KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI - GHANA

COCOA FARMERS' KNOWLEDGE AND PERCEPTION OF HAND POLLINATION AND ITS EFFECT ON THEIR PRACTICES AND YIELD.

A CASE STUDY OF TAFO COCOA DISTRICT, EASTERN REGION-GHANA.

By

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MASTER OF SCIENCE

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DECLARATION

I hereby declare that this submission is my own work towards the MSc and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

One of the leading products that is supplied on the world market from Ghana is cocoa. The cocoa sector alone employs millions of people and in the early 1960's Ghana was recorded to be the leading producer of cocoa. However, there has been a decline in the current production of cocoa which has been attributed to many factors such as pest and diseases infestations, poor maintenance, ineffective and inefficient extension system, lack of cocoa production among others. Currently, various researchers are dwelling into the application of hand pollination to increase the production of various food crops which cocoa is not an exception. The study seeks to determine farmers' knowledge and perception of hand pollination and its effect on the output or yield of cocoa and on their farm practices by using the Tafo district as a case study. Using structured questionnaires, a total of one hundred and ten (110) cocoa farmers were selected by simple random sampling techniques. The socio-economic characteristics such as gender, age, educational level, marital status, migration status, farming experience, farm size, age of cocoa trees among others were the factors on which data were collected. The data was further analyzed using descriptive analysis, the probit and Tobit model was developed to also determine farmers' knowledge and perception respectively and then the test of association between farm size and output was done using the Pearson Chi-square statistic. It was observed that male dominated the cocoa farming industry and majority of the farmers had at least basic level of education. Educational level, farm size, gender, age and farming experience were observed to have an influence on farmers' knowledge on the application of hand pollination. While the size of farm also influences the farmer's perception on the application of hand pollination; a positive relationship with the output of cocoa farmer existed. This implies that an increase in the productivity of cocoa might somehow depend on the size of the farm. This is because when a larger size farm is hand pollinated, there is the likelihood of an increase in output.

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DEDICATION

This work is dedicated to God Almighty for seeing me through life till now and the successful completion this project. Also, to my lovely wife and children for their prayers and support throughout my studies.

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I give thanks to the Almighty God for the precious life, wisdom, guidance and strength granted me to enable me school to this level.

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CHAPTER ONE

INTRODUCTION

The importance of cocoa to the world economy has led to a plethora of documentation on its cultivation, production, as well as its contribution to the global economy. Having recognised that pollination plays a major role in crop production; integrated crop production strategies are being incorporated to enhance production and they include pollinator-friendly and conservation modules which cocoa is not left out. This thesis evaluates cocoa farmers' knowledge and perception of hand pollination and its effect on their practices and yield. The chapter is divided into five main sections namely; the background of the study, statement of the problem, objectives, the research questions and lastly, the justification of the study.

1.1 Background of the Study

The saying that “Cocoa is Ghana” and “Ghana is cocoa” undoubtedly depicts that cocoa remains the major economic crop in Ghana. *Theobroma cacao L* (Sterculiaceae) which is the scientific name for cocoa is an important tree whose origin is believed to be from the native areas of the tropical rainforest of equatorial America or the Upper Amazon. The ‘food for the gods’ which is the common name given to cocoa grows more productively and profitably with latitude 20 degrees North and 20 degrees South according to Bailey et. al. (2005). But within latitude 10 degrees North and 10 degrees South is within which the bulk of the crop is produced (Kwapong et al, 2014).

Cocoa is the third most exported commodity in the world and comes just after coffee and sugar. In several tropical countries, the cocoa sector which happens to be a major economic resource, employs over 800,000 small farms families (Asamoah and Anang, 2013; Ofori-Frimpong et al.,

2007). For many decades sub-regions of West Africa grows about seventy percent of the world's cocoa (World Cocoa Foundation, 2010). A leading subsector in the growth and development of many economies in West Africa compared to other agricultural activities has been cocoa (Daguma et al., 2001).

