UNIVERSITY OF CAPE COAST

ECONOMIC EFFECT OF PEST AND DISEASE ON COCOA PRODUCTION AND ITS IMPLICATION ON INCOME OF SMALLSCALE FARMERS IN MANKRANSO COCOA DISTRICT.

EBENEZER OPPONG

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BY

EBENEZER OPPONG

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

JANUARY 2023

DECLARATION

Candidate's Declaration

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

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

Name: Ebenezer Oppong

Supervisor's Declaration

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

Principal Supervisor's Signature:.................................. Date:........................

Name: Dr. William Ghartey

ABSTRACT

Pest and disease have been reported as one of the major factors that has caused steadily decline in cocoa yield and farmer's income from cocoa production. A descriptive cross-sectional survey design was used to assess the economic effect of pest and disease on cocoa production and its implication on livelihood outcomes (income) among small-scale farmers in Mankranso cocoa district. The population composed of all smallholder cocoa farmers who cultivate cocoa in the district under consideration. A total of 200 out of the 234 cocoa farmers responded the questionnaire. Structured interview guides in a face-to-face meeting in the Mankranso cocoa district was used in the data collection. The results revealed that, the main diseases that infest cocoa in the study area are Black Pod and Vascular Streak Dieback. Again, the major pest that attack cocoa in the study area were Capside, Stem borer, Anomis, Termites and Mistletoes. The average yield per hectare was 488.3kg. The mean technical efficiency of the cocoa farmers was estimated to be 64.5%. This implies that there is scope for cocoa farmers in the study area to increase their output by 35.5%, Furthermore, there was significant effect between disease and farmer income from cocoa production. The average income from cocoa production on hectare of land in Mankranso Cocoa District was 3980.80 Ghana cedis. It is recommended among others that, COCOBOD and MoFA must devise strengthen existing to pest and disease programs in the study area.

KEYWORDS

Cocoa Production

Disease

Economic Effect

Income

Pest

Small Scale Farmers

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DEDICATION

To my beloved wife; Charity Nyarko and my son; Kobina Yeboah Oppong (K.Y.O).

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

LIST OF ABBREVIATIONS

COCOBOD	Ghana Cocoa Board
CSSVD	Cocoa Swollen Shoot Virus Disease
ESA	Entomological Society of America
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GSS	Ghana Statistical Services
IPM	Integrated Pest Management
ISSER	Institute of Statistical, Social and Economic Research
MoFA	Ministry of Food And Agriculture
UNCCC	United Nations Climate Change Conference
WSSA	Weed Science Society of America
ICCO	International Cocoa Association
FAO	Food ana Agriculture Organisation
ICI	International Cocoa Initiative
WCF	World Cocoa Foundation

CHAPTER ONE

INTRODUCTION

Background of the Study

In most developing countries, agriculture plays a crucial role in the provision of income and food to deal with food security issues for majority of rural dwellers. Again, according to Ali, Agyakum and Adadi (2021), the agricultural sector presents the largest opportunity for employment to most rural communities especially in connection to its contribution to national gross domestic product (GDP). As a result of the numerous contributions of the Agricultural sector to the supply of food and income for livelihoods, some researchers classify the economy of Ghana to be agrarian (ISSER, 2010). Interestingly, several subsectors work in connection to each other for the overall output generated by the Agricultural sector. These include; crop production, livestock rearing, forestry and fisheries or aquatic subsector. Cocoa production is a major contributor to the overall agrarian economy. Compared to other agricultural activities, cocoa has been a leading sub-sector in the economic growth and development of Ghana. Victor et al (2010), indicated that, more than 700,000 households within Ghana representing 30% (6.3 million) of the total population depends on cocoa for their survival. The Eastern, Ashanti, Brong Ahafo, Volta, Central, and Western North and South Regions are where cocoa, which is the backbone of Ghana's economy, is grown. In these Ghanaian cocoa regions, there are thought to be over 850,000 farm households engaged in cocoa production and related activities. The crop is a significant contributor to the nation's economy, generating roughly $2 billion in foreign exchange each year, (Ghana Cocoa Board, 2022)

The increase in price of cocoa from 1998 led to greater interest on the part of small farmers. This has encouraged farmers to intensify their production and with the use of input such as pesticides and fertiliser on their farms. Cocoa production is dominated mainly by smallholder farmers.

According to Wessel and Quist-Wessel (2015), in 2010, the two highest cocoa producing countries in West Africa were Ghana and Cote Devoir.

Mankranso cocoa district is the leading district with the highest cocoa productive area in the Ashanti Region of Ghana with 22,951 cocoa farms. The district has a minimum productive area of 30,300 hectares (COCOBOD ,2022).

In 1891, the country produced 0.036 tonnes of cocoa. As the crop continued to enjoy high patronage from farmers, production of the crop rose to 1,018 tonnes in 1900 and then to 316,650 tonnes in 1936 (Legg & Owusu, 1984). Recognizing the vital contribution of the cocoa crop to the development of its economy, the then Gold Coast government created the Gold Coast Cocoa Marketing Company in 1947. The company was to provide permanent marketing services to the farmers (COCOBOD Executive Diary, 2007).

However, in recent times, one of the most crucial challenges facing cocoa production in Ghana is low productivity (Dormon et al, 2004). Among the factors contributing to low productivity of cocoa in Ghana are: the aged trees; low yielding varieties; the incidence of pests and diseases; low soil fertility; poor maintenance practices, low capital, labour, other limited inputs, aged of cocoa farmers with an average of 55 years (Dormon et al, 2004, Wessel and Quist-Wessel, 2015). According to Wilson (1999) the estimated annual loss of cocoa globally is about 45% of total output of the cocoa industry world-wide. Accordingly, over 558,000 mt of the cocoa losses were attributed to insect pest infestation, approximately 368,000 mt to diseases and 337,000 mt to weeds, all adding up to 45% of output from cocoa production.

In Ghana, the effects of pest and diseases cannot be underestimated. According to Awudzi et al (2021) Capsids (Heteroptera: Myridae) are estimated to cause losses of about 25% of output. The black pod, which is caused by Phytophthora spp is the most common disease of cocoa in Ghana. This is a challenge in that most family's livelihoods depend on cocoa for survival. As a result, high losses due to the impact of pest and diseases adversely affect yield and total output thereby decreasing the financial gains accrued from their labour. In Ghana, pests and fertiliser applications will increase cocoa yields to over 1500 kg/ha (Anon, 1999.). Calendar spraying of pesticides is suggested to combat capsids and the black Pod. Weed control, elimination of mistletoes and the replacement of lost plants are also recommended to increase yield. Fertilizer, nutrients and to conduct proper shade management also increase output in cocoa production

The cocoa swollen shoot virus disease continues to spread in Ghana despite many years of attempted control of the disease. Records gathered by Cocoa Swollen Shoot Virus Disease recently, Cocoa Health and Extension Service indicate that over the years, 28,486,309 visibly infected cocoa trees were removed countrywide. Out of this number, 18,332,234 trees representing 64.4% were removed from the Western North Region alone, whilst Western South accounted for 8.8%. In the Ashanti Region, 6.6% was recorded whilst Brong Ahafo Region accounted for 1.7% and Eastern Region, 2.3%.

In order to curb the negative impact of pest and diseases on cocoa production, over the years, Ghana's governments have made efforts to initiate series of programs aimed at replacing all infected cocoa farms. Between 1970 and 1979, the Cocoa Project in the Eastern Region was implemented at a total cost of US$ 15.6 million with the intention to recover approximately 20,000,000 hectors of existing farms, replanting 14,000 hectors of farms where the crop was dead or badly diseased. As part of the project, farmers were provided with training on how to grow a new variety of cocoa that will maximize yield and reduce disease infestation. At the end of project, approximately 15,000 ha of the infested area was treated and 13,000 hectors were replanted (92 percent of target). The bulk of the recovery, the replanting and maintenance of the farms was carried out by project workers with little involvement.

In addition to the above project, from 1988 to 1993, the cocoa recovery project was initiated at with initial estimated cost of U.S.$128 million. Cultivating new cocoa farms was the target of the project. The project funded technical and extension facilities, sponsored the production and distribution of hybrid seeds, managed swollen shoot virus disease, and Cocoa Research Institute off Ghana (CRIG) funded research activities.

Statement of the Problem

Cacao (Theobroma cacao), is one of the most important tropical crops in the world due to its economic importance. Cocoa is responsible for a multibillion-dollar financial gain to the economies of most countries globally. It is the main agricultural contributor to GDP for countries where it is grown. Records show that, Africa is the largest producer of cocoa for the world. Over

68% of the world cocoa is produced in Africa. According to World Cocoa Foundation (2014), the major countries that produce cocoa from the African continent are Cote D' Ivoire, Ghana, Nigeria and Cameroon.

It is the second highest foreign exchange earner in Ghana, accounting for about 20-30 percent of all export income and responsible for about 57 percent of total agricultural exports. The sector generates about two-thirds of the revenue of cocoa farmers directly and indirectly and support the livelihoods of about four million farming households in Ghana (Ghana Statistical Service 2018) and constitutes a large proportion of the GDP of Ghana (COCOBOD 2018; ISSER 2017). Despite the significance of cocoa production in Ghana, recent yields are estimated to be 350 kg/ha on average and are far lower than other major producing countries like Cote d'Ivoire with an average yield of 800 kg/ha and Malaysia's 1700 kg/ha (Danso-Abbeam et al., 2012). Consequently, livelihood conditions of many of the approximately 800,000 smallholder cocoa farmers have deteriorated over the decades with lower returns from cocoa farming leaving them impoverished (Godfrey, 2011)

Pest and disease are significant constraints that have negatively impacted commercial production of cocoa. For instance, it was estimated that every year, the diseases of black pod cause an approximately 450, 000 tonnes of world production loss of cocoa in Africa, Brazil and Asia whereas witches broom causes 250, 000 tonnes of loss in Latin America (Queensland [Department of Agriculture and Fisheries], 2013). Also, while frosty pod rot cause approximately 30, 000 tonnes of loss of cocoa in Latin America, vascular streak dieback also causes 30,000 tonnes loss in Africa. However, swollen shoot alone causes 50,000 losses in Africa (Queensland [Department of Agriculture and Fisheries], 2013). Notwithstanding, there are measures to control and manage these diseases so as to reduce its effect on cocoa production.

Information gathered so far from the 2nd country-wide resurvey by the Cocoa Health and Extension Division, (2017) indicate that about 17% of the total cocoa area is affected by the Cocoa Swollen Shoot Virus Disease and other pests and diseases. Current reports indicate that the surveys are ongoing and covers about 315,886.06 ha of cocoa. Forty-two percent of cocoa in the Western North Region and about 25 percent in Eastern Region are diseased.

Unfortunately, farmers in the Mankranso cocoa district in Ghana whose livelihoods depend largely on the cocoa they produce have not been left out of the adverse effect of pest and diseases on their cocoa farms. Mankranso cocoa district is the district with the highest cocoa productive area in the Ashanti Region of Ghana with 22,951 cocoa farms and 15,789 cocoa farmers. The district has a minimum productive area of 30,300 hectares (Ghana Cocoa Board, 2022). Disease and pest infestation have drastically reduced yield and, in some cases, farmers needed to destroy the entire farm and replace them in order to prevent the spread of these pest and diseases on their farms. Previous studies focus on physiological effect of pest and disease on yield.

However, the economic effect of pest and disease on cocoa production and its implication on famer income among small-scale farmers in Mankranso cocoa district have not been adequately assessed to inform decision and planning. As a result, interventions and support services provided by COCOBOD and other agencies have failed to address the devastating impact of the menace on the main livelihood concerns of these small-scale farmers.

Hence the design of the study to provide insights that will allow the formulation of appropriate and strategic solution to enhance productivity, hence farmer's income to improve living.

Purpose of the Study

The purpose of this study is to examine the economic effect of pest and disease on cocoa production and it implication on livelihood outcomes (income) among small-scale farmers in Mankranso cocoa district

Specific Objectives

1. To describe the socio-demographic and farm characteristics of smallholder cocoa farmers in the study area
2. To assess the prevalence and the intensity of pests and diseases in the study area
3. To evaluate cocoa productivity in the study area.
4. To determine the effect of pest and disease on farmer income from cocoa production in the study area

Research Questions

Considering the objectives of the inquiry, the following research questions are set to direct and guide the collection, analysis, and discussion of the data.

1. What are the socio-demographic and farm characteristics of small scale cocoa farmers in the study area?
2. What are the prevalence and intensity of pests and diseases? prevalence in the study area?
3. What is the productivity of in the study area?

4. What is the impact of pest and disease of cocoa on farmer's income in the study Area?

Hypothesis

1. Null hypothesis (H_0): there is no significant effect between pests and farmer income from cocoa production in the study area.

   Alternative hypothesis (H_1): there is significant effect between pests and farmer income from cocoa production in the study area

2. Null hypothesis (H_0): there is no significant effect between diseases and farmer income from cocoa production in the study area

   Alternative hypothesis (H_1): there is significant effect between diseases on farmer income from cocoa production in the study area

Significance of the Study

The study seeks to examine the economic effect of pest and disease on cocoa production and its implication on livelihood outcomes (income) among small-scale farmers in Mankranso cocoa district. The result of the study will help farmers understand the extent of impact of pest and diseases in the cocoa producing district. Stakeholders such as government and other non-governmental organizations will through this study appreciate the kind of interventions needed by smallholder cocoa farmers in the district so that interventions will be more tailored and targeted to the challenge prose by pest and disease in the study area. Furthermore, the outcome of the study will add to the body of knowledge available on cocoa production in the district in particular and Ghana in general.

Delimitation

The study sought to examine the economic effect of pest and disease on cocoa production and its implication on livelihood outcomes (income) among small-scale farmers in Mankranso cocoa district. Again, the focus of the study was narrowed to small-scale farmers, but not large-scale cocoa farmers. Furthermore, farmers whose entire livelihood depended on the cocoa they produced were to be the focus of the study.

Limitation

Time and financial constraints posed some challenge to the success of the study. Again, the noval corona virus pandemic affected data collection especially with the observation of the social distancing protocols. Furthermore, purchasing of COVID items during the field work increased the research cost.

Definition of Key Terms

Livelihood: It encompasses people's capabilities, assets, income and activities required to secure the necessities they need to live comfortable lives without depending on others for survival.

Livelihood Outcome: These are things that makes live comfortable for a farmer such as more income, increased well-being, reduced vulnerability, and improved food security, sustainable use of resources.

Pest: These are destructive insect or other animal that attack crops such as cocoa, maize, vegetables, food livestock, etc.

Plant Diseases: It is a disorder of structure or function in plants especially one that produces specific symptoms or affects a specific location of the plant and it's not simply a direct result of physical injury.

Organization of the Study

The study is organized into five chapters. The first Chapter deal with the introduction to the study. This cover the background of the study, statement of the problem, general objective, specific objective, research questions, and significance of the study, delimitation and limitation of the study as well as definition of key terms. Chapter Two focuses on the review of literature relevant to the study. The theoretical, empirical reviews as well as the conceptual framework for the study were included. The third Chapter contain the methodology that encompass the research design, description of study area, population, sample size and sampling procedures and instrumentation to be used in the study. Chapter Three end with data collection and analysis that were conducted based on the specific objectives of the study. The Chapter Four present the results and discussions according to the objectives of the study. The summary of the findings, conclusions, recommendations and areas for future research is included in the Fifth Chapter.

CHAPTER TWO

LITERATURE REVIEW

The chapter reviews theories and approaches for the study. The review discusses the fundamental assumptions, contributions of the theories and their implication and relevance to the study. Theory of economic development, theory of trophobiosis and integrated pest management approach are the theories and approaches underpinning the study. The additional review focused on how economic effects of pest and disease of cocoa production could implicate the livelihood outcomes of smallholder farmers are conceptualized in existing literature. Also, few relevant studies were reviewed to ascertain the findings in literature. Based on the theories reviewed and conceptual review of the variables, a conceptual framework is proposed for the study.

Theories

Theory of Economic Development

The theory of economic development was propounded in the year 1934 by Joseph Schumpeter as a way of analysing business cycle means and economic process involved. Schumpeter regarded economic development as a dynamic and discontinuous processes and therefore the theory assumes that an economic system goes through a cyclical process of alternating a booms and depression with patchy crises. According to the theory of economic development, the society progresses through trade cycles and in order to break the circular flow, there is the need for an innovating entrepreneur. Innovation however, is the carrying out of new combinations such as the introduction of new goods, new methods of production, opening of new markets, the conquest of new sources of supply and carrying out of a new organisation of any industry (Schumpeter, 1934). These form the cyclical process which eventually represent a period of boom. Also, a period of absorption which is referred to as depression by the theory.

The theory of economic development was built on some assumptions that are very relevant for the study. The theory assumes a constant condition in a circular flow of economic life which is further described to mean “the economic system will not change capriciously on its own initiative but will at all times be connected with the preceding state of affairs” (Schumpeter, 1934, p.9). Consequently, Schumpeter’s theory of economic development apportions principal role to the entrepreneur and innovations introduced by him in the process of economic development (Croitoru, 2012). So that, the credit for innovations and the outburst of economic activity goes entirely to the entrepreneur. Therefore, it is understandable to say entrepreneurship is inseparable and duly embedded in innovation.

