technical efficiency tend to increase with farmer's *age* (Damian Ila et al. 2012). This assertion was confirmed by Besseah & Kim (2014) in a study conducted in Ghana; they found out that technical efficiency increases as the age of farm heads increases, suggesting that age increases cocoa farmer's experience. A related study conducted in Ghana by Danso-Abbeam et al. (2012) also affirmed that farmers experience gained through more years of producing cocoa has a positive effect on technical efficiency. However, in Nigeria Ogunniyi et al. (2012) found contrasting results that age negatively influence technical efficiency in male-headed families. According to Awudzi et al. (2016) and Kongor et al. (2016) the average age range of workers in Ghana's cocoa farms is between 18 and 70 years, but majority belonged to the youthful age group of 18 to 35 years.

2.4.2 Households and farm characteristics

Farm size, is also expected to affect technical efficiency. A study by Damian et al. (2012) posited that technical inefficiency decline with farm size. Contrary, Olufemi et al. (2015) concluded that as farmers increase their area of land cultivated, their technical efficiency reduces. Mukete et al. (2018) argue that the inverse relationship between farm size and technical efficiency could be attributed to the small-scale nature of cocoa farms.

Household size was found to have a negative impact on technical efficiency (Besseah & Kim 2014). Technical efficiency among households dampens when household size increases. Danso-Abeam et al. (2012) found a negative relationship between household size and technical efficiency in Ghana' cocoa sector. These results imply that when household size increases their technical efficiency reduces. Probably because large households spend productive times to search for family needs instead of working in the farms to boost efficiency.

Labour constraint is an important factor affecting cocoa supply and productivity (Hill & Vigneri 2014; Aneani et al. 2017; Tampe 2018). In Ghana, cocoa farmers mostly rely on family labour in the production process (Barrientos 2014; Green 2017). Labour shortages can negatively influence cocoa output (Wessel & Quist-Wessel 2015).

2.4.3 Institutional determinants

Production credit is essential in enhancing the technical efficiency and welfare of smallholder farmers in Africa (Popoola et al. 2016). *Credit availability* increases the capability of farmers to buy agricultural inputs to manage their farms. A study by Besseah & Kim (2014) concluded that access to loans, finance and credit is negatively related to technical efficiency but they found it to be statistically insignificant. Awotide et al. (2014) found a positive and significant relationship between access to credit and technical efficiency among cocoa farmers in Southwest Nigeria. Contrary to the above Danso-Abbeam et al. (2012) also found that credit availability to cocoa farmers positively influence cocoa production in Ghana.

2.4.4 Production technology

Fertilizer usage helps cocoa farmers to increase their yields (Noble 2017; Asare et al. 2017). As expected when the land has been used for a long time and farmers cannot wait for it to replenish the lost nutrients, fertilizers can help in this regard (Kongor et al. 2017; Wartenberg et al. 2018). Studies conducted in Ghana by Aneani et al. (2017) revealed that greater cocoa yield can be realized from increasing fertilizer application. Akrofi-Atitianti et al. (2018) also buttressed this claim that the quantity of fertilizer usage has a positive effect on cocoa outputs.

3 METHODOLOGY

This section focuses on the methods employed for the data collection and data analysis. It also includes the empirical methods and analytical framework on the main methods- Data Envelopment Analysis Model (DEA) and the Partial Least Squares Structural Equation models (PLS SEM).

3.1 Profile of study areas

This research was carried out in three districts of the Western Region of Ghana i.e. Bia West, Juaboso and Sefwi Bibiani-Anhwiaso-Bekwai. Sefwi Bibiani-Anhwiaso-Bekwai district is situated in the North-eastern part of the Western Region. It spans an area of 873 sq km corresponding to 8.6 % of the total land mass of the region.

The Bia West district was carved out when the Bia West district was split into two in 2012. It covers an area of 1,287,265 km^2. According to the Ghana Statistical Service the districts population is projected at 106, 382 in 2017 of which 52, 254 are male and 54,128 females (GSS 2014). The district capital is Essam–Debiso. The Bia West District borders the Bia East District Assembly to the north east, Cote d'Ivoire to the west, and the Juaboso District to the south east. The local economy is dominated by agriculture, it employs about 70 % of the district's labour force with cocoa as the main crop.

Juaboso district has a total land area of about 1,369.9 square kilometres. The district' administrative capital is Juaboso which is 360 km to the north-west of Sekondi-Takoradi Metropolitan, the regional capital and about 225 km from Kumasi, the Ashanti regional capital. The District shares boundary with Bia and Asunafo North Municipal to the North, Asunafo South and Boadi District to the east, Suaman District to the south and Ivory Coast to the west.

The projected population of the district according to the Ghana Statistical Service stands at 73, 878 with 36, 290 males and 37,588 females (GSS 2014). The main economic activity in the district is agriculture which engages about 76.2 % of the population. The major cash crops grown in the district include cocoa, oil palm and coffee, while plantain, cocoyam, cassava, maize and rice are the major food crops. Fruits, such as, oranges, pear, coconut, pineapple and vegetable are also cultivated. The district is located in the wet semi-equatorial climatic area experiencing two rainfall maxima in May-June and September-October. The mean annual temperature for the district varies between 25 ºC and 26 ºC (GSS 2014).

The Bibiani- Anhwiaso-Bekwai district is bordered to the North by the Atwima Mponua District (Ashanti Region), to the South by the Wassa Amenfi in the Western Region, West by the Sefwi Wiawso district also in the Western Region and East by the Denkyira North and Amansie East both in the Central and Ashanti regions respectively.

The district covers an area of about 873 km square. The population of the district according to the Ghana Statistical Service is projected at 153,650 with 75,471 males and 78,179 females (GSS 2014). Agriculture is the leading economic activity in the district, with cocoa as the key crop. A lot of cocoa buying companies are found in the district. Other economic activities in the district are farming, livestock rearing, lumbering, fishing and commerce.