The second largest producer of cocoa after Ivory Coast is Ghana and together, both countries represent approximately 72% of the production of world cocoa (ICCO, 2007; Vigneri, 2007). Ghana has seen cocoa to thrive in regions with high humidity, ample rainfall accompanied by high temperature (Mann, et al., 2010). As a result, about six regions which often records rainfall of about 1000-1,500 millimeters per year are ideal for the production of cocoa (MoFA, 2003). Over the years, the volume of cocoa produced in Ghana has seen a steadily growth, though there has been some ups and downs in recent years. Ghana is recorded to have a lower yield of cocoa per hectare (360 kg ha-1) among major producing countries such as Malaysia which has an average cocoa yields of 1,800 kg ha-1 and Ivory Coast which records a cocoa yield of 800 kg/ha (Anon., 1999). The major reason for low productivity in Ghana has recently been attributed to the incidence of pests and diseases as well as low pollination due to some cultural practices which affects pollinators. There is therefore the need to include pollinating agents in factors that affect productivity since pollination services results in increased production and higher quality of crops (Roubik, 1995).

1.1.1 Ecology of Cocoa Pollination

A major and critical determinant on farmers income and also in the production of food has to do with seed and fruit formation; a key process in *pollination.* The scientific study of the relationship between plant-pollinator and their environment is what we refer to as pollination ecology and it involves the floral phenology, histories, distribution as well as the behaviour of

individual species accompanied with its structure and function of natural systems at the populations and ecosystem levels. The impact of pollinators is crucial in crop production although the management of pollination systems are relatively new and rarely tried (Kearns et al., 1998). Pollinator services especially insects are under-appreciated because studies which are normally down with respect to insects are usually geared towards the management and also control of pests rather than actually encouraging pollination and pollinator acts (Clark et al., 1982 and Roger et al., 2004). This applies to cocoa with all its unique qualities (Bos et al., 2007). The synchronization among pollinator population cycle, the adequacy of pollination and the floral phenology of cocoa trees are significant issues of cocoa pollination (Young, 1983). Cocoa requires cross pollination which is mainly effected by midges belonging to Ceratopogonidae and Cecidomyiidae.

One limiting factor that regulates the setting of fruit in cocoa production has to do with the fact that cocoa is entomophilous and dependent on cross-pollination by insects (Winder and Silva, 1972). Since 1925, pollination of cocoa has been the major and one of the interesting subjects, yet not much is actually known when it comes to the mechanisms of the pollination that leads to and plays major role in contributing to the production of the fruits. Reports indicates that about 90% of the cocoa flowers produced drops immediately after opening leaving just 10% out of the total flowers that are produced to get the chance to successfully pollinate (Bos et al. 2007). This small proportion of the number of flowers produced out of the total number that becomes successfully pollinated leaves a delicate balance between crop success and failure; an assertion supported by (Entwistle, 1972; Stephenson, 1981; Free, 1993), who argued that the reproductive system of cocoa is described base on the number of flowers of which about 5% proceed to develop into mature fruits. Hence, the enhancement of knowledge on both natural and artificial

pollination leading to large crop yield and the characteristics of the cocoa tree and its flowers must be of necessity.

1.2 Statement of the Problem

Ghana Cocoa Board (COCOBOD) over the years has covered several interventions projects and programmes such as rehabilitation projects, canopy substitution, etc., as a means of increasing productivity and enhancing cocoa sustainability. The sector has also recorded a significantly high production level of 740,458 tonnes in 2005/2006 crop year which peaked at one million twenty-three thousand (1,023,000) tonnes by the year 2010/2011. Since then, annual average production has been around 750,000 tonnes (COCOBOD, 2014).

In spite of these interventions, the problem of low yields or productivity persists after the peaking period. Short to medium term policy initiatives towards increasing and sustaining production include adoption of recommendations of farming technologies by Cocoa Research Institute (CRIG) to farmers through Cocoa Health and Extension Division (CHED) and also through regular farmer education and training on good agronomic practices. Others include intensification of pests and disease control and application of fertilizers through the CODAPEC and HI-TECH programmes as well as free distribution of hybrid cocoa seedlings to rehabilitate old unproductive cocoa farms while establishing new ones.