According to Schumpeter (1934; 1961), the process of production is marked by a combination of material and immaterial productive forces. The material productive forces arise from the original factors of production such as land and labour, etc., while the immaterial set of productive forces are conditioned by the technical facts and facts of social organisation. The Schumpeterian production function can, therefore, be written as Q = *f* (k, r, I, u, v). Where, Q stands for the output, k for the Schumpeterian concept of 'produced means of production', r for natural resources, I for the employed labour force. Also, u represents the society's fund of technical knowledge and v represents the facts of social organisation that is the socio-cultural setting within which the economy operates (Haque, 2006). The functions showed that the rate of growth of output rest on rate of growth of productive factors. Likewise, the rate of growth of technology and investment of a welcoming socio-cultural environment. Schumpeter held that the alterations in the supply of productive factors can only bring about gradual, continuous and slow growth of the economic system. Additionally, the impact of technological and social change calls for spontaneous, discontinuous change in the channels of output flow thus the 'growth component' and the 'development component'.

Moreover, Schumpeter (1934; 1961) regarded land to be constant. Here, the growth component therefore, included only the effects of changes in population and an increase in the producer goods. But then again, Schumpeter maintains that there exists not a priori connection between changes in population and changes in the flow of goods and services. That is to say that, Schumpeter considers population growth to be exogenously determined. Therefore, the increase in producer goods only results from a positive rate of net savings. As a result, Schumpeter attributed the major part of savings and accumulations to profits. Then again, Schumpeter argued that, the profits can arise if innovations such as new techniques of production are employed and or if new product is introduced. Ultimately, it is the change in the technical knowledge thus (u) which is responsible for any change in the stock of producer goods. So then, the rate of capital accumulation directly depends on the rate of technical change (Kurz, 2010).

The contributions of Schumpeter have received more and more attention such that the contemporary economic theory and modern economies based on non-linear dynamics cannot go without making mention of the theory of economic development as well as stressing the relevance of innovation and entrepreneurship as a key to business economics. Also the circular flow assumption of the theory describes the situation of equilibrium and perfect competition which is to say, cost equals income, prices equals average cost and net profits are zero. What is more is that, Schumpeter indicated that this circular flow follows from continuous adaptions to small external changes which are ‘absorbed’ through routine company behaviour which is also very important as it was frequently being applied in the classical political economy (Hagedoorn, 1996).

Critics of the Schumpeterian theory of economic development are of the view that the production function is too narrow and not helpful in understanding the full complexity of production and therefore remains doubtful (Stolper, 1979). For Schumpeter, it is worth nothing that he introduced the three broad definitions of production function as; given technological possibility, blue prints with technical alternations and then the production function by factual observation (Schumpeter, 1961). Also, many author such as Clement and Doody (1966) have criticised his definition for innovation arguing that it is too broad. However, Schumpeter noted that, whether broad or vague, it is his reflection of struggle to understand the complexities that comes with technological development.

Furthermore, implication of this theory aids our understanding of the growth component which enable gradual, continuous growth of the country's economic system as a result of cocoa production and the development component which allows for spontaneous and discontinuous alteration in the channels of output flow of cocoa due to changes in the technical and social environments within which cocoa farmers operate. Also, the production function of the theory of economic development stresses on increased producer goods (cocoa) as a result of net savings but the question is; how much do cocoa producers save? Likewise, cocoa farmer's technical knowledge according to the theory will be responsible for any change in cocoa production stock which economically, is aimed at by the government. Finally, the rate of technical change of cocoa farmers is said to have a directly effect on their capital accumulation.

Theory of Trophobiosis

The theory of trophobiosis (TT) was propounded by Francis Chaboussou in the year 1985. The theory states that the susceptibility of a crop or plant to pests and diseases is subject to its nutritional state. In essence, TT suggests that pests shun healthy crops, pesticides weaken crops and weakened crops are more open to pests and disease, and therefore pesticides precipitate pest attack and disease susceptibility and thus persuade a cycle of further pesticide use. It is very evident that agribusiness continues to focus on the demise of pest and diseases instead of focusing on the health of the crop or plant and as such, agribusiness continually develop different pesticides, genetically modified organisms that produce and can even survive substantial pesticide dose (Paull, 2008).

However, Chaboussou (1985) substitute method focused solely on the health of the crop. Chaboussou's theory indicated that an excess, within the plant, of less complex biochemical molecules, such as amino acids (rather than proteins that they build to) and/or simpler (reducing) sugars such as glucose (rather than the more complex carbohydrates such as glucose polymers, starches and other polysaccharides) offers an attractive environment for pests and disease. According to Chaboussou, there are several environmental factors associated with plants and pests which further include genetic factors such as the physiological cycle of the crop or plant, their photoperiodic, climate, nature of the soil, fertilisation, nature of the stock and most importantly the effect of pesticides on the plants physiology (Paull, 2007).

The TT contend that the resistance and susceptibility to attack are functions of the nutritional state of a plant so that, when proteins are being manufactured, the plant becomes very resistant but when proteins are being broken down, the plant is expose to danger. Chaboussou (1985) further noted that "all herbicides are toxic for all plants" (p. 57). This implies that the substances used to control unwanted plants either selective herbicides to control specific weed species or non-selective herbicides are all harmful to the health of the plant. Chaboussou reported "a parallel between the effects of herbicides and those of nitrogen fertilisers … the pesticides that contain nitrogen - practically all chemical pesticides - are cations. They can replace cations such as Ca, Mg, and Zn from the exchange complex" (p.156). As a result, application of herbicides and synthetic fertilisers can lead to deficiencies in the treated plant (Cobb & Reade, 2011; Jayaraj, Megha & Sreedev, 2016).

According to Chaboussou (1985), the "artificial organo-chemicals have a very special affinity for plant tissues" (p. 39) Due to this attraction, pesticides applied to the leaves such as foliar application directly find their way into the body of the plant since plants are able to absorb essential elements through their leaves. Similarly, they absorb the foliar into the body. The absorption takes place through the cuticle and through the stomata, and since light promotes the maximum opening of the stomata, penetration of pesticides will be greater where the poison is applied in daylight (Jayaraj, Megha & Sreedev, 2016). Moreover, penetration of pesticides into the body of the plant can be via the leaves and also the roots, the seeds and the branches. Having penetrated the plant, Chaboussou argued that pesticides can be conveyed through the plant by means of apoplastic (extracellular) pathways and symplastic (intracellular and intercellular exchange thus within a cell and from cell to cell passing through the cytoplasm) pathways. Consequently, the plant so weakened and thus vulnerable to pests and disease.

Besides, there are some criticisms which according to Paull (2008) are well thought through. Paull (2008) noted that, there is the shared understanding that pesticides used on crops lose their efficacy after applying them for so long, the pests reappear and the pesticide prescribed amount or the frequency of its application needs to be stepped up or better still new pesticides need to be introduced into the spraying regime. According to Paull (2008), the justification given by the green revolution is that the pest develops resistance while Chaboussou (1985) argued that the crops are weakened, and gradually as they are continually assaulted as a result of using this chemical, more chemical intervention becomes mandatory resulting into pesticide treadmill experienced in chemical farming.

Implication of the theory to the study is that the theory suggests reasons for cocoa farmers to adopt or focus on a healthy crop and plant instead of concentrating more on the use of chemical application that weakens the crop or plant due to its consistent application. As a result the plants are no longer healthy enough to produce more and more cocoa crops leading to low yield. Therefore, low yield of cocoa is a recipe for low income and net savings.

Integrated Pest Management Approach

Integrated pest management (IPM) approach is broad-based approach that integrates practices for economic control of pest. The main idea with IPM is to suppress pest populations below the economic injury level. According to FAO (2017), IPM is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. The IPM emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. IPM combines the use of biological, cultural and chemical practices to control insect pests in agricultural production.

Likewise, IPM seeks to use natural predators or parasites to control pests, using selective pesticides for backup only when pests are unable to be controlled by natural means (Chandler et al., 2011). Hence, IPM should not be confused with organic practices because it does not discourage spraying chemicals but rather, it promotes spraying with selective pesticides only when the crop needs it.

According to Barzman et al. (2015), the use of pesticides made it possible to cocoa farmers to increase yields as well as simplify cropping systems and makes it possible to forego more complicated crop protection strategies. However, Busi et al. (2013) argued that over-reliance on chemical control by farmers is associated with contamination of ecosystems and undesirable health effects which implies that the future of crop production is also threatened by emergence of pest resistance (Paull, 2008) and declining availability of active substances.

IPM approach is built around six core principles. They include; acceptable levels of pest, preventive cultural practices, monitoring, mechanical controls, biological control and responsible use (Ehi-Eromosele, Nwinyi & Ajani, 2013). In detail, the acceptable pest level emphasis pest control and not pest eradication. IPM holds that wiping out an entire pest population is often impossible and therefore, the attempt can be expensive and unsafe. As result, IPM programmes first work to establish acceptable pest levels, called action thresholds and apply controls if those thresholds are crossed (Ehi-Eromosele, Nwinyi & Ajani, 2013). Furthermore, preventive cultural practices have to do with selecting crop varieties best for local growing conditions and thus maintaining healthy crops is the first line of defence. Also, plant quarantine, crop sanitation like removal of diseased plants, cleaning, pruning shears so as to prevent spread of infections (Sastry & Zitter, 2014).

Moreover, in IPM approach, monitoring is key. Regularly observing in a form of inspection and identification. Visual inspection, insect and spore traps and other methods are used to monitor pest levels. It is essential to keep record so as to have a thorough knowledge of target pest behaviour and reproductive cycles (Bennett, Owens & Corrigan, 2010). Mechanical control of pest happens only if the pest reaches an unacceptable level and are the first options. They include simple hand picking, barriers, traps, vacuuming and tillage to disrupt breeding. Furthermore, according to IPM approach, biological control is implemented after the mechanical controls are exhausted. Natural biological processes and materials can provide control, with acceptable environmental impact and often at lower cost (Braungart, McDonough & Bollinger, 2007). The main approach is to promote beneficial insects that eat or parasitise target pests. This is because, biological insecticides derived from naturally occurring microorganisms (for instance; Bt, entomopathogenic fungi and entomopathogenic nematodes) also fall in this category.

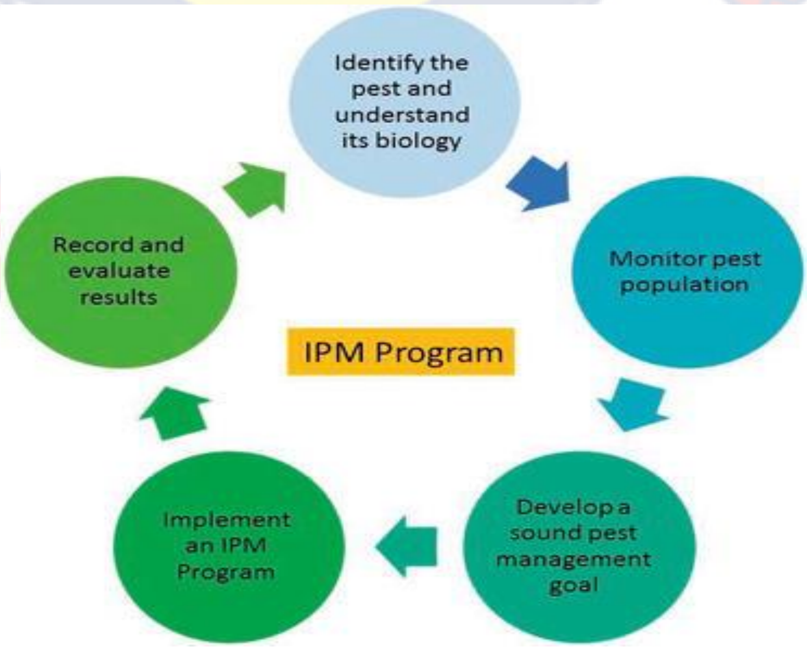

Figure 1: IPM programme framework for pest control.

Source: Abdel and El-Shafie (2018).

Last but not least is the responsible use of the pesticide if it must be applied. Artificial pesticides are used as required and often only at specific times in a pest's life cycle. Many newer pesticides are derived from plants or naturally occurring substances such as nicotine, pyrethrum and insect juvenile hormone analogues. However, the toxophore or active component may be altered to provide increased biological activity or stability. Therefore, IPM approach insist that applications of pesticides must reach their intended targets (Abhilash & Singh, 2009). Matching the application technique to the crop, the pest, and the pesticide is critical. Notwithstanding, the use of low-volume spray equipment reduces overall pesticide use and labour cost.

Barzman et al. (2015) noted that the future of crop production is threatened by emergence of pest resistance and declining availability of active substances and therefore the need for cropping systems that are less dependent on artificial pesticides. In their study titled 'Eight (8) principles of integrated pest management' revealed a proposed eight principles of IPM which according to Barzman et al. (2015), fit within sustainable farm management. The first principle is the design of inherently robust cropping systems using a combination of agronomic levers is key to prevention. The second principle is local availability of monitoring, warning, and forecasting systems is a reality to contend with. Also, the decision-making process can integrate cropping system factors to develop longer-term strategies being the third principle.

The combination of non-chemical methods that may be individually less efficient than pesticides can generate valuable synergies as the fourth principle. The fifth principle is on development of new biological agents and products and the use of existing databases to offer options for the selection of products minimizing impact on health, environment and biological regulation of pests. For the sixth principle, reduced pesticide use can be effectively combined with other tactics. Furthermore, addressing the root causes of pesticide resistance is the best way to find sustainable crop protection solutions as well as the integration of multi-season effects and trade-offs in evaluation criteria will help develop sustainable solutions being the seventh and eighth principles respectively (Barzman et al., 2015).

According to Kearns (2020), IPM approach to pest control can only be effective if the producers are familiar with the life cycle and crop thresholds of pests and to act immediate when pest numbers begin to impact on crop growth thereby causing economic damage. Kearns (2020) argued that beneficial insects should be encouraged and their numbers be regularly measured using beat sheets, sweep nets, traps or vacuums. Kearns added that patience is very important because even though information about the density of insects in a field is recorded, IPM insist that action is only taken when pests reach a specific threshold level.

Scientist argued that the IPM insist on the use of low toxicity pesticides however, this assertion is becoming increasingly common that “only least toxic pesticides” be used in IPM programs (Quarles, 2018).

As relevant to this study, the IPM approach highlight the six principles (acceptable levels pest, preventive cultural practices, monitoring, mechanical controls, biological control and responsible use) that can be adopted by cocoa farmers in the integrated pest management system. However, the effective use of this approach, farmers need to familiarise themselves with the life cycle and crop thresholds of pests. As well, the IPM cautioned that the method should not be considered as organic or natural because it promotes only recommended selective pesticides spraying and when necessary.

In summary, the theory of economic development sets the pace to highlight the production functions necessary for increased cocoa productions as well as the constitutes of the growth component and the development component which is able to stimulate economic development and then a dynamic and discontinuous processes with occasional crisis in an economy. Also, SL approach stresses on the need for cocoa farmers' involvement in the strategies geared towards poverty eradication. The approach advocates for public and private partnership and make use of structures and institutions. Then again, on one hand, the theory of trophobiosis focus solely of the healthy crop. The reason is to increase yield and avoid the use of all toxic and poisonous substances. On the other hand, the integrate pest management approach holds that for the IPM approach to be effective, farmers need to familiarise themselves with the life cycle and crop thresholds of pests. This is the only way to avoid pest impact and eventual economic damage because the farmer can to act immediate pest exceed their threshold. These theories and approaches are relevant for the study as it will guide the construction of the conceptual framework, as well as results and discussions chapters.

Cocoa Production

Cocoa is the primary agricultural cash crop in Ghana and its farming is not native to the country. Ghana's cocoa cultivation is noted to be one of the most modelled commodities and treasures within the developing world

(Barrientos, 2013). This is because, Ghana is noted to be the second largest producer of cocoa in the world. Cocoa production however, take place in the country's forested areas such as the Ashanti, Brong-Ahafo, Central, Eastern, Western and Volta, where rainfall is between 1,000-1,500 millimetres per year (Tienhaara, 2018). According to Tienhaara (2018), the crop year which also involve the purchase of the main crop begins in October whereas smaller mid-crop cycle begins in July. Furthermore, cocoa has a long production cycle which is far longer than many other tropical crops. The new hybrid varieties need over three to five years to come into production and an extra 10 to 15 years for the tree to reach its full bearing potential (Vigneri, 2008).

The cocoa production is one of the most important economic activity in Ghana's agriculture sector (Yamoah, Kaba, Amankwah-Amoah & Acquaye, 2020) and also, an integral part of the rural economy in Ghana. As established in literature, cocoa production is associated with significant contributions to the nation's gross domestic product (GDP), such that, cocoa account for 16% of the total GDP and 68% of the GDP in the primary sector (Ghana Statistical Service [GSS], 2017). As a result, cocoa has been one of Ghana's main export crops and specifically the second leading foreign exchange earner that is worth nearly 30% of all revenue from export and accountable for about 57% of overall agricultural exports (Olaiya, 2020; Yamoah et al., 2020). Therefore, cocoa production is central to the country's development, reforms and poverty alleviation strategies (Ahmed & Gasparatos, 2020).

Although most cocoa production is carried out by peasant farmers on plots of less than three hectares, a small number of farmers appear to dominate the trade. Studies have shown that about one-fourth of all cocoa farmers receive just over half of total cocoa income (Kiewisch, 2015). However, Ghana is an agricultural nation with more than half of her population engaged in Agric- production. Hence, the sector directly and indirectly employs about 2 million people and these constitute a large chunk of Ghana's GDP (Falola, Ayinde & Agboola, 2013; Puozaa et al., 2021).

In West Africa, cocoa is mainly grown by smallholders who traditionally plant their cocoa at random under thinned forest shade. This low input cultivation system uses the forest soil fertility and the existing shade (Tscharntke et al., 2011). However, cocoa cultivation requires that, certain environmental and edaphic conditions be at their optimum for successful growth of the cocoa plant. These factors include temperature, rainfall, humidity, soil types, soil pH and soil nutrition (Hutchins, Tamargo, Bailey & Kim, 2015).