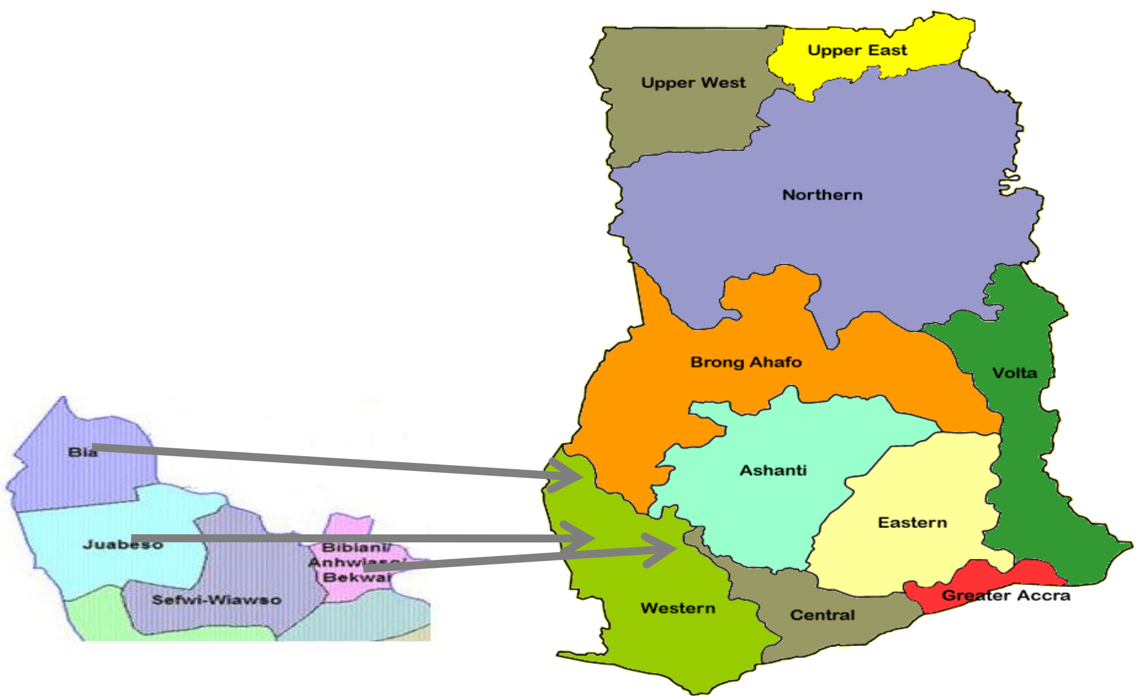

Figure 2: A map of Ghana indicating the study area

Source: Adapted from (GSS 2018)

3.2 Research design

The study applied both qualitative and quantitative methods. Primary and secondary data sets were used. The primary data was collected using semi-structured questionnaires and they encompassed socio-economic and demographic characteristics of cocoa farming households. Secondary data were gathered from articles, journals and books. These were obtained basically for reviewing related literature.

3.2.1 Semi-structured questionnaire and interviews

This study used the semi-structured questionnaires for the data collection. Questionnaires and interviews constitute mixed methods used to solicit views from study respondents in a short time period (Longhurst 2003). This study used a set of open and close ended questions to interview respondents. This was used to get data (biographical and socioeconomic) on characteristics of cocoa farmers in the study area. Other essential, information pertaining to production system and policies affecting cocoa production were collected using this tool. Furthermore, their cost of production and some problems they encountered were all included in the semi-structured questionnaires.

3.2.2 Sampling technique and sample size

Purposive and simple random sampling techniques were deployed to select cocoa farming households in the study area. The purposive sampling was used to select the extension officers while the simple random was used to select the cocoa farmers. A sample size of 90 was used comprising 90 cocoa farmers with 30 each from the three districts in the study area.

Table 1: Sample distribution across districts and communities

District	Communities	sample size
Bibiani	Wenchi, Dominibo, Nkatieso	30
Juaboso	Bonsu nkwanta, Asempanaye, Sefwi Boizan	30
Bia West	New Suyani, Yamatwa, Essam	30
Total	9	90

Source: Field Survey, 2017

3.3 Measuring efficiency of agricultural enterprises

Economist and agriculturalist alike have come up with numerous techniques for measuring the efficiency of a DMU (Hoff 2007), but these methodologies have metamorphosed over the years. Measures of efficiency have been classified into three categories namely: deterministic parametric estimation, non-parametric mathematical programming and the stochastic parametric estimation.

Among the nonparametric methods, the commonest used approach has been the Data Envelopment Analysis (DEA) which relies on simple indexing technique and mathematical programs. Additionally, the parametric method that has widely been used to measure agricultural efficiency relies on simple and complicated econometrics measures such as the stochastic frontier analysis (SFA).

Numerous studies have estimated the determinants of Technical Efficiency (TE) in Ghana' cocoa sector (see Kyei et al. 2011; Ofori-Bah & Asafu-Adjaye 2011; Danso-Abbeam et al. 2012; Onumah et al. 2013).

A study by Binam et al. (2008) used the stochastic frontier metaproduction to assess the efficiency and technical gap in Cameroun, Ghana, Nigeria and Cote'dvoire. They estimated the technical efficiency scores ranged between 0.44 to 0.74, and a weighted average of 0.61, demonstrating that cocoa farmers in these countries produced on average 61 % of prospective output with a given level of technology in each country. Among all the countries studied, Nigeria was the most efficient in producing cocoa with an overall technical efficiency of 0.74 while Ghana was the least efficient with an average efficiency of 0.44. Their results indicated that imperfect market competition, financial limitation etc., hampered farmers optimal production.

Similarly, Nkamleu et al. (2010) also studied the productivity abilities and efficiencies in West and Central African cocoa producing countries namely Ghana, Nigeria, Cameroon and Cote d'Ivoire. They found out that there was low technical efficiency in cocoa production which occurred because of the technology gap, hindered the prospect of competition among the various countries.

Dzene (2010) also examined the determinants of technical efficiency among Ghanaian cocoa farmers between the periods 2001 to 2006. His study concluded that demographic factors and non-labour inputs excluding insecticides and household size had a positive significant impact on technical efficiency. Other farm level challenges such as disease and pest like black pod, termites and mistletoe attack, flooding and bushfires affected the technical efficiency among Ghanaian cocoa farmers. Other issues like frequent fertiliser use and proper farm maintenance routines had positive and significant effects on technical efficiency.

Lastly Onumah et al. (2013) analysed the technical efficiency and productivity among cocoa producers in Ghana's Eastern region. Their results showed that external factors such as farmer's access to extension services, credit and technical support helped to reduce technical inefficiency among the cocoa producers. They also found out that male as well as older farmers were more efficient than their younger and female counterparts. Farmers who had practiced for longer periods had more experience in cocoa production so they were technically efficient.

3.4 Data Analysis Methods

The following studies have estimated the determinants of Technical Efficiency (TE) in Ghana' cocoa sector (see Kyei et al. 2011; Ofori-Bah & Asafu-Adjaye 2011; Danso-Abbeam et al. 2012; Onumah et al. 2013).