All these have not been able to curb the low productivity of cocoa by farmers in Ghana. Even though one cannot argue to the globally acknowledged fact about the economic importance of cocoa, much is not known about the factors that promote it yield. Low extension support in Ghana has been cited as one of the major constraints for low productivity in the sector. Likewise, other factors such as poor maintenance, diseases attack and pest infestations also contributing to low yield and productivity. It has been observed that serious intensification

measures in crop cultivation especially with the use of technology transfer can lead to higher yields per unit land area (ICCO, 2011). One of the most called out approach in recent times has to do with cocoa pollination. Most studies done on cocoa pollination were between the early 1950's and late 1970's. The cumulative result is that the level of concentration given to cocoa pollinators in literature is minimal leading to paucity of relevant literature on cocoa pollination especially hand pollination.

Hand pollination 'a purposeful human interference' of cocoa is a technology that has been practiced by the Ghana Cocoa Board (COCOBOD) since 1960 for the production of hybrid seed pods for distribution to cocoa farmers. Although this technique has been established as the most productive way of multiplying cocoa seed pods. Presently, only 10% to 20% of flowers produced by cocoa plants are successfully pollinated through the natural means, leaving almost 80% to 90% of the flowers to go waste posing a serious consequence on cocoa yields (CRIG, 2010). The high success rate of the hand pollination technology is evident in SPD Seed Gardens, as it resulted in an average of 50 pods per tree as against 12 pods observed from naturally pollinated cocoa tree (SPD, 2015).

In addition, introduction of hand pollination project on farmers' farms by COCOBOD which literature has not addressed may have some limitations, and farmers may also have their understanding or perception about this. It is therefore necessary to undertake such a study to assess farmers knowledge about pollination in general, their knowledge on the government's intervention of artificial pollination, whether they are willing to do it themselves and their general perceptions about hand pollination and determine its effects on their farm practices and yields. This study will test if farmer perception and knowledge on hand pollination has changed and how this activity has influenced their farm practices and yields.

1.3 Aim and Objectives of the Study

The aim of the study is to establish the importance of pollination on cocoa yields.

The study seeks to:

i. Determine factors that influence farmers' perception on hand pollination use within the Tafo Cocoa District.

ii. Determine factors that influence farmer's level of knowledge on the hand pollination techniques.

iii. Identify the relationship between farmers' knowledge, perception and each of the independent variables of farmers on the use of hand pollination and general effect on farm practices and yield.

1.4 Research Questions

These objectives raises a number of questions that need to be answered, hence, the following set of questions were set to respectively achieve the three objectives of the study.

1. Are cocoa farmers aware of the concept of pollination particularly hand pollination?

2. Do cocoa farmers undertake as part of their management practices how to conserve pollinators?

3. Are there implications with respect to their knowledge towards the use of hand-pollination practices in the cocoa industry?

1.5 Justification of the Study

The study is of importance in the sense that it adds to knowledge and literature in the area of hand pollination of cocoa in Ghana by paving the way for future research in the cocoa industry for farmers in this sector. This is because to the best of the researcher's knowledge, there are few studies done on the perception and knowledge of farmers about their decision to pollinate their farms by hand also its effect to yield in the cocoa industry of Ghana.

The findings and recommendations from the study will benefit policy makers, management and farmers in the Ghanaian cocoa industry as well as create or redefine available systems that will help farmers achieve their performance target.

Appropriate policies that will enhance growth in the cocoa industry in the country can be formulated from the findings of this study by policy makers. Furthermore, the findings and results will provide more realistic scientific information on the challenges that has to do with farmers understanding about certain key policies introduced and advocated in this sector. It will also bring to lime light the effects of farmers' perception about the implementation of hand pollination.

Similarly, the study will provide a more reliable guide that will help stakeholders, management etc. in designing a workable policy for delivering and achieving farmers satisfaction and loyalty. To the board of directors and government agencies that happens to be the main policy makers, the study will provide insights on the reasons why the use of hand pollination are sometimes compromised and the challenges involve in operating it by farmers.

To achieve national agenda of modernizing agriculture, there is the need to step up technology adoption in agricultural production and making farming a technology driven enterprise. This can

be achieved through promotion of technology adoption among farmers by facilitating their access to information and eliminating inherent barriers and constraints to technology adoption. To facilitate technology adoption, policy makers and implementers should have clearer understanding of factors affecting technology adoption among farmers and the challenges and constraints facing farmers in accessing and adopting technologies. Such understanding should be borne out of empirical assessment of farmers' situation, their perceptions and attitudes towards technologies being disseminated to them. As such findings of this study which sought to examine farmers' perceptions and adoption of improved maize technologies is very important and handy as it presents information on how farmers think about the available cocoa technologies and how these views influence their adoption decision.