In that, rainfall and temperature have significant effects on flowering and subsequent pod setting. Also, an appropriate climate is required which is mostly found within the area bounded by the tropics of cancer and Capricorn. For instance, the ideal range of temperatures for cocoa is minimums of 18-21°C and maximums of 30-32°C, thus temperatures in general must be within 18-32°C (65-90°F). Furthermore, rainfall should be plentiful and well distributed through the year. The range of rainfall distribution must be between 1,000-4,000 mm (40-160 in) per year, but preferably between 1,500 and 2,500 mm (60 and 100 in) (Hutchins et al., 2015). What's more is that, during cultivation, cocoa prefers high humidity which typically ranges between 70-80% during the day and 90-100% at night (McSweeney, New, Lizcano, Lu, 2010).

Moreover, cocoa is grown on a wide range of soil types (Hutchins et al., 2015). The trees require soils containing coarse particles which allow free space for root development, and a reasonable quantity of nutrients to a depth of 1.5m to allow the development of a good root system. Again, cocoa tree is sensitive to a lack of water so the soil must have water retention properties as well as good drainage. The chemical properties of the topsoil are mostly important as cocoa has a large number of roots that absorb nutrients. Hence, cocoa can grow in soils with pH ranging from 5.0-7.5, and can therefore cope with both acid and alkaline soil. The soil should also have a high content of organic matter of 3.5% in the top 15 centimetres of soil and must also have certain anionic and cationic balances. These environmental factors and conditions coupled with agricultural practices enhances the cocoa production. This method explains that some six million ha of the West African forest zone are planted with cocoa, which provides about 70% of the total world production (Wessel & Quist-Wessel, 2015).

According to Asamoah and Baah (2003), it was estimated that, 800,000 families cultivate cocoa on 1.45 million ha in plots of 0.4 to 4 ha and these families are seeking to expand cocoa production. It is noted that, the expansion of cocoa cultivation into the high forest zones aim to increase the national production levels of cocoa (Mohammed, Robinson, Midmore & Verhoef, 2016). Consequently, farmers who wish to increase their cocoa output, establishes new farms elsewhere in the forest zone. As a result, the search for new land has led Ghana and Côte d’Ivoire in to a large-scale deforestation (Ruf, Schroth & Doffangui, 2015; Wessel & Quist-Wessel, 2015).

Currently, little land is available for the expansion of the cocoa area so that a further increase in production has to come from an increase in yield of the existing mature trees and the replanting of old unproductive cocoa farms (Wessel & Quist-Wessel, 2015). The problem is the over-reliance on natural land productivity and expansion in land under cultivation to increase yield (Besseah and Kim 2014). Therefore, Asante-Poku and Angelucci (2013) argue that the main factors that have contributed to the increase in Ghana’s cocoa production include the support measures put in place by Ghana’s COCOBOD, the government-owned cocoa marketing board which comprised the introduction of packages of hybrid seeds, fertilizers, increase in farm-gate prices, introduction of free pest and disease control programmes, insecticides and fungicides, improved marketing facilities and the repair of roads in cocoa growing areas. So that, cocoa production figures rose from 586 tons in 2004-2005, to 632 tons in 2009-2010 and to 1,025 tons in 2011-2012 (International Cocoa Association [ICCO], 2014).

In addition, the governments of Côte d’Ivoire and Ghana had an agreement reached with over thirty-seven major cocoa and chocolate companies. This agreement was an initiative to end deforestation and replenish the trees and the forests. According to the Carodenuto and Buluran (2021), the initiative (cocoa and forests initiative) was declared at the United Nations Climate Change Conference (UNCCC) in November, 2017 to fight against conversion of natural forests to land for cocoa production in West Africa. So that in March, 2019, the governments of Côte d’Ivoire and Ghana in tandem with the cocoa companies released an action plans to aid the ending of deforestation. The plan is geared towards forest protection and restoration, sustainable cocoa production, emphasising on the livelihood of farmers, and a system of social inclusion and community engagement (Carodenuto & Buluran, 2021).

However, as it stands, the cocoa sector in Ghana has noticed a major decline in production after emerging as one of the world's leading producers of cocoa. This is due to the use of extensive cultivation methods as well as old farms cultivation (Wessel & Quist-Wessel, 2015). Report from the international cocoa association quarterly bulletin indicated that between 2012-2013, Ghana produced 835 tons of cocoa and 897 tons respectively in 2013-2014 as against 1,025 tons in 2012 (ICCO, 2014). These could be attributed to limited innovation (Vigneri, 2008) bringing about the poor yield, cocoa hybrid varieties developed by the Cocoa Research Institute of Ghana (CRIG) have seen limited adoption, as well as limited use of fertilizer application and pesticides (Gockowski, Afari-Sefa, Sarpong, Osei-Asare & Agyeman, 2013).

Despite the reduction in production of cocoa, there are different kinds of product derived from cocoa. For instance, the husks of cocoa pods and the pulp otherwise known as sweating, surrounding the beans and the cocoa bean shells can be extensively used. Examples of these use are for animal feed, soft drinks and alcohol, soap, potash, jam and marmalade and also for mulch. In detailed, a pelletized dry 100% cocoa pod husk can be used as an animal feed. The animal feed is produced by first slicing the fresh cocoa husks into small flakes and then partially drying the flakes, followed by mincing and pelleting and drying of the pellets (Adu-Amankwa & Twumasi, 2002). Also, with the preparation of soft drinks, fresh cocoa pulp juice (sweating) is collected, sterilized and bottled. In preparing the alcoholic drinks such as brandy, it is required that the fresh juice is boiled, cooled and fermented with yeast. After 4 days of fermentation the alcohol is distilled (Ntiamoah & Afrane, 2008).

Likewise, pectin for jam and marmalade is extracted from the sweating by precipitation with alcohol, followed by distillation and recycling of the alcohol in further extractions (Adu-Amankwa & Twumasi, 2002). Furthermore, cocoa pod husk ash is also used mainly for soft soap manufacture. It may as well be used as fertilizer for cocoa, vegetables and food crops (Adu-Amankwa & Twumasi, 2002; Figueira, Janick, BeMiller, 1993). To prepare the ash, fresh husks are spread out in the open to dry for one to two weeks. Thereafter, the dried husks are then incinerated in an ashing kiln. Then again, cocoa bean shells can be used an organic mulch and soil conditioner for the garden.

In addition, once the beans have been fermented and dried, they can be processed to produce a variety of products. These products include; cocoa butter, cocoa powder and cocoa liquor (Ntiamoah & Afrane, 2008). In essence, cocoa butter is used in the manufacture of chocolate. It is also widely used in cosmetic products such as moisturizing creams and soaps. Also, cocoa powder can be used as an ingredient in almost any foodstuff (Ntiamoah & Afrane, 2008). For example, it is used in chocolate flavoured drinks and desserts such as ice cream and mousse, chocolate spreads and sauces and cakes and biscuits. Cocoa liquor also is used with other ingredients to produce chocolate.

Economic Effects of Cocoa Production

Cocoa production plays a very important role in the economic life of the small farmers (Quartey-Papafio, Javed & Liu, 2020). As a cash crop, cocoa production provides needed income for the purchasing of food (Bentley et al. 2004). Cocoa is a major source of foreign exchange for Ghana and foreign exchange is good for the country. Also, cocoa money is used for hospitals and roads for the benefit of the country. Basically, cocoa is the backbone of the Ghanaian economy (Armengot et al., 2020). Therefore, a significant growth of the economy depends largely on the growth of the cocoa sector in Ghana (Bosompem, Kwarteng & Ntifo-Siaw, 2011).

Despite the significance of cocoa production in Ghana, recent yields are estimated to be 350 kg/ha on average and are far lower than other major producing countries like Cote d'Ivoire with an average yield of 800 kg/ha and Malaysia's 1700 kg/ha (Danso-Abbeam et al., 2012). Consequently, livelihood conditions of many of the approximately 800,000 smallholder cocoa farmers have deteriorated over the decades with lower returns from cocoa farming leaving them impoverished (Godfrey, 2011). Arguably, current cocoa production systems are not sustainable because of non-eco-friendly production of cocoa beans. Although there is demand of cocoa in chocolate industries, sustainable development of cocoa production and marketing is a major concern for the policy makers (Arshad, Bala, Alias & Abdulla, 2015) and also, for authorities who are currently putting in place a workable plan to accomplish the targeted goals.

The sub-cocoa sector is yet to achieve necessary synergies between emerging socio-economic and environmental trade-offs such as increasing productivity and income vis-à-vis reducing extensive cultivation and deforestation (Akrofi-Atitianti et al., 2018). Also, negative impacts of climate change on cocoa would have repercussions for the Ghanaian economy and especially for rural development (Schroth et al., 2016). Not forgetting the negative impact on productivity from higher energy prices. With respect to economic output, the very fact that productivity decreases means that households and farmers are at a disadvantage. Besides, more long-term and damaging economic impacts can occur when public perception of prolonged and wide-scale deforestation and pollution of the environment remains long after (Schroth et al., 2016).

Moreover, another economic effect in cocoa production in Ghana is low yields per ha, which is attributed to the incidence of pests and diseases, (Dormon, Van Huis, Leeuwis, Obeng-Ofori & Sakyi-Dawson, 2004). Significant yield losses from such damage are experienced in almost all parts of the world where cocoa is grown and may as well be 5-10% on average due to rats and monkeys feeding on the sweet mucilage around the beans after breaking into ripe pods of the cocoa (Dormon et al., 2004). Pests and diseases are major causes of economic losses in cocoa. This is because most cocoa farms are cultivated by very large numbers of small and often isolated cocoa farms in which adequate pest and disease control is lacking (Wessel & Quist-Wessel, 2015). There is therefore the need for government and cocoa marketing board to take full responsibility of these effects and find appropriate measures to curbing the situation if indeed Ghana acknowledges the benefits derive from cocoa production, exportation and marketing.

Pest and Diseases of Cocoa Production

In Ghana, cocoa farmers lose high levels of yield to pests and disease as this happens to be the major problem for cocoa production (Leitão, 2020). The sector is also bedevilled by soil degradation and aging tress coupled with poor agronomic practices (Akrofi-Atitianti et al., 2018). Just like other crops, cocoa is attacked by a number of pest species which also include fungal diseases, insects and rodents. Some of which comprise, frosty pod rot and cocoa pod borer, have increased intensely in the various geographical areas and are sometimes referred to as "invasive species".

Although over 1500 diverse insects are known to feed on cocoa, it is only about 2% that are of economic importance (Steffen, Grousset, Schrader, Petter & Suffert, 2015). However, research shows that when cocoa is first introduced into a new area, a formerly unrecorded pest almost always attacks it (Wheeler, 2001; Tremblay, Kimoto, Bérubé & Bilodeau, 2019). Mirid bugs such as Helopeltis are the utmost significant and generally occurring insect pests of cocoa as well as the cocoa pod borer which is a major pest in countries such as Malaysia and Indonesia. Also, Mealy bugs are generally not a major pest themselves, but are recognised vector for viruses of cocoa. Common insect pests include; Broad mite, Flower-eating caterpillars, Helopeltis and Yellow peach moth that feed on the cocoa. As a result, animals such as rats and monkeys also break into the ripe pods of cocoa and feed on the sweet mucilage around the beans (Gras et al., 2016) and ends up damaging the cocoa bean.

For instance, according to Lee (2013), severe pest infestation has resulted in an intense decreased in the area cultivated from 393,465 ha in 1990 to 190,127 in 1995 and it continued till 2005 and the area was reduced to 33,398 ha. Lee argued that, by 2013, the cocoa planted area was reduced to only 13,728 ha. This is a serious and drastic reduction in the area cultivated as noted above and as such measures have to be put in place to gain cocoa production area back.

Furthermore, there remain diseases that affect the cocoa production apart from the pest infestation. Approximately 40 percent of the annual cocoa harvest is lost to pathogens. Arguably, among the cocoa diseases, black pod caused by several species of the Oomycete Phytophthora, is the most damaging and the only disease that occurs in every growing region of the world (De-Souza, Guest, Pirovani & Hebbar, 2021). Other diseases such as frosty pod rot caused by fungus Moniliophthora roreri is equally causing a lot of damages in cocoa production as well as witches' broom cause by fungus Moniliophthora perniciosa, swollen shoot virus and vascular streak dieback cause by basidiomycete Ceratobasidium theobromae (Ali et al., 2016; Marelli et al., 2019).

For instance, it was estimated that every year, the diseases of black pod cause an approximately 450, 000 tonnes of world production loss of cocoa in Africa, Brazil and Asia whereas witches broom causes 250, 000 tonnes of loss in Latin America (Queensland [Department of Agriculture and Fisheries], 2013). Also, while frosty pod rot cause approximately 30, 000 tonnes of loss of cocoa in Latin America, vascular streak dieback also causes 30,000 tonnes loss in Africa. However, swollen shoot alone causes 50,000 losses in Africa (Queensland [Department of Agriculture and Fisheries], 2013).

Notwithstanding, there are measures to control and manage these diseases so as to reduce its effect on cocoa production.

Generally, cultural practice of weed control is mostly an issue throughout its formation (Olufemi et al., 2020). Traditionally young cocoa is weeded by manual slashing along the tree rows or around young plants. In recent times, herbicides have been introduced and used for weed control. Also, when cocoa is mature and a complete canopy is formed, heavy shading and leaf mulch inhibit weed growth so that only occasional attention to removing woody weeds is required (Leitão, 2020; Olufemi et al., 2020). Weeds will always be an issue wherever the canopy allows light to penetrate or there are aisles provided for access.

Specifically, when controlling or managing the disease swollen shoot, the infected trees and those surrounding them should be removed and destroyed to prevent further spread. Thus, there should a gap placed in-between cocoa plantation of at least 10 m (33 ft) and also, it may be possible to isolate cocoa plantation using a non-host crop such as oil palm growing between the plantation (Ameyaw, Dzahini-Obiatey, & Domfeh, 2014; Andres et al., 2018). When it comes to frosty pod rot, it is advisable to plant cocoa varieties that produce pods during the dry season. This allows the pod to avoid the disease. Also, pods showing symptoms of disease should be removed to prevent spread. An application of copper containing fungicides will help reduce disease incidence (Crozier et al., 2015).

Likewise, the witches' broom management require good sanitation as it appears to be the most effective method of controlling the disease. Also, materials known to be infected with the disease should be removed and destroyed. Here, removal of infected material can be difficult as there may be no visible symptoms. Nevertheless, new fungicides and resistant cocoa varieties are being developed to help control the disease. (Medeiros et al., 2010; Ferraz, Cássio & Lucas, 2019). In addition, black pod also requires the use of recommended protective sprays of copper containing fungicides in combination with systemic fungicides to help control the disease. Further, cocoa plants should be well spaced to allow good air circulation through the plantation as well as mummified pods should be removed and destroyed to reduce spread (Acebo-Guerrero, Hernández-Rodríguez, Heydrich-Pérez, El-Jaziri & Hernández-Lauzardo, 2012; Akrofi, Amoako-Atta, Assuah & Asare, 2015).

Eventually, there is also the need to control and manage pest infestations hindering cocoa production. Seemingly, mealybugs can potentially be controlled by natural enemies such as lady beetles, however, they are commonly controlled using chemicals. Chemical pesticides may also decrease populations of natural enemies leading to mealybug outbreaks (Daane et al., 2012). Also, in African countries, mirids are usually controlled by chemical eradication programs consisting of two sprays; conducted one month apart to target different stages of the insects' development (Mani & Shivaraju, 2016). Mirids have been shown to be attracted to trees positioned in direct sunlight and providing shade cover in the form of forest to cocoa trees can be used as part of an integrated control method (Bisseleua, Fotio, Missoup & Vidal, 2013). Also, cocoa farmers are not allowed to interplant with other hosts such as cashew, tea, sweet potato, guava, cotton or mango (Bouagga, Urbaneja & Pérez-Hedo, 2018). So that the trees used as interplant must be non-hosts thus some species of ant. An example of black ants can be used as a biological control agent (Toledo-Hernández, Wanger & Tscharntke, 2017).

Moreover, when it comes to controlling cocoa pod borer, sleeving pods in plastic bags are recommended as they mature. This prevents the insect from reaching the pods. Also, sleeves should be applied when pods are 8-10 cm (3-4 in) long and borer populations can be held in check by both black and weaver ants (Rosmanaa, Shepardb, Hebbarc & Mustari, 2013). Besides, chemical control is often economically unfeasible due to the high price of pesticides compared with the low price of cocoa. Nonetheless, where available, small amounts of contact pyrethroid or carbamate applied to underside of cocoa leaves can keep borers below an economically damaging level (Eris, Yusuf & Purwantara, 2020).

Therefore, in the quest to improve farmers' livelihood in Ghana, Cocoa Life has partnered with Tree Global, a large scale nursery operator to produce high-quality cocoa seedlings to be distributed among farmers and help rehabilitate degraded farmlands. Such that upon registering into the Cocoa Life program, farmers are invited to attend a training program to learn agricultural skills, such as pruning techniques, to increase yield. Practically, farmers can then tour one of the more than 400 demonstration plots to see the results up close. If a farmer decides to rehabilitate, he or she also receives high-quality planting materials which is now resulting in high demand for these seedlings (Boafo, 2020).