Similarly, Nkamleu et al. (2010) also used the developed metafrontier function to study the productivity potentials and efficiencies in West and Central African cocoa producing namely Ghana, Nigeria, Cameroon and Cote d'Ivoire.

Dzene (2010) and Ofori-Bah & Asafu-Adjaye (2011) also used the stochastic frontier model to examine the determinants of technical efficiency among Ghanaian cocoa farmers between the periods 2001 to 2006.

Sefriadi et al. (2013) also used the Structural Equation Model to conduct a path analysis of factors and policies affecting cocoa production in Indonesia.

Similarly, this study will also use the Data Envelopment Analysis (DEA) to analyse cocoa production efficiency of cocoa growing districts in the Western region of Ghana, and also the Structural Equation Model (SEM) to analyse the effects of policies such as the mass spraying exercise, fertilizer and extension policies and how they affect cocoa productivity.

3.4.1 Data Envelopment Analysis (DEA)

DEA is a parametric method used as a specialised model to measure the performance, effectiveness, and productivity of similar production units (identical decision-making units - DMUs) dependent on the size of inputs and outputs. DMUs transform multiple inputs into outputs, implying that a given units producing identical products known as the outputs of these given units (Staničkova & Melecky 2011).

The DEA has increasingly become the most well-known method for performance and efficiency measurement (Emrouznejad & Yang 2018). The DEA model originated from the Farrell's model used for calculating the effectiveness of a given units that has a single input and output (Stejskal & Hajek 2016).

The DEA generally uses mathematical software design models to measure the best-practice limits without a priori fundamental functional procedure assumption by computing multi-input/multi-output numerically and estimates the highest performance for each DMU comparative to all DMUs (cocoa growing districts) under observation (Guan et al. 2006). The model is built on the theory of constant returns to scale (a given unit of input produces a unit of output), when all DMUs are running at their optimal scale (CCR model).

However, the unrealistic assumptions are corrected by using the variable returns to scale (VRS) which considers all categories of returns: constant, increasing or decreasing (BCC model). Efficiency can be improved either by increasing outputs with increasing returns to scale, or by reducing outputs with decreasing returns to scale (Hudec & Prochadzkova 2013). We used the input-oriented VRS model by running the variable returns to scale. This model calculates efficiency of DMUs and at the same time provides implications on how to modify inefficient inputs for the DMUs to become more efficient.

3.4.2 Structural Equation Model (SEM)

Researchers have used the PLS SEM model in the study of cocoa production and productivity (Sefriadi et al. 2013; Abbey et al. 2016). The Partial Least Square (PLS) SEM is a convenient framework for statistical analysis that combines the numerous traditional statistical methods such as discriminant analysis, factor analysis, regression analysis, canonical correlation and multivariate procedures (Kock 2014).

The SEM uses path diagram for easy graphical visualization. The model was chosen because of its distribution-free assumption, the predictive focus and the explanatory model development approach for understanding the determinants of cocoa productivity (Kock & Hadaya 2018). SEM path analysis allows for all the coefficients of association in multiple regression models to be calculated at one time (Kock 2011).

SEM results provide standardized regression coefficients outcomes (path coefficients) therefore it can be used to model the relationships among latent variables. The model specification of the partial least square is given by Zawojska (2010) as

$$z_k = \beta_0^{(k)} + \sum \beta_i{}^{(k)} z_i + v_k \tag{1}$$

Where:

z_k = *explained variable (yield kg/ha)*

$\beta_0^{(k)}$ = *constant term*

$\beta_i{}^{(k)}$ = *regression coefficient*

v_k = *residual term*

The PLS SEM uses two approaches to calculate the causal relationship between indicators and their associated latent variables (Kock & Lynn 2012). The covariance-based SEM method calculates model coefficients (path coefficients) using the minimization of differences among covariance matrices (Lomax & Schumacker 2004). It employs the parametric assumptions in the calculating coefficients and significance levels (P values) (Hair et al. 2017). The second SEM approach is the variance-based or PLS-based SEM (Kock & Lynn 2012), this approach estimates coefficients using latent variable based on weighted aggregations of indicators. It doesn’t use the parametric assumptions in calculating P values.

3.5 Key data variables for the study and their measurement

Variables are experiential property that takes different values or categories. To progress from the conceptual to the empirical level, theories are converted into variables. Based on the previous studies, the main data variables for the research were farm size (in hectares), types of inputs used, and sources of labour as well as extension contacts.

Two measurement scales were used to measure these variables. They are the nominal and interval scales. The nominal scale was used to measure the socio-economic characteristics of the sampled cocoa farmers such as level of education, gender, types of inputs used, farm preparation techniques and systems, fertiliser usage and access to credits, and extension service (contact). The interval scale was used to measure the variables related to the farmers' land holdings (for instance farm size), years of farming, household size; quantities of agrochemicals used and farm output.

3.6 Tools for data analysis

The study employed Smart-PLS 3 to analyse the multiple regression while Microsoft excel was used for constructing frequency tables and charts. The DEA model was also deployed to analyse the Efficiency Measurement System (EMS).

3.7 Limitations of the study

1. A farmer with knowledge about the subject matter may not have been factored due to simple random sampling technique used.
2. Poor record keeping on the part of farmers made acquisition of quantitative data difficult

4. RESULTS

This chapter provides the results of the empirical analysis. It comprises of the descriptive analysis of the sample input-oriented resource use efficiency (DEA) analysis and the structural equation modelling.

4.1 Sample Description

This section entails both the social and economic characteristics of cocoa farmers for all the three districts in the study region. The major focus includes age of respondents, sex distribution of respondents, sex of respondents, education of respondent, farm experience, quantity of pesticides and fertilisers used yield of cocoa, extension services, labour used by respondent and the cost involved and farm size.