1.6 Research Methodology

The study will employ a case study approach that will also make use of survey methodology involving the use of structured questionnaires; stratified random sampling procedures with the data being analyzed using IBM SPSS version 22. The study will be conducted in Tafo Cocoa District in Eastern Region, Ghana. The collected data from respondents will be analyzed and numerical simulations involving charts, bar graphs etc. will be use in the analysis.

1.7 Scope of the Study

The study will be limited to the Tafo Cocoa District which is bounded by four administrative or political districts with 10 operational areas containing smaller communities. A total of 110 cocoa farmers will be interviewed (50% beneficiaries; 50% non-beneficiaries) with at least 11 farmers from each operational area where pollination took place.

1.8 Limitation

The study was skewed to concentrate only on cocoa farmer's knowledge and perception of hand pollination and its effect on their practices and yield at the Tafo cocoa district in the Eastern region of Ghana neglecting the other regions such as Western, Volta, etc.

1.9 Organisation of the Study

The thesis is made up of five chapters. The first chapter describes the general introduction and covers the background of the study, statement of the problem, objectives, research questions, delimitation, significance, research methodology, and organisation of the study. The review of studies that had been done by other researchers form the second chapter. Chapter three takes into account the methodology employed while Chapter four presents the results and discussion by performing the analysis obtained from the findings of the study. The summary, conclusion and recommendations are presented in the last chapter.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Although the significant impact of cocoa to the world cannot be questioned leading to a large documentation about its cultivation, production and contribution to the world especially Ghana, majority of the research done are skewed towards the socio-economic factors, agronomical (Osei-Bonsu et. al., 2002), soils and fertilizers studies (Appiah et al., 2000), as well as integrated pest management with very little work done on the studies of insect pollinators and related species. This section seeks to review relevant literature pertaining to the subject matter of the thesis. Firstly, the historical nature of cocoa production in Ghana as well as some government agricultural policies, the structure and stability of the Cocoa Flowers making inference on fruit setting will be reviewed theoretically and then proceed to understand the factors that affect the production of cocoa. Furthermore, reviews on pollination and cocoa pollinators that is the ecology of cocoa pollinators would be looked at since important gaps still remain in this regard. Lastly, the perception farmers have in the cocoa industry would also be reviewed.

2.1 History of Cocoa Production

The origination of cocoa can be traced from the headwaters of the Amazon (Manu, 1989). Cocoa which is an important commercial crop has its cultivation and value spread in ancient times throughout central and Eastern Amazonian towards the north through to Central America. Furthermore, it is planted extensively in areas that share borders with the Gulf of Guinea in West Africa; notably Dahomey, Nigeria, Ghana, Cote d'ivoire, Sierra Leone, Togo and Liberia

(Kishore, 2010). Records from the Ministry of Manpower, Youth and Employment, 2007, shows that, the missionaries from Dutch were credited to be the first people to grow cocoa along the coastal areas of the then Gold Coast now Ghana as early as 1815, with the Basel missionaries also giving the farming of cocoa a try by planting cocoa at Aburi in the year 1857. But, these efforts by these missionaries did not yield a positive result for the spreading of cocoa cultivation until one man who was an indigene of Osu by name Tetteh Quarshie brought Amelonado pods of cocoa from Fernando Po in the year 1879 and tried it at Akwapim Mampong by establishing a farm there. Cocoa cultivation began to spread when farmers bought cocoa pods from Tetteh Quarshie's farm to plant. The government of Ghana in recognition of the contribution of cocoa to the development of Ghana established the Ghana Cocoa Board (COCOBOD) in the year 1947 to be the main government agency responsible for the development of the industry. It is indicated in the study of Ensminger et al. (1995), which a Swedish botanist by name Linnaeus having observed the reputation gained by cocoa assigned the plant species to genus named *Theobroma cacao L.* - which literally means the “food for the gods”. About 1.6 million Ghanaians are recorded to be small farmers that produce cocoa on plots in forest areas that are less than three hectares (ha) (ESDD, 2002).