Factors Affecting Cocoa Productivity

Bymolt, et al (2018) In their work Demystifying the cocoa sector in Ghana and Côte d'Ivoire chapter 10, Production and yield assessment on cocoa productivity reviewed that average cocoa yields in Ghana, according to past studies, are normally between 400 and 530 kg/ha.in their findings on all home land planted with cocoa in Ghana, respondents reported an average yield of 806 kg during the main season and 281 kg during the light season. This equates to a household producing an average of 1,087 kg of cocoa per year with a mean yearly production of 423 kg/ha from this.

Suh and Molua (2022) did a study in South West Region of Cameroon that assessed the causes of low cocoa production. The results show that household characteristics and household assets (farm size, labor, and level of education), good agricultural practices (harvesting mistletoe, water shoot, and infested pods, and spraying pests and diseases), and institutional factor (capital) all had a positive and statistically significant effect on cocoa output, supporting all their hypothesis.

Kongor et al (2018) did a work on Constraints for future cocoa production in Ghana. The study was done in the cocoa all the six cocoa growing Regions in Ghana, according to the findings, cocoa production and profitability were low, averaging 234 kg ha-1 and Gh 568 (about US$ 150) per ha, respectively. Capsid and black pod disease control, fertilizer application, and pruning were the farm management strategies that substantially ($p>0.05$) influenced cocoa productivity. They concluded that effective farm management techniques, such as spraying for black pod and capsids, pruning, and fertilizer application, would significantly increase cocoa productivity and, consequently, farmer income. They would also ensure sustainable production rather than overly increase in farm land of cocoa farm which eventually results in lower productivity. Their finding disagrees with Suh and Molua which report farm size was significant factor that affect cocoa yield.

Wessel and Quist-Wessel (2015) reviews the state of cocoa farming in West Africa, where six million hectares of the crop are cultivated, accounting for around 70% of global production. In their review, they reported that, the prevalence of pests and diseases, the old age of cocoa plantations, and a deficiency in soil nutrients are the main causes of low output. Furthermore, they reported that in some regions of Ghana and Côte d'Ivoire, black pod diseases result in yearly pod losses of up to 40% in cocoa output. They also review that mirids cause yield loss of 25% in Ghana and average of 35 % in Côte d'Ivoire

Ploetz (2016), reported that cocoa diseases caused 20% decrease in cocoa yield in 2012.

In summary, cocoa yield is affected by Good Agricultural practices such as pruning, phytosanitary harvesting, pest and disease control. Also farmer age and educational level also affects the yield of cocoa. Farm size and age of the farm also plays significant role in yield determination of cocoa production. Black pod is an important disease that cuases pod loss which have affect productivity. Mirids and capsids have been also being identified as important pest that affects cocoa yield. Also the findings are similar to Suh and Molua (2022) who reported in their findings that

Implication on farmer Income (Livelihood outcome)

Improving the livelihood of farmers is a crucial aspect of government's plans for reducing poverty in Ghana. The government of Ghana is committed to reaping the full benefit from the cocoa sector and has therefore put in measures to ensure that the country increases its cocoa production as well as processes more cocoa beans into downstream products for both the local and export markets (Awua, 2002). Due to this reason, the government of Ghana introduced a Cocoa Disease and Pest Control Project (CODAPEC) nationwide to help address the two major causes of decline in cocoa production- pests and diseases. Under this agenda, cocoa farms across the country were sprayed with insecticides and fungicides at no cost to the farmers. This exercise has resulted in tremendous increases in cocoa production from 340,562 metric tons in the 2001/02 season to 496,846 metric tons in 2002/03 and 736,000 metric tons in the 2003/04 seasons, respectively (Appiah, 2004).

The percentage of locally processed beans has also jumped from 20% to 35% with further re-capitalization and expansion programs underway to reach a target of 50% in the near future (Appiah, 2004). The beans are normally processed into four semi-finished products, namely, cocoa liquor, cocoa butter, cocoa powder and cake, and a finished product, chocolate (Ntiamoah & Afrane, 2008). Subsequently, improving cocoa farmer's livelihoods is key to growing the country's economy and supporting the country status. The term livelihood is used to describe how people make a living, which includes an individual's capability, assets, income and essential activities to secure the necessities of life (Hankins & Rassi, 2015).

According to Parry (2015), livelihood strategies such as livelihood diversification is as a result of cocoa farmer's income and assets. Parry indicated that factors that influence livelihood diversification comprise, household head, sex of respondents and distance to market. In the research conducted among the cocoa farmers in Atwima Mponua District, in the Ashanti Region, it was found that cocoa farmers diversify from cocoa and crop farming because respondents prioritise income/revenue as their reason for livelihood diversification. Finding was also consistent with Nasa'i, Atala, Akpoko and Kudi (2010) whose study showed that rural farmers diversify sources of livelihood to increase households' income portfolios. Therefore, for government and NGO's to help farmers in their quest for better livelihood strategies, there is the need to intensify agricultural strategies such as increasing cocoa farmer's skills and diversifying quality and quantity of cash crop for exports and building resilience in food security among cocoa growing communities (Achterbosch, van Berkum, Meijerink, Asbreuk & Oudenda, 2014).

Furthermore, the WCF Cocoa Livelihoods Program (CLP) is working to increase farm level productivity of cocoa and food crops of smallholder, cocoa-growing households in West and Central Africa (Carodenuto & Buluran, 2021). This initiative is geared towards increasing farmer income and strengthening cocoa communities through three main objectives. The objectives include; increasing farm-level cocoa productivity to 1000 kg/ha, improved service delivery efficiency for long-term and improved farmer resiliency with a focus on food crop productivity (Carodenuto & Buluran, 2021). Phases 1 and 2 of this programmes have been rolled out already and farmers are benefiting greatly from these initiatives. Therefore, implementing agricultural strategies to improve cocoa productivity without considering the multiple effect that might impact on productivity is unthinkable particularly on income and food security (Achterbosch et al., 2014) as they constitute the major reasons for crop diversification.

Income

Cocoa farming is the backbone of Ghana's economy. Approximately, 850,000 small scale cocoa farmers make up 60% of the country's agricultural base (Ghana Cocoa Borad,2022). However, despite their importance to Ghana's economy development, many cocoa farming families live in poverty (Peprah, 2015). As a global commodity, cocoa bean sales and smallholder incomes are affected by international price fluctuations, which are transmitted directly to domestic and farm-gate prices (Nisurahmahet al., 2017). It is noted that cocoa farmers earn a per capita daily income of approximately USD $0.40-$0.45 on cocoa (International Cocoa Initiative [ICI], 2017). This means that the amounts to an annual net income of USD $983.12-$2627.81 which accounts for two thirds of cocoa farmers' household income (ICI, 2017). As a result, cocoa farmers in Ghana do not earn high income from the sale of cocoa.

Several factors affect cocoa farmers' ability to earn high incomes (Falola et al., 2013). The majority of Ghana's cocoa farmers are self-employed and operate small-scale farms of 2 to 5 hectares. Given their small farm size, yields are often low at an average of 0.42 tonnes per hectare. Moreover, farmers struggle to access extension services which help to enhance farming techniques and boost yields (Afriyie-Kraft, Zabel & Damnyag, 2020; Baiphethi & Jacobs, 2009). Low yields reduce the amount of income generated by farmers and prevent them from accruing savings. Likewise, the production function of theory of economic development stresses on net savings as a result of increased producer goods coupled with the rate of technical knowledge of the farmers to have a bearing on their capital accumulation.

Besides, the high cost of farming inputs also affects farmers' income (Agarwal, 2018; Baiphethi & Jacobs, 2009). The costs associated with hiring adult labour as well as purchasing fertilisers, farming equipment and pesticides places a large financial burden on farmers and further diminishes the income that they gain from cocoa production (Agarwal, 2018). According to ICI (2017), the 29 cocoa-growing communities that are being supported in Ghana, only 36% of farmers could afford farming inputs. This clearly shows the extent to which Ghana cocoa farmers are faced with financial difficulties and hence their access to farming inputs.

While cocoa farming still remains important for rural households, farmers are looking for diverse opportunities to increase and stabilise their incomes. Understandably, cocoa is a seasonal crop which further implies that cocoa farmers' incomes are not stable all year-round and therefore, cocoa farming families experience keen economic vulnerability and deepened poverty during off-seasons (Baiphethi & Jacobs, 2009; Dodd et al., 2020). Few farmers are able to save money and many lack economic resilience strategies such as insurance or alternative income sources (Falola et al., 2013). Farmers have to borrow money to cover household expenses and farming inputs for the next season, yet access to credit is limited in rural communities (Dodd et al., 2020). These issues are exacerbated for women cocoa farmers who experience multiple barriers to cocoa production (Peterman, Behrman & Quisumbing, 2014). As a result, they are required to take on additional labour by balancing cocoa farming with other income-generating activities (Elias, 2015).

Regarding low earnings and weak economic resilience, cocoa farmers struggle to meet household needs (Schmidt, Gilbert, Holtemeyer & Mahrt, 2020). According to Danso-Abbeam and Baiyegunhi (2020), a study conducted to assess cocoa farmers' household income and expenditure found that cocoa farming households' expenditure, excluding their farming inputs, exceeded their mean total income. This shows as inverse relationship between their income and expenditure. This has a direct impact on children in cocoa-growing communities. Children may engage in child labour because their parents cannot afford to hire adult labour (Adonteng-Kissi, 2018; Nepal & Nepal, 2012). Additionally, children in poor cocoa farming households are less likely to attend school than their higher income peers (Adonteng-Kissi, 2018). In the face of the abolishment of school fees, expenses such as textbooks and uniforms remain financial barriers for poor families. As a result, limited education prolongs inter-generational poverty as households with uneducated heads are more likely to be poor.

There is therefore the need for government and organisational bodies responsible for interventions to support cocoa farmers with intervention strategies and initiatives in strengthening their incomes and help them overcome poverty. Moreover, International Cocoa Initiative (ICI) works in cocoa growing communities throughout Ghana to mobilise Community

Service Groups which provide low-cost adult farm labour and to facilitate additional income-generating activities for women (ICI, 2017).

Small Scale Farmers

Small-scale farmers are notable in agriculture as smallholder farmers or smallholders. A smallholder is a small farm which is being operated under a small-scale agriculture model (Harris & Fuller, 2014). The definitions vary widely for what constitutes a smallholder or small-scale farm, including factors such as size, food production technique or technology, involvement of family in labour and economic impact on the family and community as a whole. According to Hlophe-Ginindza and Mpandeli (2020), small-scale agriculture presents an opportunity to improve the livelihoods of the rural poor and ensure food security. This is because, small-scale farming is often more productive and sustainable than large-scale models. This counter-narrative falls in line with the widely observed phenomenon and the theoretical debate on the inverse relationship between farm size and farm productivity (Helfand & Taylor, 2020).

Critics of the smallholder farming systems often question their productivity, efficiency, and competitiveness, given the low agricultural productivity in Sub-Sahara Africa (SSA). For instance, Collier and Dercon (2014) caution against the celebration of smallholder farms as a superior model of production. The point is, Collier and Dercon were not necessarily indifferent about the growing evidence of the efficiency of smallholder farms. Nevertheless, speaking from a methodological standpoint, they challenged such efficiency assertions, arguing that in Africa, it is usually more of a celebration of the relative successes within small farms than actual comparison with large farms.

Smallholder farms play a key role in the food security equation (Baiphethi & Jacobs, 2009). Smallholder farms are key to ending hunger and undernutrition worldwide. However, these farmers are increasingly facing barriers to household sustainability as a result of low income and profitability (Fan & Rue, 2020). According to Aliber and Hall (2012), research showed that, attempts aimed at expanding the smallholder sector by government as part of its extensive job creation strategy to support smallholder farmers as well as the growing working population have generally been costly and ineffective. The argument still stands that; smallholders should not all receive the same kind of support because they are not a homogenous group. Whereas some smallholders should be supported to move up to commercially oriented and profitable farming systems, some should be supported to move out to seek non-farm employment opportunities or even diversify their crop production (Adato & Meinzen-Dick, 2002). Thus, the reason for SL approach to encourage responsiveness and participatory.

In most African countries, farming is characterised by many small and marginal-scale farmers with small farm holdings. These farmers in question, produce only a limited number of crops which occupy comparatively large portion of the production area. These agricultural systems have degraded the natural biological interactions responsible for generating ecosystem services that are essential to agriculture, including soil fertility thus- nutrient cycling and retention, water-holding capacity, pest and disease control and pollination (Kremen & Miles, 2012). Furthermore, many of the rural farmers, who had previously managed to successfully cultivate crops for subsistence use and to supplement their income, now experience poor yields while others have ceased production. The reasons can be attributed to increased urbanization, poor productivity and competition from commercial agriculture, which is producing food more effectively and at lower prices (Masters et al., 2013).

As a result, the high reliance of cocoa smallholders on farm productivity for their income has compromised the livelihoods of many smallholder families (Arsyad et al., 2019). However, because smallholding farms frequently require less industrial inputs and can be an important way to improve food security in less-developed contexts, addressing the productivity and financial sustainability of small holders has become an international development priority which is subject to implementation because, it is being measured with indicator 2.3 of Sustainable Development Goal 2.

Also, strategies to promote smallholder agriculture as a business can help to overcome these obstacles and move smallholders with profit potential towards greater prosperity, while also contributing to the achievement of goal 2 of the Sustainable Development Goals. Notwithstanding, it is therefore, imperative that small-scale farmers adopt new technologies just like the commercialised farmers so as to increase production and, consequently, ensure food security. An improved productivity of these small farmers is the key to providing practical, sustainable solutions able to address the growing problem of food security on a global scale (Hlophe-Ginindza & Mpandeli, 2020).

Conceptual Framework

The proposed conceptual framework for the study is constructed from the reviewed literature based on the variables under study. Also, ideas and elements of the theory of trophobiosis and integrated pest management approach form the basis of this framework. Therefore, Figure 3 presents the conceptual framework of economic effects of pest and disease on cocoa production and its implication on livelihood outcomes (income) among small scale farmers in Mankranso Cocoa District. From Figure 3, pests and diseases affect the plant health. The health of the plant influences yield. Yield also predict the farmer income from cocoa production. There other explanatory variables the also affect the cocoa yield.

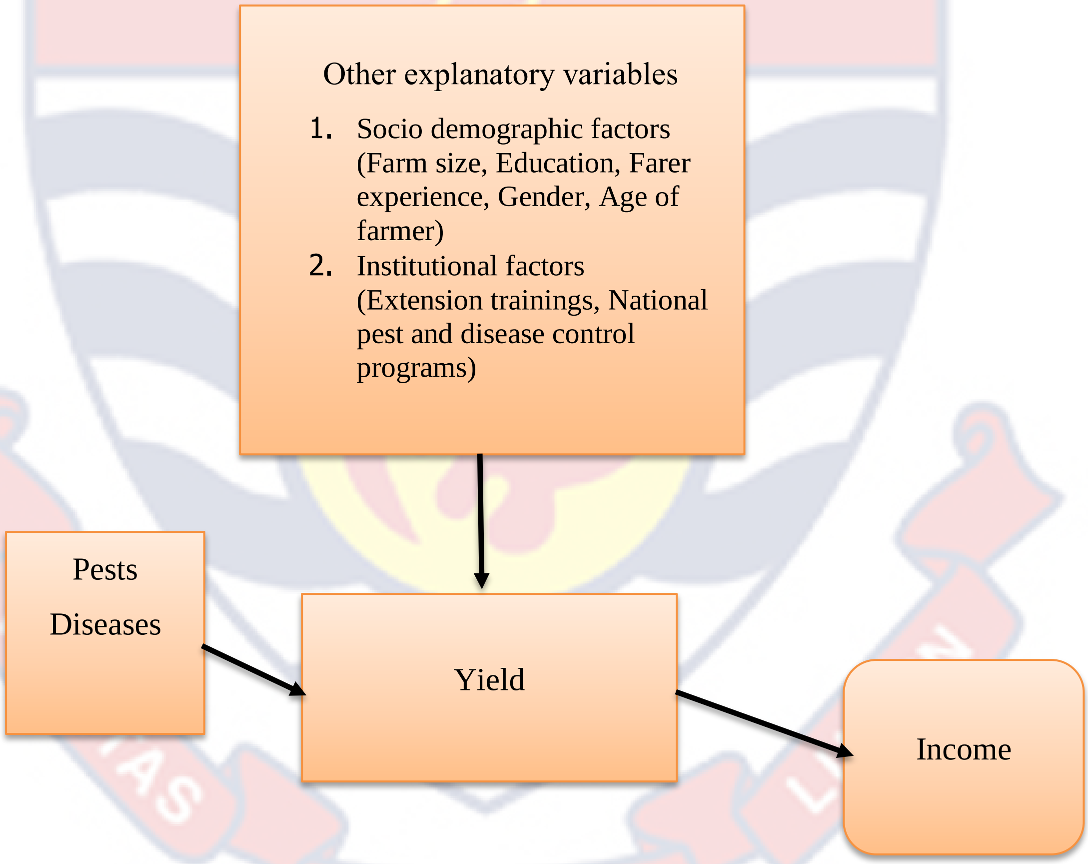

Figure 2: Conceptual Framework of Economic Effects of Pest and Disease on Cocoa yield and its Implication on Livelihood Outcomes (income) among Small Scale Farmers in Mankranso Cocoa District.

Source: Authors construct (2021).

Chapter Summary

Reviews of theories of economic development and trophobiosis, and integrated management approach were insightful as they provided detailed information on principles, assumptions and contributions to the study. Further reviews on key concepts of the study which highlighted the dimensions of cocoa production, its economic effects and implication on livelihood outcomes. Ongoing debates in literature about cocoa producer's income and food security are equally established in the reviews. Based on the conclusion drawn from literature, the proposed conceptual framework is constructed for the study (see Figure 3).