4.1.1 Sex of respondents

Majority of the respondents were males (76 percent) while females from the study districts were females (24 percent) this is shown in figure 3 below

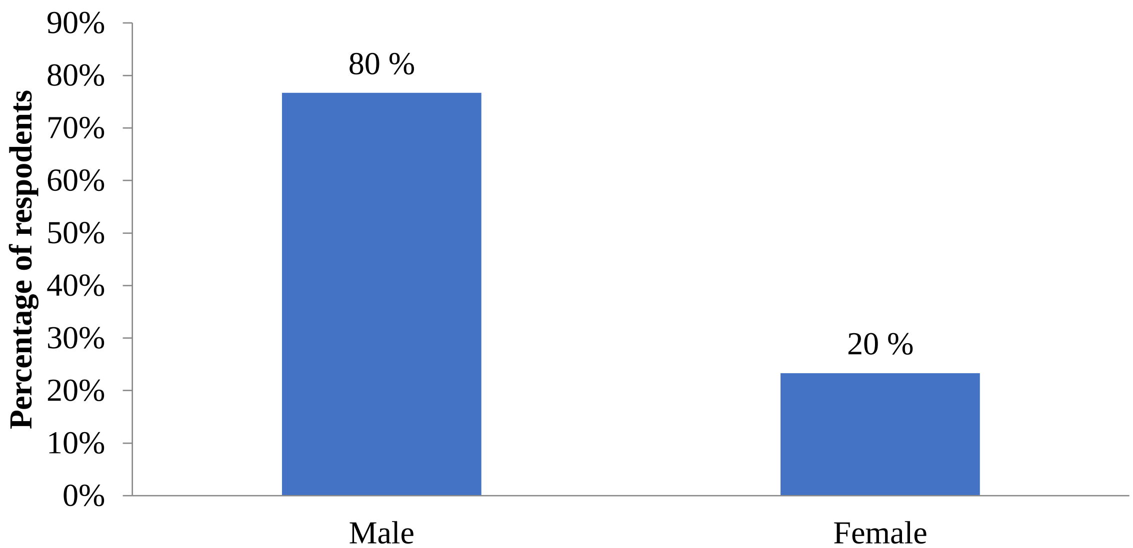

Figure 3: Sex of respondents

4.1.2 Educational characteristic of respondents

14.4 percent of the respondents were illiterates without any form of education. 45.6 percent had completed primary education (primary and JHS). Most of the respondents constituting 20 percent had secondary education. 12.2 percent had some vocational or technical education. Lastly, 7.8 percent had also completed tertiary education (universities and polytechnics). This is depicted in table 2 below.

Table 2: Educational status of respondents

Education status	Frequency	Percent
No education	13	14.4
Primary/JHS	41	45.6
Secondary/ SHS	18	20.0
Technical/Vocational	11	12.2
Tertiary	7	7.8
Total	90	100.0

Source: Field survey, 2017

4.1.3 Types of pesticides used

With regards to the pesticides farmers use in their farming activities, the findings have pointed out that majority of the respondents (42.2 percent) reported using Confidor (Imidacloprid) followed by Sumitox (34.4 percent) and (23.3 percent) for Akatemaster (Bifenthrin) as illustrated in figure 4 below.

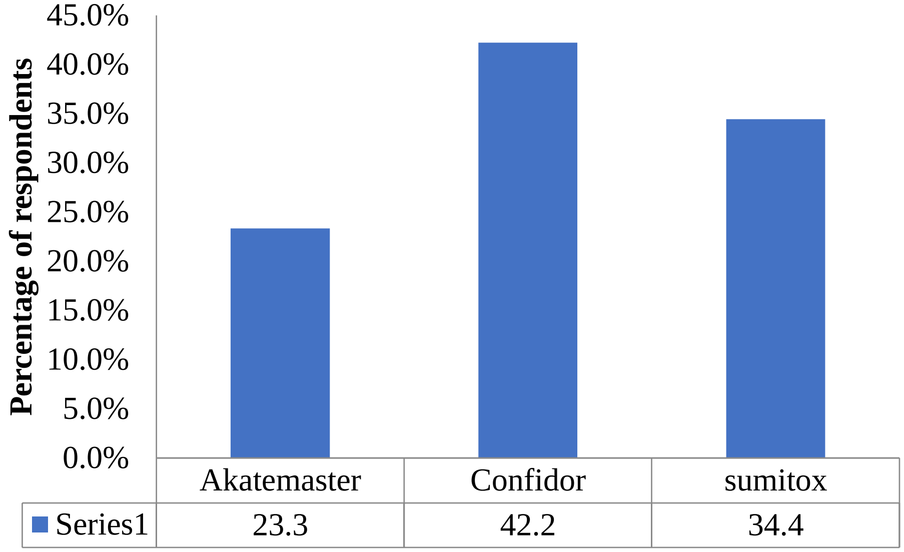

Figure 4: Types of pesticides used

4.1.4 Farm labour

As can be evidenced from figure 5 below cooperative labour represents the main type of labour respondents in the study area rely on for their farm activities. Cooperative labour refers to when farmers come together and help each other when the need arises. This represented 32.2 percent of all cocoa labour. Apart from cooperative labour, hired labour was also very high constituting 30 percent. Family and self-labour constituted 10% and 26.7% respectively.

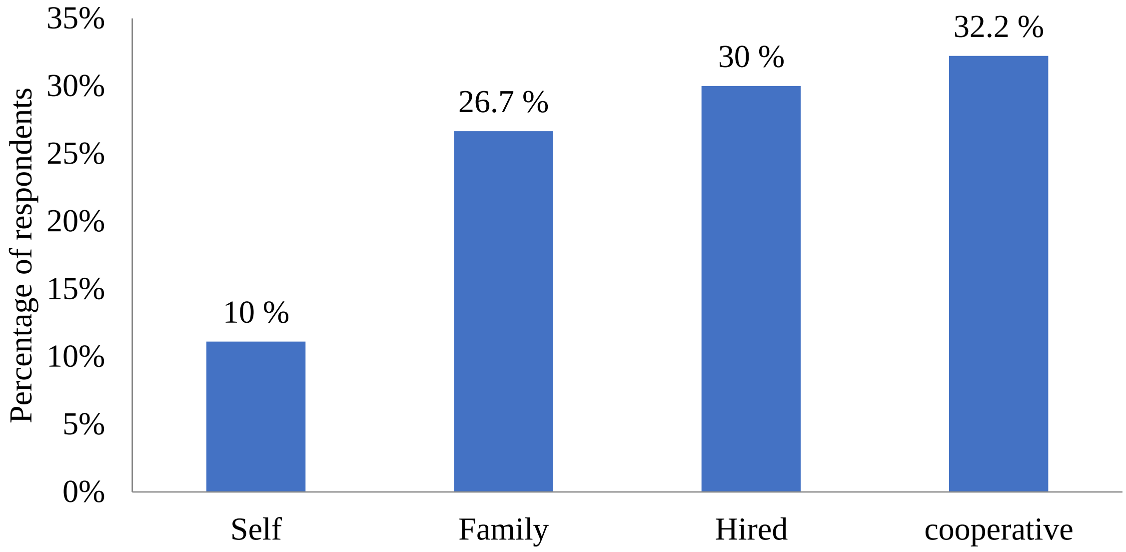

Figure 5: Labour types used in cocoa production

4.1.5 Satisfaction with extension services

Figure 6 below represents if respondent were satisfied with the extension services they received. 82.2 percent of respondents said that there were satisfied with the current extension services been offered, while 17.8 percent were not satisfied with the extension services provided them.