With respect to the exportation of cocoa to Europe; the very first exportation was dated 1585 which was from Veracruz to Cadiz. With the subject of exportation, Ghana has seen a remarkable increase in the level of tonnes of cocoa it has exported over the years. In the year 1900, Ghana exported about 546.72; this figured increased to 2,856.00T in 1905 and in 1936 about 317,220T was exported and that figure represented half of the total world production at that time (Manu, 1989). However, according to Adjinah and Opoku (2010), Ghana became the leading producer of cocoa in the year 1964/1965. Although the early 1960's saw Ghana becoming the world's largest cocoa producer, by the early 1980's the production of cocoa in Ghana had dwindled almost to the

point of insignificance. Factors recorded to have attributed to the drop of cocoa production from more than 450,000 tons per year to a low 159,000 tons in the year 1983/84 includes the increasing aging of trees, bad weather, widespread disease, as well as low producer prices. In the work of Clark, 1994, a revision in the figures shows that cocoa production in the year 1988/89 amounted to 301,000 tons; with the year 1990/91 recording 293,000 tons; and 305,000 tons were recorded in 1992/93. The year 1993-1994 saw a decline of the crop to 255,000 tons but the crop was projected to return to the range of 300,000 tons in the year 1994/1995.

With six out of ten regions recorded to produce cocoa, the main seasons identified to be the production period in Ghana are classified as the light crop season which normally begins from September to June, and from October to May, which is normally the main crop season. A lot of activities go into the cultivation of cocoa starting with planting, and then proceeding to maintenance, harvesting, drying and then bagging the beans for either exportation or marketing.

The main varieties of cocoa that are produced in Ghana are of three types, namely; Amelonado, Amazonia and Hybrid (COCOBOD, 2009; Tudhope, 1909). The Amelona and Amazonia have the longest duration which takes about five (5) years to bear fruit whilst the hybrid requires just three (3) years of gestation period. Maintenance is the activity that is carried out within this period in order to ensure good yield. This involve the activities such as spraying, fertilizing and weeding with these processes going on until harvesting time which comes as a result of the yellowish nature of the cocoa pods. According to Clark (1994), farmers perform these measures with the quest to increase cocoa production.

2.2 Government Agricultural Intervention Policies

Agricultural policy as defined by Mundia (1991), is an instrument that is used to influence the allocation of resources within the agricultural sector. From 1975 till date various governments have embarked on several policies with the hope of making the agricultural sector more profitable. Some of the policies include but not limited to the provision of extensions and inputs to farmers, credit facilitators which has been a very important actor in the market, disease and pest control (CODAPEC) programme, agricultural pricing policy, hi-technology programme (CHTP), etc.

The year 2001 saw a remarkable change of agricultural policies in the cocoa sector, even though it was not acknowledged (Nyanteng and Sieni, 2000) in that period. According to them, when it comes to agricultural policies, the only periods to consider is the year 1970-1982 and from 1983 to 1995, a period they grouped as pre-and post-structural adjustment periods due to the political instability during those periods. Some of the policies that were implemented during those periods include the return of the monopoly system of cocoa purchase, import controls, subsidization of imported consumer goods, as well as operation feed yourself (a policy that was aimed at achieving self-sufficiency in food production). The Economic Recovery Programme (ERP) was launched in the period from 1983-1995 to review the structures that are hindrance to economic growth. The main goal was to restructure the state's institutions and it was supported by the World Bank in order to increase the production and marketing of cocoa. This led to new name given to it as Structural Adjustment Programme (SAP).

With respect to pricing policy, Cuong (2000), defined it as a policy that is concern with the influence of the level of prices received by farmers and paid by consumers for farm products. It can however be defined in a lay man's term as government strategies that affects agriculture

input prices and outputs. According to Rao (1989), the input price relates to fertilizers, interest and wage rates as well as prices of tractors. Agriculture pricing has been categorised by many researchers (Krueger, 1996; Cuong, 2000) as direct and indirect. Direct pricing policies includes government procurement, import tariff, quota system and subsidies with the indirect pricing consisting of exchange rate and credit policy.