CHAPTER THREE

RESEARCH METHODS

General Overview

This chapter looks at the research design used for the study, procedures and techniques used in collecting, managing and analysing the data. It also presents the study population to be used, the sampling procedure for the study and the sample. Also, the instrument to be used for the collection of the study data, pilot-testing of the instrument, data collection procedure, data processing and analysis done per the objectives of the study.

Research Design

The study used a cross-sectional survey design to measure the outcome and the exposures in the respondent of the study at the same time. The design allows for the inclusion or exclusion of some respondent depending on the criteria set for the study and this is followed by assessing the exposure and the outcomes of the selected respondent (Setia, 2016). The measure of the exposure and the outcome of the respondent helps the research find the association between the variables of the study. This allows for the generalization of the study to a larger population from a sample to make inferences about the population characteristics (Creswell, 2011). The design does not allow for the manipulation of variables, hence enhancing the precision of the evaluation of a data point in a population. Higher precision allows for distribution of resource decrease the risk of individual respondent falling through the cracks.

The advantage of cross-sectional survey design includes the fact that it is less expensive and fast, thus, it allows researchers to collect a lot of information quickly. Due to the easy generalization of the sample to the population characteristics, there is a small merge for errors in the research, thus, maximizing the integrity of the research. Cross sectional survey design is also good for descriptive analysis and the generation of hypothesis (Beatty, Cosenza, & Fowler Jr, 2019).

However, the limitation of cross-sectional survey design includes the cost association as large sample are needed to make generalisation implying high cost of research. It is more likely to have high merge of errors if the sample size is relative small, because the findings alone could be due to chance or coincidence. It is also difficult to determine exactly if outcomes follows exposure in time or exposure rather results from outcomes. The design has an inherent limitation of not being able to verify information received from respondent.

In this research cross-sectional survey design was adopted to the data collection being a one-time data. The design was also expected to help find the inter-relationship that exist between the variables of the study, hence, enabling generalisation to be made about the population from the sample data.

Description of the Study Area

The study area of the research is Mankranso Cocoa District. Mankranso is the district capital of Ahafo Ano south district of the Ashanti region of Ghana. The area lies along 6^{o} 49'N and 1^{o} 52'W which put it is at the north-western part of the Ashanti Region with a land area of approximately 645.54km^2 representing 2.6 percent of the entire region. The district is bounded by Ahafo Ano South-East District to the North, Atwima Mponua District to the South, Atwima Nwabiagya Municipal to the East and Ahafo Ano North Municipal to the west. The district is located in the forest zone of the country, which determine the rainfall and ground water supplies.

The population of the Ahao-Ano South-West District of which the study area forms part of was estimated at 62,529 (Ghana Statistical Service, 2010). A reduction of 6,154 from the 2000 population of 68,683, representing a 1.09 percent growth. The district is mainly of an agrarian nature, which employs approximately 74.9 percent of the area labour force. Agriculture practiced in the area includes crop, livestock, fisheries, agro-forestry and non-traditional commodities. The area practices mono-cropping, mixed cropping and mixed farming. The district (area) contributes 74.9 percent to agriculture production according to the Ministry of Finance and Economic Planning (2019), which was greater than the regional average of 36.6 percent and national average of 45.8 percent. This shows that majority of the district income earned by household comes from agriculture. However, the major challenge faced by these farming households is the limited access to extension services due to the large extension to farmer ratio of 1: 2580. The major crops farmed in the study area include cocoyam, plantain, and cassava, vegetables with cash crops like cocoa and oil palm. Mankranso cocoa district is the leading district with the highest cocoa productive area in the Ashanti Region of Ghana with 22,951 cocoa farms. The district has a minimum productive area of 30,300 hectares, (Ghana Cocoa Board, 2022).

Source of data

The study used primary data which was collected from the study area for the research. The use of primary data for this study was necessary due to the absence of research work on economic effect of cocoa pest and disease in the study area. This helped to generate first-hand information on the economic effect of cocoa pest and disease on farm incomes in the study area. The primary data of the study based on the objectives conceived by this research was collected from cocoa growing areas in Mankranso cocoa district.

The Study Population

According to Singh and Masuku (2014), a study population is the entire set of units to be used in drawing a conclusion for a study. The target population of a research is made up of homogenous units, out of which a unit (sample) can be drawn to make generalization which allows for the homogeneous units. In this research, the study population is cocoa farmers in the Mankranso cocoa district. According to Ghana Cocoa Board (2020), the seven operational areas selected Mankranso cocoa district have an estimated 600 cocoa farmers. The distribution of the population is displayed in Table 1 below.

Table 1: Population of Cocoa farmers used for the study

Operational Area	Number of Farmers
Bonkwaso	84
Yawhenekrom	85
Mpasaso	88
Esssenkyiem	83
Abaasua	84

Dotiem	90
Boatengkrom	86
Total	**600**

Source: Field Data (Oppong, 2021)

Sampling Procedure

Generally, larger sample size is preferable to small sample size because the larger the sample size of a study, the lower the margin of sampling error associated and the higher the chances of the sample being representative of the study population. The study adopted the multistage sampling technique to select the cocoa farmers (sample) from the cocoa farming population of the study area. Based on the Krejcie and Morgan (1970) sample determination table, an equivalent population of 600 was given as 234 sample. A multistage sampling technique then conducted as shown below:

Stage one: The research selected Mankranso cocoa district out of 13 cocoa district Ashanti Region purposively due to it high cocoa production capacity in the district. This was also necessary to help isolate the Mankranso cocoa district from nearby districts.

Stage two: the researcher purposively selected 7 opertaional areas under the Mankranso cocoa district. This was done because all the 7 operational areas have been affected to some extent by cocoa pest and disease s in the district.

Stage three: The researcher used proportionate sampling to have the population equivalent represented in the sample (equal representation).

Table 2: Sample Size based on Operational Areas

Operational Area	Number of Farmers
Abaasua	33
Boatengkrom	33

Bonkwaso	34
Dotiem	32
Essenkyiem	33
Mpasaso	35
Yawhenekrom	34
Total	**234**

Source: Field Data (Oppong, 2021)

Data Collection Instruments

The study used a well-structured questionnaire and an interview schedule as the instruments of data collection to obtain information from respondent concerning the objectives of the study. For the instrument to be acceptable and to meet the objective of the study, the validity and reliability of the instrument were ensured by the researcher. The instrument was made up of both close ended and open-ended questions found across the four (4) sections of the instrument.

The research instruments (questionnaire) consist of 3d (3) sections as follows:

Section 1: Examine the socio-economic, socio-demographic and farm characteristics of smallholder's cocoa farmers in the study area. This section of the questionnaire was focused on the socio-economic, socio-demographic and farm characteristics of cocoa farmers, which included their age, gender, educational attainment, educational years, household size, income level, years of farming, farm size, land ownership status, farmers base organization association, source of farm income, alternative livelihood, access to credit, information and input among others.

Section 2: Identify and access the extent of disease and pest prevalence in the area. This section allowed cocoa farmers to identify pest and disease they have encountered or experience on their farm presently or in the past. This section of listed all pest and disease associated with cocoa production in Ghana according to research. The first part of the section asked cocoa farmers to identify the pest and disease based on the extent to which they have experienced it. Farmers thick the pest and disease base on the extent of experience. The second part of the section asked cocoa farmers to rate the prevalence of the identified pest and disease in terms of destruction caused on a Likert scale with 1- very low and 10- very high.

Section 3 To evaluate cocoa productivity in the study area .This section provided farmers the opportunity to account for production in the last cocoa production cycle due to farmers' poor record keeping. This section of the questionnaire asked farmers to indicate their output level and input. The cost items were costed by farmers. Also, the average price of cocoa at the year under consideration the study was asked from cocoa farmers. The cost of the control option used by the farm during the period was also asked.

Data Collection Procedure

The research employed the service of a research assistant and 4 enumerators, who were trained on the nature, structure and administering of the research instrument to the selected cocoa farmers. As part of the training, the research instrument was explained to the enumerators in English Language but due to the perceived language barrier envisaged before the study, the enumerators were equally trained on the use of the local dialect (Twi) to be used on the field. This helped respondent to understand the questions and respond to them appropriately. The research data was collection started on the 15th March, 2021. Twenty-one days were used in the data collection.

Pre-Test

The researcher undertook pilot-testing to ensure the research instrument was reliable and valid. The rational for the pilot-testing was to help the research identify possible errors that could affect the result of the study. The researcher in ensuring the quality of the research instrument ensured it readability, clarity, relevance, understanding and representative by both the administrator of the instrument and the respondent. All errors encountered during the pilot-testing was corrected and modified before the actual data collection was done.

The pilot testing was done on the 10th March, 2021 on 50 cocoa farmers in the Sabrunum operational area in the Mankranso cocoa district. The result of the pilot tested data was analysed through SPSS 25.0 to ensure that the constructs were reliable based on Pallant (2001). According to Pallant (2001), for an instrument to be reliable, its Cronbach's alpha coefficient should be 0.70 or more. Cronbach's alpha reliability coefficient was calculated to describe the internal consistency of all items measured on Likert-type scales. The result of the pretest is shown in Appendix E. The Cronbach's alpha for the pre-test was 0.918. this represent 91.8% of reliability

200 farmers responded the questionnaire out of 234 sample size of the study. This represent 85 percent response rate.

Data Processing and Analysis

The data collected from the field was entered and stored in Excel for clearing. After clearing, the data was transferred and analysed using IBM Statistical Product and service solutions version 25.0. The data collected from the study areas were analyzed based on the various objectives as follows:

Objective 1: To describe the socio-demographic and farm characteristics of smallholder cocoa farmers in the study area

. The objective was analyzed using frequency and percentages. Also, mean and standard deviation was presented for variables that were measured on ordinal scale and interval scale. Also, Cross tab was done to also find out if there exist significant association among the variables using Chi-square test.

Objective 2: To assess the prevalence and the intensity of pests and diseases in the study area . Pest and disease identified and acknowledge by the farmers was analyzed using descriptive statistics (frequency and percentages). The extent of pest and diseases prevalent in the areas were ranked using Kendall's coefficient of concordance with the pest or disease having the highest mean ranked the 1st to the last. Also, the agronomic practices engaged in by cocoa farmers was analyzed using descriptive statistics such as frequency and percentages.

Objective 3: To evaluate cocoa productivity in the study area. The objective was analyzed using appropriate economic analysis tools such as estimation of revenue, cost, revenue per hectare, revenue per output, output per hectare. Technical efficiency analysis was done to determine the productivity in the study area.

Objective 4: To determine the effect of pest and disease on farmer income from cocoa production in the study area. The objective was analyzed using appropriate economic analysis tools such as estimation of revenue, cost, revenue per hectare, revenue per output, and gross margin analysis.

Multiple linear regression was conducted to find the factors that influence income from cocoa production.

Model Specification

Gross Margin

Gross margin is derived from the difference between the total revenue and the variable cost. Variable cost comprises of all cost that changes in the production process of the farm enterprise. In most instance, the variable cost is also referred to as the operating cost like the administrative expenses and selling expenses of undertaking an enterprise. It is expected that as output increase, the cost associated fall. Therefore, cost is a function of output and total revenue a function of price and output. As the general rule, if the total revenue is greater than cost, gross margin becomes positive. If cost is greater than revenue, gross margin becomes negative. However if both are the same, then gross margin will be zero. Positive gross margin is more preferred.

Mathematically, $GM = TR - TVC$ 3.1

Hence;

$$TR = P.\,Q \qquad 3.2$$

$$TVC = f\,(Q) \qquad 3.3$$

Where; GM = Gross margin

TR= Total Revenue

TVC = Total Variable Cost

P = Price per unit of output produced

Q = Quantity of output produced

Loss and Profit

The concept of profit and loss forms the basics of an enterprise, as it vital to the long term survival of a business. Thus, the life span of a business depends on its profit worthy. Profit is the engine of any farm enterprise. In agriculture profit and loss making is not a stable concept as agriculture enterprises is mixed up in risk and uncertainties. This make profit a reward for such risk and uncertainties. Profit or loss is the difference between total revenue and cost. Where total revenue is a function of the price and output produced, while cost is a function of output. When revenue excess cost, then profit is obtained and when cost excess revenue, loss is incurred. However, there are cases where the cost of production can be equal to the revenue obtained, in this case, we say that the business has break even.

Therefore Profit and loss can be defined mathematically as;

$$\text{Profit/ Loss} = TR - TC \qquad 3.4$$

Where;

$$TR = P.\,Q \qquad 3.5$$

$$TC = TFC + TVC \qquad 3.6$$

Hence; TR = Total Revenue

TC= Total Cost

TFC= Total Fixed Cost

TVC= Total Variable Cost

P = Price per unit of output produced

Q = Quantity of output produced

Stochastic Frontier Production Function Model

Stochastic frontier production function analysis was employed to examine the productivity and technical efficiency of cocoa farmers. Technical efficiency is defined as the ability to achieve a higher level of output given similar levels of inputs (Farrell, 1957). The stochastic frontier production function independently proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977) is defined by:

$Y_i = f(\beta; X_i).\exp(v_i - u_i), \qquad u_i \geq 0$

Where: Y_i is the production of the i^th^ firm, X_i, vector of input quantities of the i^th^ firm, β, vector of unknown parameters to be estimated; v_i *is* assumed to account for random effects on production that is not within the control of the producer and u_i is a non-negative error term measuring the technical inefficiency effects that fall within the control of the decision unit.

Technical efficiency (TE) of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the farm. Technical inefficiency is, therefore, defined as the amount by which the level of production for the farm is less than the frontier output:

TE = Y_i / Y_2 where Y_2 = highest predicted output for the farm, Y_i is the actual output of the farm

Technical inefficiency = 1- TE

This study follows Donso-Abeam et al (2012) model used in estimating technical efficiencies in their work "Technical Efficiencies in Ghana Cocoa Industry". The models for the estimation of technical efficiencies are as follows;

$$\mathbf{Y = AX_1^{\beta 1}.\ X_2^{\beta 2}.X_3^{\beta 3}.}\ \varepsilon \qquad \text{(I)}$$

The linear transformation of (1) is done by taking the natural logarithm of both sides of the equation to obtain (2):

$$\mathbf{\ln Y = \ln A + \beta_1 \ln X_1 + \beta_1 \ln X_1 + \beta_3 \ln X_3 + \varepsilon i} \qquad (2)$$

Where: Y = output of cocoa beans in Kg; X1 = Labour input in man days (+); X2 = NPK fertilizer in kg (+); X3 = agrochemicals used in liters (+); Ln is the natural logarithm

The error term, $\varepsilon_i = u_i - v_i$ is composed of 2 component, the symmetric error term accounting for deviation because of factors which are out of the farmer's control (v_i) and error term accounting for the deviation because of inefficiency effects (u_i), and i= 1, 2,….n farmers.

The sigma square (σ^2) and lamda (λ) was estimated in this study using the maximum likelihood (ML) approach. The sigma square was used to determine the good fit of the model whiles lamda estimate was used in calculating the efficiency frontiers using R statistical package.

After the Cobb-Douglas production function was estimated, the inefficiency model was also estimated in the second stage by using the residuals in the first model and socio-economic variables, farm size (ha), farm management, disease prevalence and pest prevalence. Socio economic factors includes; age of farmer (years), sex (1= male, 0= female), extension training (0= no trainings, 1 = had training),

Multiple Linear Regression (MLR) Model

A system for analyzing the relationship between a number of independent variables (or predictors) and a single dependent variable (or criterion) is known as multiple regression analysis. This is extension of OLS by adding additional explanatory variables, multiple linear regression expands simple linear regression. Because we believe that the response variable is directly related to a linear combination of the explanatory variables. The model allows to predict the effect of combination of explanatory variables on the response variable.

$yi=\beta 0+\beta 1xi1+\beta 2xi2+...+\beta_n xi_n+\epsilon$ **where, for** $i=n$ **observations**

:yi=dependent variable

xi=explanatory variables

$\beta 0$=y-intercept (constant term)

x_{in}= the last independent variable

ϵ=the model's error term (also known as the residuals)

Table 4: Definition of Variables for Multiple Linear Regression

	Variables	Measurement	Expected Direction
Dependent Variable	**Income (dependent variable)**	Continuous scale	
Independent Variables			
	Gender	1-male 0- female	+/-
	Farm maintenance cost	GHC	-
	Farm size	hectares	+/-
	Extension Training	1-yes 0- no	+
	Diseases incidence	Continues scale	-
	Pest incidence	Continues scale	-

Source: Field Data (Oppong, 2021)

Chapter Summary

The chapter dealt the methodological underpinning of the research taking into consideration the study area of the research, sampling techniques, population, research instrument and the model specification. The study area of the research was Mankranso cocoa district (the largest cocoa district in terms of productive farm size). The research used the cross-sectional survey design. The study used primary data obtained through the use of the structured questionnaire with a sample size of 234 out of a population of 600 cocoa farmers in the seven operational areas selected from the cocoa district. The collected data was analyzed using SPSS 25.0. 200 farmers responded the questionnaire out of the 234 sample size selected for the study, representing 85% response rate

CHAPTER FOUR

DISCUSSION

Introduction

The chapter looks at the results obtained from analyzing the study data. The results of the study were based on the objectives of the study. The first section looked at the socio -demographic characteristics of farmers and farm level characteristics. The second section looked at the extent of pest and disease infestation in the study and the third section looking at the income from cocoa production in the study area. The last part looks at the effect pest and disease on income of cocoa farming in the study area.