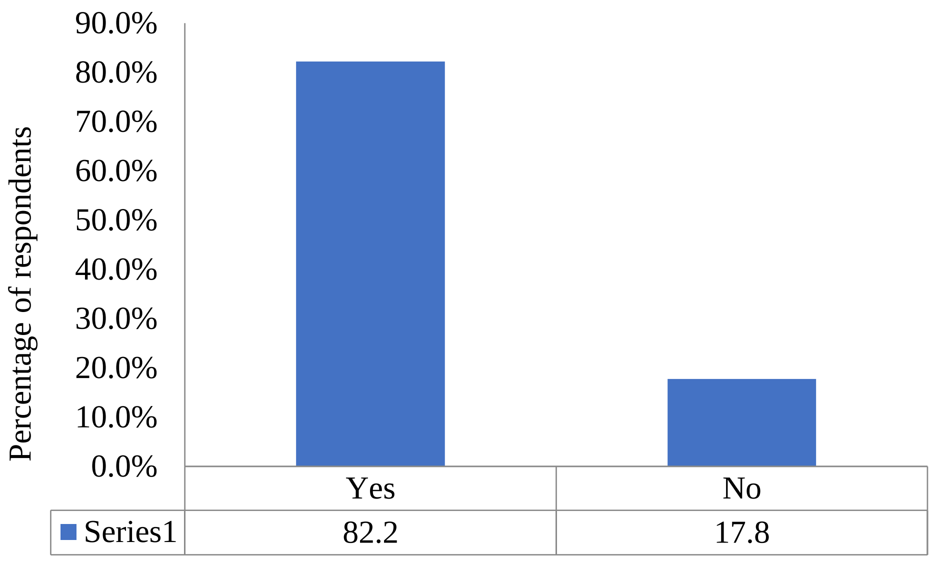

Figure 6: Satisfaction with extension services

4.1.6 Benefits from extension services

This research also enquired from farmers if they benefited from any form of extension services in the previous farming season prior to the field survey. Majority of the farmers responded to have received extension services 82.2 percent while 17.8 percent responded they never received any form of extension services. This is represented in figure 8 below.

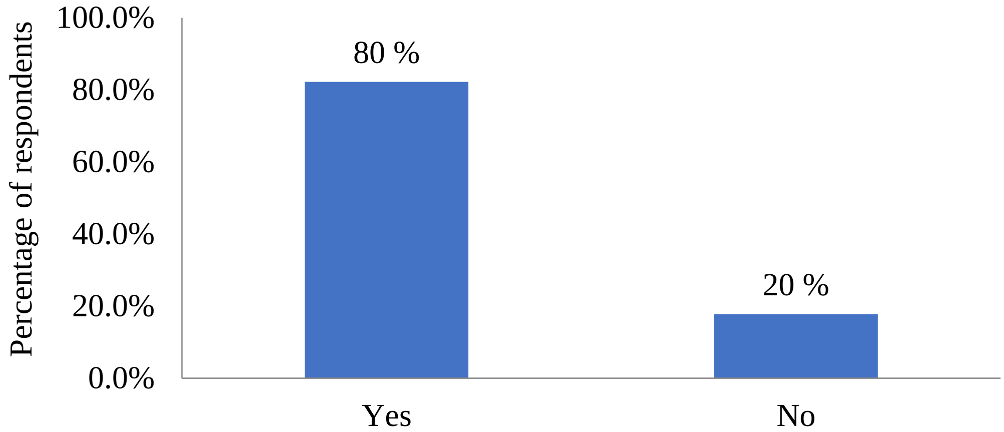

Figure 7: Benefits from extension services

4.1.7 Benefits from mass spraying program

With regards to government's flagship mass spraying exercise to boost cocoa production, majority of respondents reported benefitting from the program (78.9 percent), while 21.1 percent were not beneficiaries. The breakdown is represented in figure 9 below

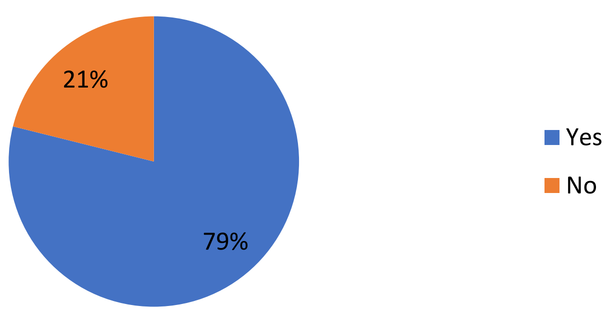

Figure 8: Benefits from mass spraying program

4.2 Definition and summary statistics of variables

Table 3 below shows the combined descriptive statistics of the variables used in the study. This took into consideration their mean, standard deviation, minimum and maximum values. The table consist of 27 variables out of which 4 were used in the data envelopment model to calculate the resource use and they included farm size, fertiliser, labour, herbicides and yield whereas 4 variables namely CODAPEC mass spraying, extension service, fertilizer price subsidy and cocoa yield were used to analyse their effect on cocoa productivity.

Table 3: Variables definitions and descriptive statistics

Variables	Mean	Std. Deviation	Minimum	Maximum
Age of respondent (years)	**42.39**	9.52	25	66
Sex of respondent (dummy)	**0.23**	0.43	0	1
Educational (status)	**1.53**	1.12	.00	4.00
Enrolment (years)	**8.30**	5.49	.00	19.00
Household size (Members of family)	**5.67**	3.17	1	16
Farm labour (Number of households working on cocoa farms)	**3.19**	2.52	.00	14.00
Farm experience (Years)	**16.82**	8.51	4.00	40.00
pesticides used (litres/ha)	**10.11**	8.78	1.00	36.00
Fungicides used (litres/ha)	**9.67**	7.81	.00	34.00
fertilizer application (GHC/50kg)	**1.18**	0.384	1	2
Fertilizer used (GHC/50kg)	**10.80**	8.71	.00	35.00
Cost of fertilizer (GHC/50kg)	**70.00**	0.00	70.00	70.00
Total cost of fertilizer (GHC/50kg)	**806.67**	860.46	.00	6300.00
Cocoa output (Kg/ha)	**45.28**	43.90	1.00	200.00