With the policy of Cocoa Disease and Pest Control (CODAPEC) programme, which is popularly known as Cocoa Mass Spraying Programme, the goal was to control pest and diseases that affect production and also to help minimize the cost farmers incur on insecticides in order to also boost their morale to put in their maximum best in the cocoa industry. In the studies done by Akosa (2001), it was observed that the introduction of the mass spraying activity increased production to over 580,000 tons.

The economic activities that is mostly related to the cocoa sector consists of production, which then moves to transportation, quality control and lastly marketing of cocoa. The goal is to come out with policies in these areas in order to help improve the cocoa industry. The inconsistencies in the implementation of these policies had led to difficulty in putting in place certain institutional structures.

2.3 Structure and Stability of Cocoa Flowers

One allogamous tropical woody species that was formerly in the *Sterculiaceae* family before reclassified in the *Malvaceae* family according to Alverson et al. (1999) is cocoa. Cocoa's fruit characteristics and seed as well as it geographical distribution categorised it into two groups namely; Criollo also known as *Fine Cocoa* and Forastero also known as *Theobroma leiocarpa*, though a third group known as the mixed or hybrid cocoa which is believed to have originated from the hybridization between the Forastero and Criollo group has been observed (Cheesman,

1944). The Forastero type of cocoa forms the bulk of cocoa in the then Gold Coast but for the last two decades, the Cocoa Shoot Virus Disease (CSSVD) Control Unit of the COCOBOD has recorded 17.83% of the Hybrid; 8.48% of the Amelonado; 58.52% of the Amazon and 15.17% of the mixed group with recent data according to Eskes (2001) showing that an estimated 30% of the *T. cacao* were the type that is been grown today. In the work done by Adomako and Adu-Ampomah (2000), they observed that about 70% of cocoa trees are traditional populations due to the preferential farmers give to it by collecting it seeds from preferred trees that are likely to be inbred.

The nature in which cocoa is prepared is almost the same throughout West Africa with primary and secondary forests being the major targets for cocoa cultivations (Dguma et al., 2001). Though large farmlands correspond to large cocoa farms, it does not necessarily leads to large output and thus has made cocoa a destroyer of tropical forests (WWF, 2006) as increased in cocoa farms and production are mainly done through the expansion of undisturbed areas. Many stakeholders as well as researchers has called for the revision of this approach (World Bank, 1987; MES, 2002; Asare, 2006) since it only promotes deforestation and fragmentation. Hence, the alternative method been called out for has to do with the boosting of cocoa production by targeting its flowers for the efficient use by insect pollinators.

According to Motamayor et al. (2002), cocoa flowers are small and cauliflorous in natures which are also hermaphroditic with each of its five anthers separated by a folded sepal from the central stigma which depicts the importance of vectors in its pollination. Bos et al. (2007) in his work observed that cocoa flowers present itself all year-round although its peak are normally around the early wet seasons. In a similar manner, Lachenaud and Mossu (1985), explained that cocoa flowers are usually abundant in full sun with records indicating it growth to be around 125,000

flowers per tree each year. However, Paulin et al. (1983) observed that the intensity of flowers can vary among genotypes. Cocoa farms in Ghana generally observe scanty and spasmodic flowers between January to March during which the dry season is attained and later experience high flowering at the very beginning of the raining season starting from April. However, there is a decline which leads to almost nil flowers during the peak of the main-crop and later increases when this crop is removed from the trees; a situation Valle et al. (1990), explained to be the fact that flowering intensity always decreases due to an increase in the number of pods developing on the tree as result of competition for space in order to assimilate and vice versa.

It has been shown in various countries that grow cocoa that flower production and pot setting which is controlled either directly or indirectly by environmental factors such as rainfall and temperature are influenced by the seasons on flowering pattern of cocoa (Dyamond and Hadley, 2008). In regions where there are seasonal variability in rainfall and temperature according to Asomaning et al. (1971) may hinder flowering in those regions.