Objective 1: Examine socio-demographic and farm characteristics of smallholder’s cocoa farmers in the study area

Data Collection

Data was collected from 200 farmers responded from total sample size of 234 farmers from 7 operational areas in the Mankranso Cocoa District. Out of the 200 respondents, 26 were from Abaasua, 30 from Boatengkrom, 30 from Bonkwaso, 28 from Dotiem, 30 from Essenkyiem, 29 from Mpasaso and 27 from Yawhenekrom. figure 3 below is a representation of the distribution of the respondents.

A. FARMER CHARACTERISTICS

Gender distribution of respondents

Figure 1 presents the sex distribution of the respondents. Out of the total number of respondents (200), 145 (72.4%) were male and 55 were female. This observation is in agreement with Aneani et al. (2012) and Baffoe-Asare, Danquah and Annor-Frempong (2013) who indicated that cocoa production in Ghana is male dominated. This is due to the laborious nature of the work involved. As a result, females in cocoa growing districts mostly engage in food crop production. Ogunniyi et al. (2012) also reported male dominance in cocoa production in Nigeria.

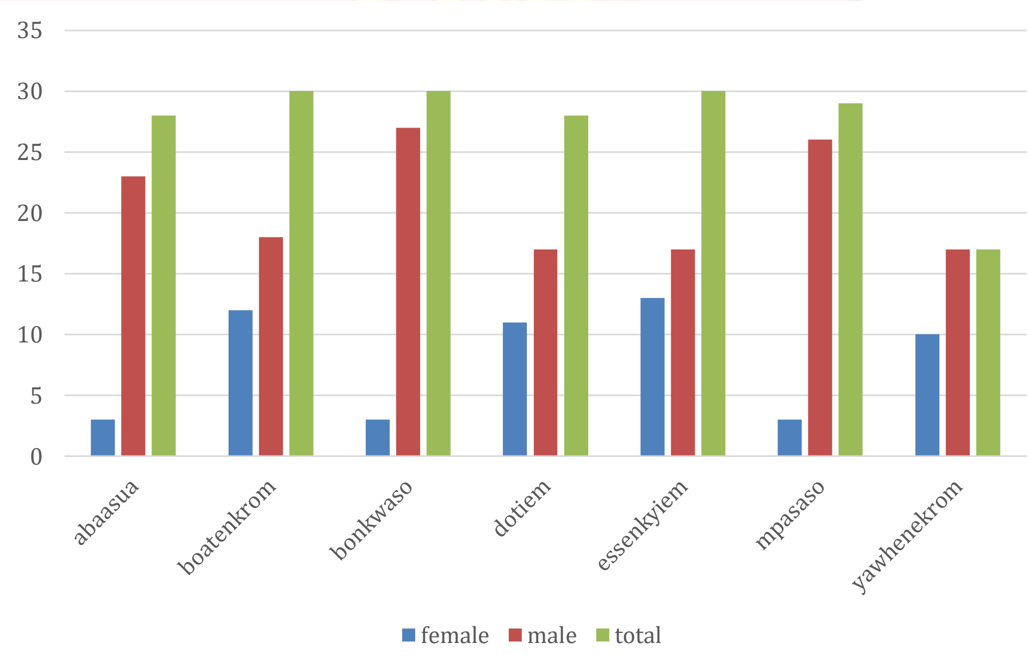

Figure 3: Sex distribution of respondents across communities

Source: Field Survey (Oppong, 2021)

Age Distribution of Respondents

From Table 5, the average age of the respondents is about 53years of which the mean age of males was about 56years and that of the females is 47years. With a maximum age of 87 years (males) and 78years (females), it means people still continue to farm cocoa well into their retirement from civil work. The average age of the farmers shows an aging cocoa farmer in the area. The age categories reveal that., 2 percent of the respondents were between the ages of 20-29years, 13.5 percent were between 30-39years, 25 percent were between 40-49years, 27.5 percent were 50-59 years, and 32 percent were 60years and above. The results further reveal that about 60percent of the respondents are above 50years, 52percent are between 40-59years, 38percent between 30-49years and 15percent less than 40years. This clearly shows an aging farmer population. The proportion of respondents below 40years perhaps indicates either lack of interest of or opportunities for the youth to go into in cocoa farming as a career. In their work, Ali, Awuni and Danso-Abbeam (2018) and Denkyirah et al. (2017) reported that the average of cocoa farmers age in Ghana was 46years. Furthermore (Okoffo et al. 2016) in their study reported that most of cocoa farmers were between the ages of 40 and 59 and their results conform with their study. Although age may positively correlate with experience, observation made by the study about the age of cocoa farmers may not be linearly correlated with the strength required to carry out the laborious activities in cocoa farming.

Table 5: Age Distribution of Respondent

Age category	sex of respondents		Total
	female	male	
20-29	1 (0.5%)	3 (1.5%)	4 (2.0%)
30-39	15.0 (7.5%)	12 (6.0%)	27 (13.5%)
40-49	20 (10.0%)	30 (15.0%)	50 (25.0%)
50-59	10 (5.0%)	45 (22.5%)	55 (27.5%)

60+	9 (4.5%)	55 (27.5%)	64 (32.0%)
Total	55 (27.5%)	145 (72.5%)	200 (100.0%)

Source: Field Survey (Oppong, 2021)

Highest Educational Level of respondents

The educational level of farmers plays a crucial role in farmer literacy and their production decision making processes. The figure 4 presents result on the highest educational attainments of the respondents. The results revealed that majority (52.5percent) of the respondents had primary level of education, about a fifth (19.5 percent) had secondary school level education, 2.5percent had tertiary, 1percent had Vocational/technical and about a 24.5% of cocoa farmers in the study area had professional certificate education. None of the respondents was without some form of formal education. Based on this, coupled with the level of experience, it can be assumed that the farmers interviewed had adequate appreciation of the knowledge cocoa pests and diseases and their impact on socio-economic circumstances.

Avane, Amfo, Aidoo and Mensah (2021) and Aneani et al. (2012) reported that the average level of education for most cocoa farmers in thei study of cocoa farmers were primary school. This they attributed to parents taking them out of school to assist on cocoa farms. Another reason is the absence of schools in some cocoa districts, requiring people to travel for several miles often on foot to attend school. This is a demotivating factor for schooling in many cocoa communities in general and study area in particular.

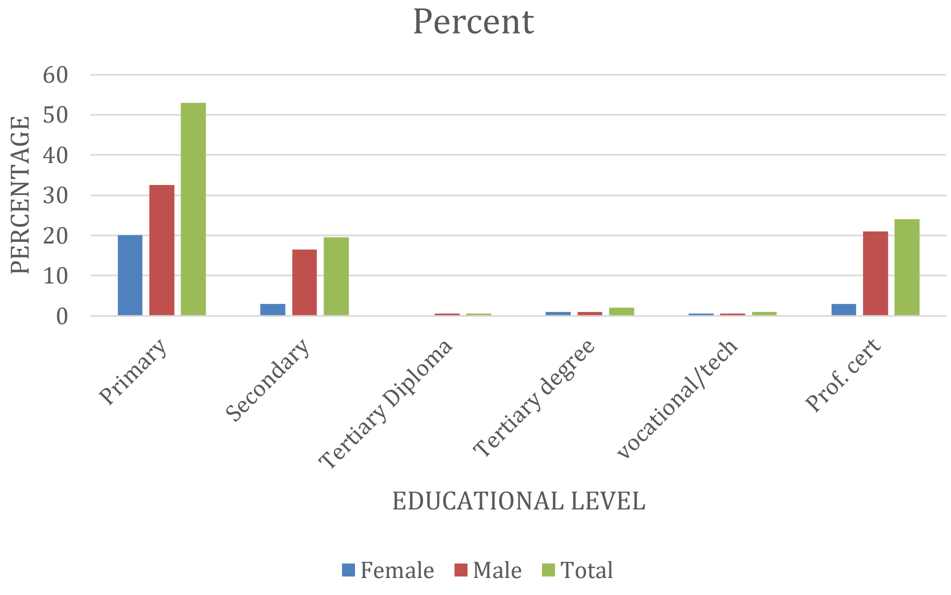

Figure 4: Educational Level of respondents

Source: Field Survey (Oppong, 2021)

Years of Experience in Cocoa Farming

Experience is important because it allows us to make more accurate decisions in uncertain situations. The more experience we have, the more accurate the outcomes of our decision. Generally, farming experience refers to the time a farmer has spent in the farming occupation since he/she started making independent production decisions. As farmers accumulate experience over time, they gradually switch from outmoded agricultural technologies to improved technologies on the basis of observed performance and learning by doing (Ainembabazi & Mugisha 2014). On-farm experiences shape farmer is knowledge, perceptions and management practices (Osterman, Landaverde-Gonzalez, Garratt, Gee, 2021).

The results on cocoa farming experience is presented in Table 6. In all, 80percent of the respondents have over 10years cocoa farming experience, and about 57percent have more than 15years of experience. In all, the minimum cocoa farming experience is 3years, the maximum is 48years and the average is about 19years (male: 20years, female: 14years). The respondents are thus very experienced in cocoa farming and this reflects a higher likelihood of deeper understanding of issues relating to cocoa pests and diseases.

Experience in cocoa farming

Table 6: Farmers Experience in Cocoa Production

experience in cocoa farming	sex of respondents		Total
	female	male	
<6yrs	4 (2.0%)	7 (3.5%)	11 (5.5%)
6-10yrs	12 (6.0%)	17(8.5%)	29 (14.5%)
11-15yrs	19 (9.5%)	26 (13.5%)	45 (22.5%)
16-20yrs	7 (3.5%)	29 (14.5%)	36 (18.5%)
21-25yrs	10 (5.0%)	29 (14.5%)	39 (19.5%)
26-30yrs	1 (0.5%)	7 (3.5%)	8 (4.0%)
30+yrs	2 (1.0%)	30 (15.0%)	32 (16.0%)
Total	55 (27.5%)	145 (72.5%)	200 (100.0%)

Source: Field Survey (Oppong, 2021)

Membership of farmer organization, extension contacts and extension visits

Agricultural extension is aimed primarily at improving the knowledge of farmers for rural development. It plays a critical role in farmer technology transfer and facilitation of rural development. It identifies farmers' problems for further investigation Danso-Abbeam et al. (2018). According to them, lack of adequate extension contacts and inadequate extension services have been identified as one of the main limiting factors to the growth of the agricultural sector and rural community development at large. Okoffo, Mensah and Fosu-Mensah (2016) reported that cocoa farmers receive limited number of extension visit from extension agents. Membership and participation in farmer group; such as cooperative activities provide farmers with opportunities to access various benefits including extension contacts.

The study asked if the respondents belonged to a farmer group, if they had extension contact of any form, and also indicate the number of extensions visits they received on their farms. From the results in Table 7, 194 (97%) of the respondents belonged to a farmer group. Similarly, 194 (97%) also responded to receiving or participation in extension agent contact. Related to that, a significantly greater proportion of farmers (189: 94.5%) who had extension contacts are members of farmer group. This suggests a significantly strong relationship between farmer group membership and access to extension services. On extension visits, 90% of the respondents indicated to have received visits. Out of this, 74 (37%) received a visit, 61 (30.5%) received two visits, 28(14%) received three visits, and the remaining received more. This suggests although a greater proportion of farmers in the study area have extension contact, most of them are only able to receive a limited number (up to two) of extension visits. Contradictory to Okoffo, Mensah and Fosu-Mensah (2016), who reported that cocoa farmers receive limited number of extension visit from extension agents. This increase in extension visit is as result of mass recruitment which increase the number of extension field staff to over 1500 in 2019.

Table 7: Extension contact * farmer group membership Crosstabulation

	Response	
Contact with extension agent	no	yes
	11 (5.5%)	189(94.5%)
Farmer group membership	6(3.0%)	194 (97.0%)

Extension agent visits

Extension agent visit	No. of visits	Frequency	Percent
194 (97.0%)	0	20	10.0
	1	74	37.0
	2	61	30.5
	3	28	14.0
	4	16	8.0
	6	1	.5
	Total	200	100.0

Source: Field Survey (Oppong, 2021)

Farm size of cocoa farmers in the study area

In cocoa farming, farm size correlates with the resource requirements and the expected outputs at the end of the season. The results on the farm sizes presented in Table 8, which shows that the farm sizes of the respondents ranged between 0.8hectares and 20hectares. About 26% of the farms are 2 hectares or less and about 45 percent are between 2.1 and 4 hectares. Together, over 70 percent of the farms are 4 hectares or less in size. The mean farm size is about 3.6ha. The result of the study compares favorably by Asamoah and Owusu-Ansah (2017) who reported on average farm size of 2 to 3 hectors and that of Wessel and Quist-Wessel (2015) reported in their work, Cocoa production in West Africa, a review and analysis of recent developments that majority of cocoa farmers have 2 or less hectors of farm size.

Also, the results agree with Huetz-Adams et al (2017) work findings that reported that Ghanaing cocoa farmers cultivate 3.65 hectares of cocoa on average, with the most owning between 2 and 5 ha.

Table 8: Farm Size of Respondent

farm size in hectares	sex of respondents female	male	Total
<2.1ha	23 (11.5%)	29 (14.5%)	52 (26.0%)
2.1-4.0ha	28 (14.0%)	63 (31.5%)	91 (45.5%)
4.1-6.0ha	4 (2.0%)	35 (17.5%)	39 (19.5%)
6.1-8.0ha	0 (0.0%)	14 (7.0%)	14 (7.0%)
8.1-10.0ha	0 (0.0%)	3 (1.5%)	3 (1.5%)
>10.0ha	0 (0.0%)	1 (0.5%)	1 (0.5%)

Source: Field Survey (Oppong, 2021)

Objective 2: Identify prevalence and intensity of disease and pest prevalence in the area.

Prevalence and Intensity of Cocoa Pests

The prevalence cocoa pests were assessed based on the pests experienced by famers on their farms during the cropping year. Also, pest intensity was assessed based on the extent or level of economic damage caused by the pests rated on a scale of 1-10 (see the results in Table 9). The prevalence of cocoa pest was assessed by farmer confirmation of pest experience on their farms during the course of the year followed by a rating of the level of devastation of the pest experienced. From the results in Table 9, nine (9) cocoa pest infestation were confirmed in the area. These pests included; aphids, anomis, capsid, cocoa pod borer, mealy bug, mistletoe, stem borer, stink bug and termites (in alphabetical order). Out of these pest Table 8, five pests were more prevalent. These are capsid (99% of cases), misletoe (97.5% of cases), termites (96% of cases), anomis (90.0% of cases) and stem borer (84.5% of cases). The minor prevalent were mealy bug (45% of cases), cocoa pod borer (39.5 of cases%), stink bug (27 of cases%) and aphids (18% of cases).

Table 9: Pest Prevalence and Intensity in the Study Area

Pest	Pest prevalence			Pest intensity		
	Responses		Percent of			
	N	Percent	Cases	Mean	Std. Dev	Mean Rank
Anomis	181	15.2%	90.5%	7.2	2.768	6.45
Capsid	198	16.6%	99.0%	8.85	1.54	7.89
Cocoa pod borer	79	6.6%	39.5%	4.35	2.81	3.64
Cocoa shoot borer	54	4.5%	27.0%	3.49	2.729	2.63
Mealy bugs	90	7.5%	45.0%	4.22	2.457	3.41

Mistletoes	195	16.3%	97.5%	7.58	2.139	6.76
Stem borer	169	14.2%	84.5%	6.51	2.714	5.3
Stink bug	36	3.0%	18.0%	3.37	3.092	2.63
Termites	192	16.1%	96.0%	7.2	2.404	6.3
		100.0%	597.0%			

Source: Field Survey (Oppong, 2021) n=200

Based on the mean and the mean rank of, the pest intensity (devastation rating) in Table 8, Capsid(Akate) was the most devastating disease (M:8.85; MR: 7.79), followed by Mistletoe (M:7.58, MR:6.76), Anomis (M:7.20, MR:6.45), Termites (M:7.20, MR:6.30) and Stem borer (M:6.51, MR:5.30). Less devastating pest were Cocoa pod borer (M: 4.35, MR: 3.64), Mealy bug (M: 4.22, MR: 3.41), Stink bug (M:3.49; MR: 2.63) and the least being Aphids (M: 3.37, MR:2.63).

The results of the study is in line with Aneani and Ofori-Frimpong (2013) who found out that Capside pest of cocoa has in recent times caused major havoc for cocoa production in Ghana. The Kendall W indicated that there was a 57 percent agreement among cocoa farmers as to the devastating extent of effect of these pests in their cocoa farms.

Awudzi et al (2021) reported that Capsid (Mirids) is most dominant cocoa pest in their study. Also Anikwe (2010) reported that the cocoa stem borer, which was previously recorded in Nigeria as a small insect pest, is quickly emerging as a serious pest of cocoa. This shows how devastating stem borer as a pest in cocoa has risen in recent times. Futhermore, Djuideu, et al (2021) reported in their study that terimite is attaining a major pest status in Africa. The study recorded 96% of cases of termite's attack. It was found that

Figure 6: Termites destroying stem of the cocoa source: Oppong 2020

Figure 7: Severe termites' infestation of cocoa tree. source: Oppong 2020

The mean and mean rank of the pest intensity presented in Table 9 suggests that most devastating pest is capsid (M:8.85, MR:7.89), followed by Mistletoes (M:7.58, MR:6.76), Anomis (M:7.20, MR:6.45), Termites (M:7.20, MR:6.30), and stem borer (M:6.51, MR:5.30) respectively. The less devastating pests were Cocoa pod borer (M:4.35, MR:3.64), Mealy bugs (M:4.22, MR:3.41), Cocoa shoot borer (M:3.49, MR:2.63), and Stink bug (M:3.37, MR:2.63) being the least.