Market Price of cocoa (GHC/61.5 kg)	**475.00**	0.00	475.00	475.00
Extension services received last year	**1.18**	0.38	1	2
Frequency of Extension Service received (number of visits)	**1.17**	0.38	1	2
Mass Spraying Benefit (D)	**1.02**	0.67	0	2
Type of labour used	**2.83**	1.01	1	4
Cost of labour (GHC/day)	**84.64**	88.65	2	500
Cost of weeding (GHC/day)	**2.23**	0.79	1	3
Cost of transport 50 kg (from farm to cocoa shed)	**221.72**	215.11	5	1000
Farm size (Land/ha)	**5.78**	3.15	1	15

Source: Field survey, 2017

4.3 Result of DEA analysis (objective one)

The input-oriented VRS model was used to calculate the resources used in cocoa production. This is because agricultural inputs such as fertiliser, herbicides, seeds are directly controlled by respondents which makes them key determinant factor in farmer's decision variables. The combined results of the DEA for all the districts revealed that (TE_{CRS}) of 0.599, pure technical efficiency (TE_{VRS}) of 0.699 and Scale efficiency of 0.844. From the three districts the Juaboaso districts farmers were highly efficient followed by farmers from Bibiani Anhwiaso Bekwai district. However, farmers from Bia west district were less efficient. These are showed in table 4 below.

Table 4: DEA results on efficiency by districts

Districts	Overall Technical Efficiency (CRS)	Pure Technical Efficiency (VRS)	Scale Efficiency Score
Juaboso	0.69	0.79	0.89
Bibiani	0.57	0.66	0.85
Bia west	0.52	0.64	0.79
Pooled	**0.59**	**0.69**	**0.84**

Source: Field survey 2017

Table 5: Average resource used by districts

Variable	Juaboso	Bibiani	Bia west
Farm size (Land/ha)	2.28	2.35	**2.37**
Fertiliser (GHC/50kg)	823.67	**875.33**	721
Herbicides (litres/ha)	**11.5**	9.57	8.5
Labour (man-days)	91.33	**110.67**	51.93

Source: Field survey 2017

4.4 Resources used in cocoa production

The fundamental input used in production are the factors of production and hence resources. On the average, farmers in the Bia West district cultivated more land per hectares even though it was the least efficient among the three districts. Contrary the most efficient district (Juaboso) had on average the smallest farm size.

With regards to fertilizer usage, the Bibiani district used the most (875) kg. With the Bia West district using the least quantity (721) kg. Interestingly, the Juaboso district used the highest number of herbicides among all the three districts (11.5 litres) for every hectare of land, whilst the Bia west district used the least number of herbicides (8.5 litres) per hectares.

The labour used in the farm also shows an interesting result. The most efficient district (Juaboso) rather used the least labour in their cocoa production. Whiles the least efficient (Bibiani and Bia west) used more labour.

4.5 SEM results (objective two)

In pursuant to meeting objective two of this study, which sought to examine the role of policies (e.g. such as the mass cocoa spraying, and fertilizer policy), as well as extension services and their effects on cocoa productivity, the Structural Equation Model was used. The results of the analysis are shown below.

4.5.1 Validity and reliability of the SEM model

The study used a number of measurements to determine the validity and reliability the (inner) model. These measures employed included construct reliability, convergent validity and discriminant validity. Construct reliability measures the degree of internal consistency of the model, and it is measured using the Cronbach's alpha with acceptable minimum value between 0.50 through 0.7 (Hair et al. 2011; Straub et al. 2004). The higher the value to 1 indicates greater internal consistency and ultimately reliability.

From the construct reliability and validity measurements as evident in table 6 below all the factors have higher loading of 1.000. Construct validity measures how the observed measurement variables rationally connect to each other (Fornell & Larcker 1981).

On the other hand, the convergent validity measures the degree to which the measurement variables altogether describe the construct showed in the structural model (Hair et al. 2011). It is measured using the Average Variance Extracted (AVEs), a minimum loading of 0.50 with a composite reliability (CR) with acceptable minimum of 0.70 (Fornell & Larcker 1981; Hair et al. 2011).

As indicated in table 6 below, all models the variables had AVEs of 1.000 indicating that each construct together explain adequately the constructs they represent. Also, the CR values for all constructs were above the acceptable minimum threshold of 0.70. Furthermore, Rho_A was also used to validate the CR scores. All the Rho_A values exceeded the minimum acceptable threshold of 0.50 implying that they support the convergent validity measurement of the model.

Discriminant validity measures how enough the items are explained by their respective constructs other than other constructs in the structural model (Hair et al. 2011). Item cross-loadings which are a measure of discriminant validity indicates that the factor loading of measurement items for each construct is higher on their respective constructs than they load on other constructs (Chin 2010; Hair et al. 2011). This confirms that discriminate validity of constructs in the proposed model was adequate as seen in the variables loadings and cross loading table 7 below. The entire cross loading obtained the highest scores of 1.

Table 6: Construct Reliability and Validity

Variables	**Cronbach Alpha**	**Rho_A**	**Composite reliability**	**AVE**
EXTS	1.000	1.000	1.000	1.000
FERT	1.000	1.000	1.000	1.000
MS	1.000	1.000	1.000	1.000
Yield (Kg)	1.000	1.000	1.000	1.000

Source: own calculations

Legend: AVE=Average Variance Extracted.

Table 7: Variables loadings and cross loading

	EXTS	FERT	MS	Yield
EXTS	**1.000**	0.295	0.597	0.314
FERT	0.295	**1.000**	0.170	0.589
MS	0.597	0.170	**1.000**	0.138
Yield (Kg)	0.314	0.589	0.138	**1.000**

Source: own calculations, from field survey, 2017

Legend: FERT =Total cost of fertilizer used in cocoa farming, MS=Benefit from CODAPEC mass spraying, EXTS= Extension advisory and services

4.5.2 Results of the SEM

Table 8 and figure 9 below presents the results of objective two of this dissertation. The results show that the proposed model accurately predicts 37 % the influence of agricultural policies on cocoa productivity in the three cocoa districts of Ghana. The main determinant that influenced cocoa productivity was the fertiliser subsidy policy (β =0.543). This was followed by the policy on extension services (β =0.197).