The general observation made in cocoa flowering and supported by the work of Stephenson (1981) and Bos et al. (2007) is that the numbers of flowers produced always exceed the final numbers of mature fruits obtained. One characteristics of the reproductive system of cocoa has to do with the fact that although there are high numbers of flowers being produced sometimes more than 50,000, not more than 5% produce fruit set and proceed to develop into mature fruits (Free, 1993). The flower usually opens up at dawn causing the anthers to immediately burst up. However, due to anthesis, unpollinated flowers may fall within two days; a problem Paulin (1981) observed that it can be solving by hand-pollination since hand-pollination can result in only a 10% flower drop three days after pollination.

Very low fruit set of cocoa relative to the numerous flowers the tree produces has been reported by several researchers (Frimpong-Anin et al., 2014; Stephenson, 1981; Pıas and Guitian, 2006). Hence, there is obviously a delicate balance between the success and failure of cocoa crops. Factors that has been identified for these include scarcity of the main pollinators (ceratopogonid midges), especially in the dry season (Young, 1982; Young, 1986). Although, some authors especially Glendinning (1972) and Kaufmann (1975) argued that pollination success is affected by the spatial arrangement of staminodes around the style of the cocoa flower which normally limit fruit set, others (such as Kaufmann, 1973; Murray, 1975; and McGregor, 1976) believed that cocoa flowers are nectarless and odourless. However, contrary to the work done by Kaufmann (1973), Murray (1975), McGregor (1976) and Young et al. (1984) demonstrated the presence of microscopic nectaries on the pedicels, sepals, and further gave guide lines of the petals and staminodes that produce odour. His findings showed that these characteristics of the cocoa flower make it unattractive to many potential pollinators, and as a result only insects that have evolved with the plant will successfully pollinate it. The morphological and behavioural characteristics of ceratopogonid midges, however, make them effective pollinators of cocoa (Frimpong-Anin et al., 2014; Toledo-hernández et al., 2016).

2.4 Factors affecting Cocoa Production in Ghanaian

When it comes to the production of cocoa, Ghana is a force to reckon with due to its importance not only in the world but also due to the foreign exchange proceeds derived from it. Although the production yields seem to be on track, there are some inconsistencies in it which according to Dormon et al. (2004) is as a result of a number of factors which includes drought (the major factor that leads to low level of cocoa production in the sector). This assertion that is firmly

supported by Thompson (2005). In Thompson's work, he advocated that the prolonged drought in the 1980's were the major cause of low production of cocoa in the country because a recorded 30 to 40 percent of farms located in the Volta, Ashanti and Brong Ahafo region were affected. Furthermore, aging of cocoa trees has also been observed by the COCOBOD (2004) to be another cause for low production of cocoa in Ghana.

To vividly account for this low production of cocoa, several researchers have used statistical methods and developed models to investigate this cause. An example is the study conducted by Uwagboe et al. (2012). Their research observed that pest and diseases largely contributed to the low production of cocoa. By the use of socio-economic factors, systematic sampling and integrated pest management utilisation, they were able to pick their respondents. Information was elicited from respondents through the use of structured questionnaire and their findings were presented in graphs charts and analyzed with chi-square. Their results showed that about sixty (60) farmers which happen to be majority of the respondents were males and had formal education. The Utilization of Integrated Pest Management was high (75%) and corresponded with higher output.

Similarly, Dormon et al. (2004) developed a diagnostic study to comprehend farmer's opinions on the reasons for low production in the cocoa sector. Using a randomly selected three towns in the district of Suhum-Kraboa Coaltar for their study, they gathered information using an action research approach and analyse their results qualitatively. Their findings showed that low productivity was as a result of two factors that are biological and socio-economic. The socio-economic factors which include low producer price index were observed to be indirect.

In another work done in the Offinso district in Ghana, Kyei et al. (2011) examined the factors that affect the efficiency of cocoa farmers to determine its effect on cocoa production.

Administering questionnaires were the method used in collecting their data and with the help of Stat statistical tool, they were able to stochastically estimate the production frontier function and the inefficiency determinants based on the variables of the socio-economic factors of the individual farmers. Their study showed a statistically significance at 0.00% for the production functions. With labour, quantity of fertilizers, pesticides, modern equipment, age of trees and farm sizes collectively grouped as the input factors in their study, they observed that labour and age of trees were not significant. However, in the estimation of the inefficiency component, it was observed from their model that apart from the age of farmers, most of the characteristics under study were not significant. In their recommendation, they indicated that the ability to use and adjust properly the factors such as labour, capital and age of farms would lead to an increase in the production of cocoa and vice versa.