Awudzi et al. (2021) reported in their study Farmers' knowledge and perception of cocoa insect pests and damage and the implications for pest management on cocoa in Ghana that cocoa mirids is the leading cocoa pest over the years. They concluded that cocoa mirids causes an estimated 18 percent loss in cocoa production. Djuideu et al. (2021) also reported that termite is the leading cocoa pest in West Africa causing cocoa yield losses of 1000’s of tonnes. The study agrees with Aneani and Ofori-Frimpong (2013) who found out the Capside pest of cocoa has in recent times caused major havoc for cocoa production in Ghana.

Prevalence and Intensity of Cocoa Diseases

The prevalence of cocoa diseases was assessed by farmer confirmation of diseases experience on their farms during the course of the year followed by a rating of the level of devastation of the diseases experienced. From the results in Table 10, seven (7) cocoa diseases were confirmed in the area. These included Black Pod, Phythopthora canker, Pink disease, Root disease, Swollen shoot (CSVD), Vascular streak Dieback and Witches broom (in alphabetical order). Out of these, two diseases were more prevalent and these are blackpod (100% of cases) and Vascular Streak Dieback (75.9% of cases).

Table 10: Disease Prevalence and Intensity in the Study Area

	Disease prevalence			Disease intensity		
	Responses N	Responses Percent	Percent of Cases	**Mean**	**Std. Dev**	**Mean Rank**
Black Pod	199	31.9%	99.5%	9.12	1.512	6.55
Phythopthora canker	71	11.4%	35.7%	3.64	3.403	3.33
Pink disease	42	6.7%	21.1%	3.28	2.903	3.16
Root disease	46	7.4%	23.1%	3.41	3.069	3.25
Swollen shoot (CSVD)	94	15.1%	47.2%	5.10	3.074	4.1
Vascular streak Dieback	151	24.2%	75.9%	5.92	2.733	4.85
Witches broom	20	3.2%	10.1%	2.95	2.628	2.77
Total	623	100.0%	313.1%			

Source: Field Survey (Oppong, 2021) n=200

The least prevalent diseases were Swollen shoot (CSVD) (47.2%), Phythopthora canker (35.7%), Root disease (23.1%), Pink disease (21.1%), and Witches broom (10.1%). Based on the mean and the mean rank of the disease intensity (devastation rating) in Table 10, blackpod disease was the most devastating disease (M:9.12; MR: 6.55), followed by Vascular Steak dieback (M:5.92, MR:4.85) and swollen shoot (M:5.10, MR:4.10). Less devastating diseases were Phythopthora canker (M: 3.64, MR: 3.33), Root disease (M: 3.41, 3.25), pink disease (M:3.28; MR: 3.16) and the least being witches broom (M: 2.95, MR:2.77). The model was a good fit as no interdependence was recorded with an asymptotic significance of $p < .05$. This indicates there are significant difference among the various cocoa diseases (chi-square= 556.957). The Kendall W indicated that there was a 47 percent agreement among cocoa farmers as to the devastating of extent of these diseases. From the results there is a strong positive correlation between the prevalence and the intensity of the disease.

This notes that, much attention must be paid to devise strategies to address the infestation of the black pod disease because it contributes majority of pod loss which affect cocoa yield negatively.

Similar study conducted by Guest (2007) reported that black pod disease causes an estimated cocoa yield loss of up to 20 to 30 percent with annual tree death of 10 percent due to its activities. The study is further supported by Adeniyi et al (2019) study in West Africa that reported that black pod disease causes an estimated 30 percent to 90 percent of losses in cocoa yield. .

The results of the study agree with Mbarga et al. (2020) who reported that black pod disease was the major cause of cocoa loss in Cameroon. Oduro, Apenteng and Nkansah (2020), Adeniyi et al (2019) and Akrofi et al. (2017) studies in Ghana confirms the findings of this study as they reported that the Ghanaian cocoa sector is affected dominantly by the black pod disease despite various government intervention to reduce it spread.

Agronomical Practices

Cocoa farmers carry out several agronomics practices in ensuring their farms are secured and kept healthy. The results as shown in Table 11 shows that, nearly all (99.9%) of the farmers engage in disease control. Off the 199 respondents interviewed, (99%) of the respondents as part of the agronomic practices engage in weed control. Again, (98%) engage in fertilizer application, whiles (97.5%) control pest on the cocoa farm. Furthermore, it was revealing that, (82.5%), and (78.5 %) respectively engage in early harvesting and removal of disease and over ripped pods. Meanwhile a few cocoa farmers (about 16%) of the respondents practice irrigation on their cocoa farms.

Table 11: Agronomical Practices

Practices	**Yes**	
	Frequency	**Percent**
Disease control	197	99.9
Mass CODAPEC	131	65.5
Pruning	127	63.5
Fertilizer Application	196	98.0
Weed control	198	99.0
Early harvesting	165	82.5
Irrigation	32	16.0
Pest control	195	97.5
Sanitary harvesting	158	78.5

Source: Field Survey (Oppong, 2021) **n= 200**

Marty-Terrade and Marangoni (2012) reported that the main agronomical practices of cocoa farmers are the frequent harvesting and post-harvest treatment. Wessel and Quist-Wessel (2015) also reported that agronomic practices such as pest and disease control, maintaining soil fertility and good harvesting practices have been the main agronomic practices of cocoa farmers in Ghana. Akrofi-Atitianti et al. (2018) added that the basic agronomic practices have to do with wed control, fertilizer application and spraying of agrochemicals. The results of the study clearly show the farmers in the study area practices different agronomic activities in the area especially disease control.

Objective 3: To evaluate the income from cocoa production in the study area.

Output and Revenue from cocoa production.

From Table 12, the minimum yield per farmer was found to be 4 bags (256kg) and maximum yield was 85 (5440kg) bags with an average yield of 22.4 (1433.6kg). Also, average yield per hector 7.64 bags which represent 488.3 kilogram of dried cocoa beans. The average income per hector is 5041.2 Ghana cedis with an average maintenance cost of 3249.9 Ghana cedis.

Table 12: Cocoa Output Analysis in the Study Area

Output	Minimum	Maximum	Mean	Std. Deviation
Yield per farmer (kg)	256.00	5540.00	1433.6	801.28
Yield per hectare (kg)	64.00	1792.00	188.3	256.00
Revenue per farmer (cedis)	2640.00	56100.00	14576.10	8263.50
Revenue per hectare (cedis)	660.00	18562.50	5041.24	2646.71

Source: Field Survey (Oppong, 2021) n=200

The study agrees with Bymolt, et al (2018) who reviewed that past literature in their study Demystifying the cocoa sector in Ghana and Côte d'Ivoire shows an average of cocoa per hector is between 400 and 530 kg/ha.

Coulter and Abena (2010) reported that if farmer practice good agricultural methods, production can increase to 1000–2000 kg per hectare. Also work done by Aneani and Ofori-Frimpong (2013) revealed that an experimental potential yield of cocoa is 1898.3kg of per hectare representing 29.7 bags of dried cocoa beans. They also revealed in their findings that farmer potential yield was 1875.1kg of cocoa output per hectare representing 29.3ba gs of dried cocoa beans.

From this, it could be seen that there is a huge yield gap in the study area. The difference between experimental yield per hectare (1898.3kg/ha) reported by Aneani and Ofori-Frimpong (2013) and the actual yield in the study per hectare (488.3kg/ha) gives a yield gap of 1410kg/ha representing 22 bags of dried cocoa beans in Ghana.

Technical Efficiency

This section presents the results of the stochastic production frontier that measured the technical efficiency levels of cocoa production in the Mankranso district. The estimation results of the stochastic production frontier and the inefficiency effects are presented in Tables 13 and 14, respectively. Figure 8 displays the distribution of technical efficiency levels among cocoa producers in the study area.

The maximum likelihood estimates of the stochastic Cobb-Douglas production frontier and the inefficiency model were estimated simultaneously (one-stage estimation) following the Battesse and Coelli (1995) approach with the use of R software (version 4.2.3). A generalised likelihood ratio test was conducted for the two models: Cobb-Douglas and Translog, with a formulated hypothesis where the null hypothesis was to subject the technical efficiency modelling to the Cobb-Douglas model against the alternative hypothesis for the Translog model to show which of the two functions is the best fit for the data. The result was insignificant, with a chi-square value of 8.369. The test results for data collected from the study area show that the Cobb-Douglas functional form should be accepted. Hence, the Cobb-Douglas model is the best fit for the data.

Since the Cobb-Douglas model is the best fit for the data, its estimates have been presented to discuss the results of the technical efficiency. The estimated sigma square value of 0.18 was significant at a 1% alpha level, which shows a good fit for the model and the correctness of the specified distributional assumptions. The estimated gamma is 0.644, and it is highly significant at less than 1%. It implies that 64.4% of the deviations in the total outputs are largely as a result of technical inefficiency (factors are within the cocoa farmers' control), whereas 35.6% of the deviation is as a result of random shocks. Some of the random shocks could be pest and disease infestations, unfavourable weather conditions, measurement errors, etc. (Onumah et al., 2013). It implies that policies that target the technicalities of production for efficient production will significantly impact the performance of cocoa farmers. It also shows a good fit for the model since it is significant.

From the table 13, the output responded positively to labour but negatively to insecticide and fertiliser (NPK). The insecticides were significant in determining the level of cocoa output. The result in the table shows that a percentage increase in insecticides results in a 0.756% decrease in cocoa output. This finding is similar to Danso-Abbeam et al. (2012), who reported that agrochemical intensity of insecticide and rate of insecticide application are determinants of cocoa output in their work on technical efficiency in Ghana's cocoa industry. The inputs, especially the insecticides, should be efficiently used to ensure an optimal level of cocoa output.

Table 13: Maximum likelihood estimates of stochastic Cobb-Douglas Production Frontier Model of Cocoa Farmers.

Variables	Coefficients	Standard Error
Intercept	2.998***	0.476
lnLabour	0.097	0.080
lnInsecticides	-0.756***	0.131
lnFertilizer (NPK)	-0.006	0.047
Variance Parameters		
Sigma Squared (σ^2)	0.180***	
Gamma (γ)	0.644***	

Distribution of Technical Efficiency Scores of Cocoa Farmers

The distribution of the technical efficiency scores of cocoa productions in the study area, as presented in the Figure 8, varies widely among cocoa producers, ranging from a minimum of 19.98% to a maximum of 95.13%. This shows that none of the cocoa farmers was fully efficient (technically). The wide variation in the technical efficiency estimates can be associated with differences in the efficient allocation and use of resources among the cocoa farmers (Yevu & Onumah, 2021).

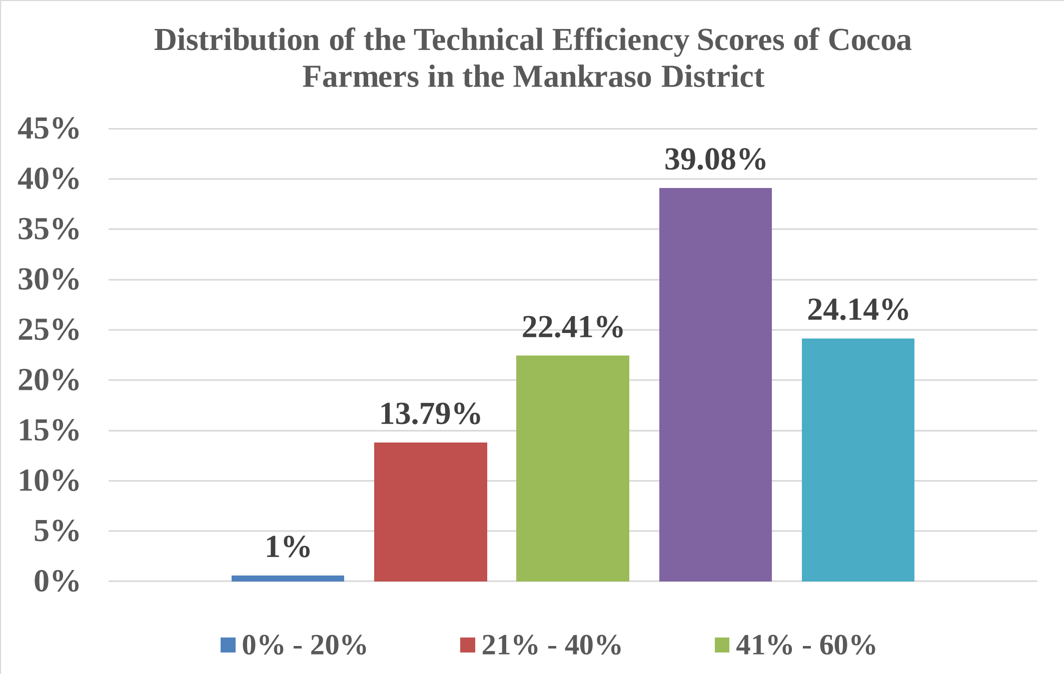

Figure 8: Distribution of Technical Efficiency Scores of Cocoa Farmers in the Mankranso District

The mean efficiency of the cocoa farmers was estimated to be 64.5%. This implies that there is scope for cocoa farmers in the study area to increase their output by 35.5% by adopting new technologies, practices, and the efficient allocation of resources for the production of cocoa (Yevu & Onumah, 2021). The finding of this study is in line with Binam et al. (2008), who estimated 74%, 65%, and 58% as technical efficiency values of cocoa producers in Nigeria, Cameroun, and Côte d'Ivoire, respectively, as cited by Danso-Abbeam et al. (2012) in their work, Technical Efficiency in Ghana's Cocoa Industry.

The majority (39.08%) of cocoa farmers are technically efficient from 61% to 80%, followed by 24.41% of the cocoa farmers with technical efficiency scores between 41% and 60% and 24.14% with technical efficiency ranging from 81% to 100%. However, only about 1% (approximate value) of the farmers were technically efficient, ranging from 0% to 20%.

Determinants of Technical Efficiency of Cocoa Production in the Mankranso District

Table 14 shows the results of the inefficiency model. Farm management (pruning, early harvesting, sanitary harvesting, pest and disease control), farm size, and disease prevalence were found to be significant determinants of technical efficiency in cocoa production in the study area. Disease prevalence was found to reduce farm productivity. When the cocoa plant is affected by diseases, the health of the plant is negatively affected, which reduces the plant's ability to produce at optimum levels. Farm size was found to increase the technical efficiency level of cocoa farmers. Thus, farmers who operated on larger farms were more technically efficient than their counterparts who operated on smaller farms. This implies that, as farm size increases, cocoa farmers become more technically efficient in their production of cocoa, which reflects an increase in their outputs. This finding is in line with the findings of Nkamleu and Ndoye (2003) and Danso-Abbeam et al. (2012), who stated that increases in cocoa output have been attained by increasing the farm area.

Farm management was also found to be an important factor in increasing cocoa farm technical efficiencies. As the farmers improve their management practises (disease control, pruning, weed control, early harvesting, irrigation, and pest control), the cocoa yield will significantly increase. The results of the study support Kongor et al.'s (2018) work on constraints for future cocoa production in Ghana, which concluded that effective farm management techniques, such as spraying for black pod and capsids, pruning, and fertilizer application, would significantly increase cocoa productivity and, consequently, farmer income.

Table 14: Determinants of Technical Inefficiency of Cocoa Farmers in the Mankranso District

Variable	Coefficient	Standard Error
Intercept	2.388***	0.515
Age	-0.003	0.005
Formal education	-0.187	0.153
Extension training	0.423	0.331
Extension visits	-0.263	0.057
Sex	0.019	0.112
Pest prevalence	-0.025	0.049
Diseases prevalence	-0.074*	0.040
Farm size	-0.174**	0.078
Farm management	-0.216***	0.0547

NB: *, **, and *** signify the level of significance at 10%, 5%, and 1%, respectively.

OBJECTIVE 4: **Effect of Pest and Disease on Farmer Income from Cocoa Production in the Study Area**

Table 15: Economic analysis on Cocoa Production

Revenue/cost (cedis)	Mininum	Maximum	Mean
Revenue per Hectare	660.00	18562	5041.24
Maintenance cost per Hectare	400.00	4370.00	1060.44

Gross Margin per Hectare	-1400.00	15487.00	3980.80

Source: Field Survey (Oppong, 2021) n=200

In Table 14, the average cost of maintaining a hectare of land was 1060.44 Ghana cedis. The highest maintenance cost per hectare was 4370.00 Ghana cedis and lowest maintenance cost was 400.00. the average revenue on a hectare of cocoa land was 5040.24 Ghana cedis. This give average gross margin of 3980.80 Ghana cedis on a hectare of cocoa produced. This implies that, the gross profit from cocoa production on land was 3980.80 Ghana cedis only.

Table 16: Regression on factors influencing income from cocoa production

Variables	Coefficient	P values
Constant	3.592	0.118
gender	-0.441	0.660
Farm Size	-0.122	0.049*
Extension Training	0.232	0.000***
Disease Incidence	-0.170	0.015**
Farm maintenance cost	-0.418	0.000***
Pest incidence	-0.005	0.939

P value = 0.05, N = 200, R square = 0.357

A multiple linear regression was conducted to investigate the factors that influence income from cocoa production in the study area and the result is presented in Table 15. The dependent variable was income (gross margin per hectare) and independent variables were management cost, farm size results indicate that, fertilizer application and disease control on the cocoa farm influences the overall yield of cocoa produced in the study area. These variables altogether recorded an adjusted R- square value of (r= 0.357) at p >0.05. This indicates that the prediction or relating variables that influences income from cocoa predicted income by (35.7%). The positive beta coefficient associated with extension training on income means that, a unit increase in extension training in the study area increases income by (0.232) and it was significant on the income. The negative beta coefficient associated with farm maintenance cost demonstrates that a unit increase in farm maintenance cost decreases income of cocoa by (-0.418). Farm maintenance coast was highly significant on the income. For a farmer to get higher income, then he should either maximize output to get more revenue or minimize his maintenance cost. Furthermore, the negative beta coefficient associated with farm disease incidence incidence demonstrates that a unit increase in diseasese incidence in the study area decreases income from cocoa farming in the study area by (-0.170).