Contrary to our a priori expectation, the mass spraying exercise did not influence cocoa productivity in this study. It rather had a negative influence on cocoa productivity in the three districts. The negative influence of this policy on cocoa output might be due to the frequency and the farmer's ability to sustain it themselves when that of the governments was not conducted at regular intervals. What this means is that farmers are still faced with the problem of low yields resulting from pest and disease infestation.

Table 8: Path coefficients

Variable relationships	Coefficients	Standard Errors	t- statistics	p-values	Remarks
MS=>yield	-0.072	0.106	0.680	0.481	insignificant
EXTS=>yield	0.197	0.107	1.846	0.050**	significant
FERT=>yield	0.543	0.132	4.121	0.000***	significant

Source: own calculations

Legend: ** p<5%, ***p<1%

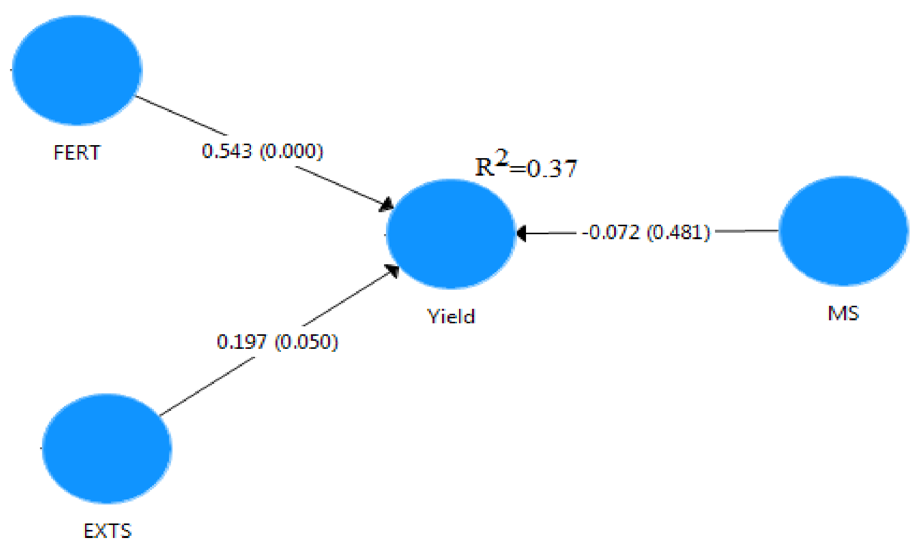

Figure 9 Results of SEM

5 DISCUSSIONS

The majority of respondents (cocoa farmers) were males 76 % whilst female farmers formed 24 %. This clearly shows that cocoa farming is male dominated occupation. This can probably be attributed to the tedious nature of the activities associated with cocoa farming for instance, planting, harvesting, processing and packaging. The women helped in the farming process but as cooks or farm helps during the harvesting period. The results are similar to the findings of (Boadi-Kusi et al. 2017; Kongor et al. 2017; Adeleke et al. 2017). They all concluded that cocoa production is male dominated.

The study also pointed out that 14.4 % of respondents in the study area were illiterates (with no formal or informal education). On the contrary 85.6 % of respondent have had some form of education. 45 % had attained the level of primary education (primary and JHS), whilst 30 % had completed or attended Senior High School (SHS) and 12.2 % had some vocational education. Surprisingly 7.8 % had some tertiary education. Education plays key roles in farms productivity and efficiency, with some level of literacy, they will be able to absorb what the extension officers teach them (Dhaka & Chayal 2016). Education also plays an essential role in farmer's decision making and their ability to use modern agricultural technology (Cavane 2016).

The descriptive results show that about 42.2 % of cocoa farmers used the Confidor (Imidacloprid) pesticides. Whilst farmers that used Sumitox constitute 34.4 % and 23.3 % for Akatemaster (Bifenthrin). This suggests that Confidor was the main pesticide used by cocoa farmers in these three districts. These three pesticides are widely used because they are approved by the COCOBOD aid farmers to control capsids. Farmers use more of the Confidor fertiliser because it is included in the list of fertilisers the government has subsidised whilst the rest are not subsidized. The government has slashed the prices of fertilisers to encourage more farmers to use more fertilisers to increase cocoa productivity. This result is similar to that of (Kongor et al. 2017; Affum et al. 2018).

Furthermore, this study has revealed that 32.2 % of cocoa farmers labour comes from cooperative labour. Besides cooperative labour, hired labour was also very high among cocoa farmers in the three districts constituting 30 %. Family and self-labour jointly constituted 10 % and 26.7 % respectively to the cocoa labour demand. Fadzim et al. (2017) pointed out that cocoa output increase among Ghanaian cocoa households can be attributed to increase in labour productivity. Our result is similar to the conclusion of (Babalola et al. 2017).

Findings from this study have also pointed out that 82.2 % of respondents were satisfied with the extension services they received prior to conducting the field survey. Contrary a little 17.8 % revealed their dissatisfaction with the extension services. This confirms the findings of Okwoche et al. (2015) that Nigerian cocoa farmers are were satisfied with the extension services they received.

In addition to the level of satisfaction with extension services provided to cocoa farmers, majority of the farmers responded to have received extension services 82.2 % while 17.8 % responded they have never received any form of extension services. They didn't benefit from the extension services probably because they do not belong to any cooperative society and their farms might be out of reach of the extension officers. The advisory services offered to cocoa farmers allow them to be abreast with modern technology (Hennessy et al 2017). This support enables cocoa farmers to avoid production and marketing problems leading to sustainable production (Ruifa et al. 2009).

This study has also indicated an interesting finding about the government of Ghana' flagship mass spraying exercise that has the aim of boosting cocoa production. Majority of respondents representing 78.9 % reported that they have benefited from the program while 21.1 % were not beneficiaries of the program prior to conducting the field survey. Our finding corroborates Duker & Sakpaku (2011) results. They found out that 78.0 % of farmers interviewed in the Juaboso district were satisfied with the mass spraying exercise. However, the exercise needs to find lasting solutions to the problems that prevents it from reaching a wider coverage which include inadequate spraying personnel, logistical problems etc. (Anang et al. 2013).

The pooled DEA results for study area showed a mean overall technical efficiency (TE_{CRS}) score of 59 %, pure technical efficiency (TE_{VRS}) of 69 % and scale efficiency of 84 %, this means is that on the average, cocoa farmers are capable of lowering their farm inputs by 31

% in the production of the same quantity of cocoa beans. The efficiency results are indication of the fact that farmers in these districts are inefficient when it comes to utilisation of resources and technology. Cocoa farmers in these districts can reduce their inefficiencies by increasing their technical efficiency from the current 69 % (Juaboso), 57 % (Bibiani) and 52 % (Bia West).

However, the mean technical efficiency (69 %) recorded in the study area is higher than that of Danso-Abbeam et al. (2012). They recorded a technical efficiency of 49 % in a similar study in the Bibiani-Anhwiaso-Bekwai District. Other studies by Binam et al. (2008) also revealed that the mean efficiency of Ghana's cocoa farmers was estimated at 44%. Similarly, Dzene (2010) study found out that the mean technical efficiencies for cocoa farmers in Ghana' Western region were 48.6, 48.3, and 47.2 % for the years 2002, 2004 and 2006 respectively.

The study has also revealed that cocoa yields depends largely on the agricultural inputs, such as pesticides, fertilisers, insecticides that are used in the production process (Aidoo & Fromm 2015). The results show that on average farmers in the Bia West district cultivated more land per hectares 2.37 ha. It's interesting to point out that it was the least efficient among the three districts (technical efficiency).

Contrary the most efficient district (Juaboso) had on average the smallest farm size. Our results are synonymous to (Buabeng 2016). He found out that cocoa farm sizes in Ghana are comparatively small often ranging from 0.4 to 4.0 ha.

On the other hand, with regards to fertilizer usage, the Bibiani district used the most (875) kg while the Bia West district using the least quantity (721) kg. Our results on fertilizer used were higher than that found by Afrane & Ntiamoah (2011). Their study revealed than 106 kg of fertilisers was used by cocoa farmers.

With regards to herbicides used the results showed that, the Juaboso district used the highest litres of herbicides among all the three districts (11.5 litres) for every hectare of land, whilst the Bia west district used the least amount of herbicides (8.5 litres) per hectares. Our results are consistent with the findings of Oppong et al. (2016), they found out that on average farmers used 8.57 litres/ha in a similar study.

This study also revealed that labour used in cocoa production influenced total yields. Old farmers increased their labour use and labour cost by to hiring more labour (Aneani et al. 2012). The Juaboso district used 91.3 labours per man day in their cocoa production. Whist the least efficient (Bibiani and Bia west) used 110.67 and 51.93 labour per man day. More labour employed in the production process leads to reduced marginal products due to the law of diminishing returns (see De Wit 1992; Shepherd 2015; Sommers & Beldavs 2017). The low technical efficiency recorded for Bibiani can be attributed to the law of diminishing returns.

In addition, the results of the SEM showed that the fertiliser subsidisation and the extension services provided to farmers as the key policies that determined cocoa productivity in the three districts. However, the CODAPEC mass cocoa spraying program initiated by the government to curb diseases and pest in the cocoa sector rather had a negative effect on cocoa productivity. This means that there are certain lapses with the program that needs to be re-examined to find solutions to them. During the field trip most of the farmers complained about the frequency of the spraying exercise, they lamented that the spraying needs to be increase from the current twice a year to about four times a year.

The fertilizer subsidies were seen to be a positive effect on productivity. The subsidies have relieved farmers of the excessive cost of procuring fertilisers, meaning with a little amount, they can have ample fertilisers for their farms. These findings are consistent with similar studies carried out by (Victor et al. 2010; Yawson et al. 2010; Gockowski et al. 2013; Vaast & Somarriba 2014).

Also, the extension services farmers received had a positive effect on yields. Implying that when farmers are able to receive more trainings from extension agents, they will be able to learn new and improved methods of production which in turn will boost their productivity. Our results corroborate studies done by (Awudzi et al. 2016; Mukete et al. 2016; Pratiwi & Suzuki 2017).

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The DEA result demonstrated that cocoa farmers in the study area can reduce their farm inputs usage by 31 % to produce the same quantity of cocoa beans. The efficiency results demonstrate that farmers in these districts use resources and technology inefficiently. With regards to resources used in cocoa production, the study found out that on average farmers in the Bia West district cultivated more land per hectares 2.37 ha. On the other hand, this study also revealed that the Bibiani district used the most fertilisers (875) kg. With the Bia West district using the least quantity (721) kg.

Another important resource used was herbicides, our results showed that, the Juaboso district used the highest litres of herbicides among all the three districts (11.5 litres) for every hectare of land, whilst the Bia west district used the least number of herbicides (8.5 litres) per hectares. The Juaboso district used 91.3 labourers per man days in their cocoa production. Whist the least efficient (Bibiani and Bia west) used 110.67 and 51.93 labourers per man day respectively.

The study also observed that among all the three policies implemented to boost cocoa production in Ghana, fertiliser subsidisation and the extension advisory and services provided to farmers were the key factors that influenced cocoa productivity in the study area. However, the CODAPEC mass cocoa spraying program initiated by the government to curb diseases and pests in the cocoa sector was not significant and this could be due to very few farmers who had access to these services rather had a negative effect on cocoa productivity in the study area.

6.2 Policy recommendations

In the light of the above, the following recommendations are proposed:

The extension services department need to be adequately strengthened to educate farmers on the best farm technologies and practices to improve production and reduce farmers' technical inefficiency. This can be done by the ministry of agriculture and COCOBOD. Provision should be made to employ more extension officers; this will make their services accessible to farmers.

More resources should be invested in the CODAPEC mass spraying exercise in order to reach greater mass of farm families. Monitoring and evaluations should be done periodically to assess the strengths and weakness of the CODAPEC exercise to ensure effectiveness and efficiency.

To improve farmers’ efficiency, it is also recommended that farmers orient their farming policies towards advancing their managerial expertise with respect to the usage of inputs such as fungicides, pesticides, fertiliser, and insecticides according to COCOBOD’ recommendations.

This study pointed out that fertiliser subsidisation has the potential to increase cocoa productivity, the government through COCOBOD in partnership with the private sector should put in place policies that would ensure that fertilisers are constantly made available to farmers always during the farming season at subsidised and affordable prizes. This would make cocoa farmers able to buy and use them in their right quantities.

Farmers should be encouraged to form and join farmer-base-organisations as this will assist them to have access to vital support services needed to improve their efficiency levels.

6.3 Suggestions for further research

1. This study narrowly focused on cocoa production in three districts in the Western region of Ghana. This Studies can be replicated in other cocoa growing regions to serve as a cross validation to verify and improve the findings of this study.
2. This study also focused on just one cocoa season. Other studies using panel or time series data should be carried out to study the efficiency of cocoa farmers in other cocoa growing regions. This will provide a detailed understanding of the patterns of efficiency levels over time.

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