Diseases incidence in the study area was significant. This implies to increase income from cocoa farming in the study areas the farmer should improve disease. It could be clearly seen that if a farmer pays less attention disease control, his cocoa output will be reduced which will also decreases. This is further support by Adeniyi et al (2019) study in West Africa that reported that black pod disease causes an estimated 30 percent to 90 percent of losses in cocoa yield. Thus, a reduction in yield as results of disease will lead to income from cocoa production. Similar study by Aneani and Ofori-Frimpong (2013) reported that cocoa farmer's ability to control disease was significant to predicting cocoa yield but not fertilizer application. Thus, disease control increases farmer's income. Also, Ploetz (2016), reported that cocoa diseases caused 20% decrease in cocoa yield in 2012. Also farm size was statistically significant on the yield. The negative coefficient on of the farm size suggests that a unit increase in the farm size decreases farmers revenue by (-0.122). Farm, size was statistically significant. From regression table above, although pest incidence was not statistically significant but a unit increase in the pest incidence in the study area reduces the income by (0.005)

In summary, disease incidence, far maintenance cost, extension training and farm size have significant effect on the income from cocoa farming in the study area.

There was no significant effect between the pest and income hence the null hypothesis for pest on income was accepted.

In the other hand, there was significant effect between the diseases and income, hence the null hypothesis for disease on income was rejected.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This last chapter of the study presents the summary of the study. It specifically highlights the methodology used for data collection and data analysis as well as the ley findings, conclusions drawn and the major recommendations for policy.

Summary of the Study

This survey was carried out in Mankranso to assess the economic effect of pest and disease on cocoa production and its implication on income (income from cocoa farming) among small-holder farmers in Mankronso cocoa district. Mankranso is the district capital of Ahafo Ano south district of the Ashanti region of Ghana. The following research questions guided the study:

1. What are the socio-demographic and farm characteristics of small scale cocoa farmers in the study area?
2. What are the prevalence and intensity of pests and diseases?

   prevalence in the study area?
3. What is the productivity of cocoa production in the study area?
4. What is the impact of pest and disease of cocoa on farmer's income in the study Area?

The study used descriptive a cross-sectional survey design using questionnaire as the main instrument to elicit data that addresses the specific research questions posted in the study. The study adopted the multistage sampling technique so select the cocoa farmers (sample) from the cocoa farming population of the study area using three stages of sampling. At stage one, the communities that fell under the Mankranso cocoa district were purposively selected. For stage two, the researcher purposively selected 7 cocoa growing operational area where there is high level of disease infestation. At the final stage, the researcher purposively selected cocoa farmers' base on the criteria below; must be a cocoa farmer for more than 1 year, should have had issues with cocoa pest and disease before, must be the owner or care taker of the cocoa farm, and finally the farmer selected should have a past yield records from his farm. In all a total of 200 out of the 234 sample size responded the questionnaire using a validated research instrument. The study employed both descriptive and inferential statistics were used to analysed the data. Precisely the descriptive statistics were analysed using frequencies and percentages especially the demographic characteristics and standard deviations as well as inferential statistics. The Kendall's coefficient of concordance, regression and cost benefit analysis were used to analyse objective three and four.

Key Findings

The following findings were obtained after the discussion of the results.

1. Majority of the farmers were between the ages of 41-60 with most having primary school qualification with about 12years of farming experience.

2. An overwhelming majority of the farmers have access to agricultural extension services and have attended trainings on good agricultural practices (GAP).
3. Most of the farmers were members of farmer-based organization.
4. The main diseases that infest cocoa in the study area are Black Pod and Vascular Streak Dieback.
5. Again, the major pest that attack cocoa in the study area were Capside, Stem borer, Anomis, termites and Mistletoes.
6. Termites was emerging as major pest in the study area
7. The mean technical efficiency in the study area was estimated to be 64.10%
8. Farm size, management practices and disease incidence were factors that affect cocoa farmers efficiencies in the study area.
9. There significant effect of extension training, disease incidence, farm size and farm maintenance cost on the income from cocoa farm in the study area
10. There is no statistically significant difference between pest and income in the study area.
11. There was significant difference between disease and income from cocoa production

Conclusion

There should policy that will attract the youth into the cocoa production industry to replace the aging farmers. The issues with child labour education should properly explained in context so that the next generation should not be eliminated but equipped with skill to successfully take over from their aging parents.

Stakeholders to extension can take advantage of farmer-based groups for training and knowledge dissemination to the cocoa farmers.

Furthermore, stakeholders in the cocoa industry should find effective way to reduce pest and diseases identified in the study diseases to reduce their impact on cocoa yield and income.

In addition, management practices such as pruning, pest control, disease control, sanitary harvesting and early harvesting influence yield. If farmers want to increase their output, then they have to improve their farm management practices.

Moreover, the study concludes the termites is becoming major pest in the study area.

Also, on a hectare of land, a farmer gets average income of 3980.80 Ghana cedis only from cocoa production.

Lastly, diseases in the study area should be controlled effectively to limit its effect negative effect on the farmer income from cocoa production.

Recommendations

1. Cocoa farmers in the study area are aging as a result, the Ministry of Food and Agriculture, COCOBOD and other Stakeholders must ensure that strategies are put in place to enable the youth to venture into cocoa production to replace the aging populace.
2. Most of the farmers in the study area have basic education and so MoFA , COCOBOD and other stakeholders must institute training programmes to

sensitize cocoa farmers on the use of improved technologies and management practices. this to expose the farmers to modern technologies to curb disease and pest infestation.

3. MoFA, COCOBOD and other stakeholders, in the cocoa value chain should take advantage of the farmer's association during trainings since majority of the farmers interviewed were members of farmer's associations. This would make it easy to reach out many farmers within a short possible time.
4. Cocoa farmers in the study area, COCOBOD and MoFA should pay attention to Black Pod and Vascular Streak Dieback which impacts negatively on the yield of farmers and their income. Measures must be put in place to reduce the impact of these diseases or remove them completely.
5. In addition, COCOBOD, MoFA and other direct stakeholder in the cocoa industry should strategies to reduce the Impact of Capside, Stem borer, termites, Anomis, and Mistletoes.
6. MoFA , COCOBOD and other stakeholders must endeavours to supply subsidize fertilizer and cheap labour for farmers to ensure timely fertilizer application, regular weed control and maintenance of the cocoa farms to help control cocoa pest and diseases. Irrigation must be also subsidizing to farmers to increase their yield.
7. COCOBOD, Local Authorities, Farm Based Organisation and MoFA should strengthen existing disease and pest programs in the study area to reduce disease incidence

Suggestions for Further Research

1. Similar study should be replicated in all the cocoa growing districts in Ghana to establish the extent of disease infestation in the cocoa farms.
2. Further studies can be conducted using purely qualitative methodology to ascertain the effect of disease infestation on cocoa yield.
3. The effect of cocoa mass spraying should be assessed to find its effectiveness to pest and disease control.

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APPENDICES
APPENDIX A
UNIVERSITY OF CAPE COAST
DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

This study is designed to examine **"economic Effect of pest and Disease on Cocoa production and its implication on livelihood outcome (income) among small scale farmers in Mankranso cocoa district"**. You have been identified as individual to provide information to achieve the objectives of the study. The interaction session is expected to last for about 15 minutes. Please respond frankly to the questions on this questionnaire/Interview Schedule. Be assured that all the information that will be provided will be used for the intended objectives and will be kept confidential. Your name and phone number have been requested to assist us reach you again for follow up questions.

IDENTIFICATION PARTICULARS

Name of enumerator: ……………………………………………
Date of interview: ……………………………………………….
Name of respondent: ……………………………………………
Questionnaire number: …………………………………………..
District: ………………………………………………………….
Community: ……………………………………………………...

Section 1: Socioeconomic Characteristics of Farmers

1. Gender of respondent? Female [ ] Male [ ]
2. How old are you? ……………………………. (years)
3. Marital status of respondent? Single [ ] Married [ ] Cohabitation [ ] Divorced [ ] Widowed [ ]
4. What is your religion? Christian [ ] Muslim [ ] Traditionalist [ ] Others [ ]
5. Ethnicity: ……………………………………………………….
6. What is your Educational level? No formal [ ] Primary[ ] Secondary[ ] Vocational/Technical [ ] HND/Diploma [ ] Degree[ ] Professional certificate [ ]
7. Years of formal Education ………………………… (years)
8. Household size ……………………………………….
9. Status of respondent in the household: 1. Head 2. Spouse 3. Child Other: ……
10. How many,

	Male	Female
<18 years		
18- 36 years		
37- 55years		

>55 years		

11. How many years have you been farming ……………………………………….. (years)
12. What is your farm size ……………………………………………………….(acres)
13. Are you a member of any farmer group? Yes [ ] No [ ]
14. If yes, mention ……………………………………………………………
15. What is your occupation? Primary …………………. Secondary ……………………..
16. What is your average monthly income (GH₵) ……………………………………..
17. Do you have contact with extension agents? Yes [ ] No [ ]
18. How many times in the past year have you had visit(s) from extension agent…………..
19. What is the status of your farm land? a. Own land [ ] b. Lease [ ] c. Family land [ ] d. Rented [ ] e. others (please specify)……………………
20. Apart from cocoa farming, what other enterprise does this household engage in? (Tick as appropriate) About how much per week do you make from the sources?

		YES /NO	N. K
Farming	Crop		
	Livestock		
Trading			
Hunting			
Civil service			
Wage labour			
Artisans			
Tailoring			
Others (specify)			

21. Who do you sell your produce to? a. Cocoa marketing firms ( ) b. Individuals ( ) c. Cooperative society ( ) d. Cocoa Board ( ) e. Others (specify) ( )
22. Where do you sell your cultivated cocoa? a. Farm gate ( ) b. in the market ( ) c. in the house ( ) d. others (specify)
23. Do you use any form of micro credit or loan for your farming activities a. Yes ( ) b. No ( )
24. What is your source of income? Farming [ ] Trading [ ]Teaching [ ] Others, specify
25. What is your source of credit for farm? (**Choose all that apply**) a. Self-financing b. Family/friends ( ) c. Bank loan ( ) d. Farmer group/co-operatives ( ) e. NGOs () f. Other (Please Specify) ……………………………..
26. What is your source of farm labour? a. Hired ( ) b. Family labour ( ) c. shared labour ( ) d. Other (Please Specify) ……………………………..

Section 2: Extent of pest and disease prevalence in the study area.

a. Please indicate if any of the following pest or disease has been experience on your farm before. Please after identifying the pest or disease rank them according to the most experienced over the years.

Pest/ Disease	**Thick box if pest is experienced**
Diseases	
Black Pod	
Witches broom	
Pink disease	
Swollen shoot	
Vascular streak Dieback	
Phythopthora canker	
Root disease	
Pest	
Capside	
Anomis	
Stem borer	
Termite	
Stink bugs	
Mistletoes	
Cocoa pod borer	
Cocoa shoot borer	
Mealy bugs	

b. Please indicate the rate of prevalence of the pest and disease identified in a on your farm. The rate of prevalence of the pest and disease affecting yield is placed on a Likert scale with 1- very low to 10- very high.

Pest/ Disease	1	2	3	4	5	6	7	8	9	10

Diseases										
Black Pod										
Witches broom										
Pink disease										
Swollen shoot										
Vascular streak Dieback										
Phythopthora canker										
Root disease										
Pest										
Capside										
Anomis										
Stem borer										
Termite										
Stink bug										
Mistletoes										
Cocoa pod borer										
Cocoa shoot borer										
Mealy bugs										

Section 3: Determine economic value of yield infested.

With reference to your cocoa production activities in the 2020, please complete the table below.

Production measures	**2020**
Actual output	
Disease/pest output	
Price per bag	
Cost of controlling pest/disease	
Maintenance cost	

APPENDIX B

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1563111106.308	6	260518517.718	17.825	<.001[b]
	Residual	2820740848.075	193	14615237.555		
	Total	4383851954.384	199			

a. Dependent Variable: gross margin per hectar

b. Predictors: (Constant), fmSizeha, extVisits, SUMDISEASES, management cost per hectare, sex, SUMPEST

Residuals Statistics[a]

	Min	Max	Mean	Std. Deviation	N
Predicted Value	-1695.09	25191.35	4245.36	2802.64691	200
Residual	-12812.68	34733.64	.00	3764.91396	200
Std. Predicted Value	-2.12	7.47	.00	1.000	200
Std. Residual	-3.35	9.09	.00	.985	200

a. Dependent Variable: gross margin per hectar

APPENDIX C

```
> lrtest(Opp_Cobb_Douglas)
Likelihood ratio test

Model 1: OLS (no inefficiency)
Model 2: Efficiency Effects Frontier (EEF)
  #Df  LogLik Df  Chisq Pr(>Chisq)
1   5 -96.158
2  13 -86.224  8 19.867   0.006375 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
1


#RESULTS OF THE TRANSLOG FUNCTION OF THE SFA

> Opp_Translog<-
sfa(lnYPH~lnLAB+lnINS+lnNPK+lnLABlnLAB+lnNPKlnNPK+lnINSlnINS
+lnINSlnNPK+lnINSlnLAB+lnNPKlnLAB|age+educ+fmSizeha+extVisit
s+EXTTRAINING+sex, data=EbenOppong)
> summary(Opp_T41, extraPar=TRUE)
Efficiency Effects Frontier (see Battese & Coelli 1995)
Inefficiency decreases the endogenous variable (as in a
production function)
The dependent variable is logged
Iterative ML estimation terminated after 33 iterations:
log likelihood values and parameters of two successive
iterations
are within the tolerance limit

final maximum likelihood estimates
                Estimate Std. Error z value  Pr(>|z|)
(Intercept)     0.3823968  3.3836479  0.1130  0.910020
lnLAB           0.8764582  1.1712861  0.7483  0.454287
lnINS          -2.6850212  1.2965173 -2.0709  0.038364 *
lnNPK           0.6439600  0.7102749  0.9066  0.364600
lnLABlnLAB     -0.2772055  0.2231810 -1.2421  0.214212
lnNPKlnNPK     -0.1314141  0.0966223 -1.3601  0.173805
lnINSlnINS     -0.4252349  0.2352445 -1.8076  0.070664 .
lnINSlnNPK      0.1730822  0.1488915  1.1625  0.245044
lnINSlnLAB      0.3304082  0.1781767  1.8544  0.063684 .
lnNPKlnLAB     -0.0009511  0.1269699 -0.0075  0.994023
Z_(Intercept)   1.1315597  0.5964669  1.8971  0.057814 .
Z_age          -0.0120333  0.0088895 -1.3537  0.175847
Z_educ          0.2453864  0.2978898  0.8237  0.410082
Z_fmSizeha     -0.1808667  0.1190025 -1.5199  0.128547
```

```
Z_extVisits   -0.2584533  0.1331774 -1.9407  0.052298 .
Z_EXTTRAINING  0.2647069  0.3814613  0.6939  0.487727
Z_sex          0.1289889  0.1960270  0.6580  0.510528
sigmaSq        0.2940555  0.1024247  2.8709  0.004092 **
gamma          0.7767059  0.1147485  6.7688 1.299e-11 ***
sigmaSqU       0.2283947  0.1067635  2.1393  0.032415 *
sigmaSqV       0.0656609  0.0230540  2.8481  0.004398 **
sigma          0.5422689  0.0944409  5.7419 9.363e-09 ***
sigmaU         0.4779065  0.1116991  4.2785 1.881e-05 ***
sigmaV         0.2562438  0.0449845  5.6963 1.225e-08 ***
lambdaSq       3.4783984  2.3014021  1.5114  0.130680
lambda         1.8650465  0.6169825  3.0229  0.002504 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
1
log likelihood value: -82.90096

cross-sectional data
total number of observations = 174

mean efficiency: 0.6806064
```

```
#LIKELIHOOD RATIO TEST OF OLS AND THE TRANSLOG FUNCTION
(SFA)

> lrtest(Opp_Translog)
Likelihood ratio test

Model 1: OLS (no inefficiency)
Model 2: Efficiency Effects Frontier (EEF)
  #Df  LogLik Df  Chisq Pr(>Chisq)
1  11 -94.945
2  19 -82.901  8 24.087    0.00123 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
1
```

```
#LIKELIHOOD RATIO TEST OF THE COBB-DOUGLAS FUNCTION AND THE
TRANSLOG FUNCTION

> lrtest(Opp_Cobb_Douglas,Opp_Translog)
Likelihood ratio test

Model 1: Opp_Cobb-Douglas
Model 2: Opp_Translog
  #Df  LogLik Df  Chisq Pr(>Chisq)
1  13 -86.224
2  19 -82.901  6 6.6465     0.3548
```

APPENDIX D

Kendall's W Test of pest Intensity

Test statistics	
	Pests
N	200
Kendall's W[a]	.568
Chi-Square	908.313
Df	8
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

APPENDIX E

Reliability Test

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	50	25.1
	Excluded[a]	149	74.9
	Total	199	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.918	17