Furthermore, a multiple regression analysis that has to do with analysing the impact of climate change on the level of cocoa production was performed by Anim-Kwapong and Frimpong (2005). Their analysis showed that over 60% of the variation in the dry cocoa beans could be explained by combining the preceding year's total annual rainfall; the total rainfall in the two driest month as well as the total sunshine duration. Their study further indicated that low cocoa production is as a result of prolonged dry seasons (drought), low soil fertility, pests and diseases, lack of access to improved planting materials, and low farmers income received from their output. They also indicated that low income, goes a long way to demoralise the farmers to further invest in their cocoa farms, hence their inability to adopt new practices that will help minimize the consequence of climate change on the production of cocoa.

2.5 Pollination and Cocoa Pollinators

Pollination involves the transfer of pollen from the anthers to the stigma of a flower where the pollen germinates and the pollen tubes grow down the style to fertilise the ovules by pollinating agents such as birds, bees, bats, butterflies, moths, beetles, or other animals, or by the wind (Bastiaan J.D. Meeuse, 2018). However, the pollination of cocoa is an area that remained imperfectly understood with wind as a pollinating agent almost ruled out in various studies due to the heaviness of pollen grains that usually forms chunks and becomes very difficult to travel on their own (Harland, 1925). However, experiments conducted in South America showed that wind can play a major role in increasing pollination and this can be achieved by artificially increasing air currents in the field with motorized knapsacks sprayers, thus stimulating wind pollination. But this technique was found out only to be effective in doubling cocoa bean yield on self-compatible varieties (Soria et al., 1980).

Insects are exclusively the most pollinated agent of cocoa. One important pollinator are midges which come from the family Ceratopognidae (bitting midges of about 1-4mm long). Winder (1977) indicated after performing a review on five papers that, female specimens are the main pollinators of cocoa but Kaufmann (1975) explains that there were four times more males than female specimen in cocoa flowers just that the rate at which the males pollinate are of a lesser extent. Kaufmann further explained that females normally visit cocoa flowers due to the protein-rich pollen grains which are important for egg maturation.

The flower pedicel being cut and allowing it to drop into ethanol (alcohol) remain one of the earliest methods for sampling cocoa-pollinating midges (Cope, 1939; Billes, 1941). Even though the method indicated in the work of Cope (1939) and Billes (1941) was critical in finding cocoa-pollinating midges, the work done by Posnette (1944) showed the inefficiency in this method due

to the observation being made that there was a high tendency of the insect escaping before the flower drops into the alcohol. In Posnette work which has been proved to be very efficient, flowers were carefully examined and specimen tubes containing insects enclosed. The mouth of the tube were subsequently closed spontaneously with a cork after slowly bringing it near the flower making it possible for the flower together with the midges to be trapped. Although, most studies especially those on adult midges apply this method, the difficulty in trapping insects as well as the high tendency of the target escaping is yet to be accounted for.

Due to the importance of pollinators as natural agents for fruit and seed formation in majority of crops, the use of appropriate tools and sampling methods according to Frimpong et al. (2009) is of necessity in studying their population. In their work, they developed a survey and monitoring protocols for cocoa pollinators in Ghana by using a yellow, white and blue UV-bright painted traps (UVPPT), as well as McPhail traps and motorized aspirators to sample cocoa pollinators for a period of 13 consecutive and successive months. After assessing the effectiveness of the traps and diurnal active period of the pollinators for six days, they observed that the peak period for pollinating cocoa by *ceratopogonid* midges were between 07.00 and 12.00h. All the three methods used in their work were effective in sampling the *ceratopogonid* midges although the UVPPT was the most efficient in their sampling effort. Their work was able to determine that the meliponine bee *Liotrigona parvula Darchen* was the insect that visits cocoa flowers and thus concluded that the effectiveness of the bee in cocoa pollination must be investigated. However, their work could not determine the diversity of midges caught.

To make up for the gap in the work of Frimpong et al. (2009), the same authors observed in their new work conducted in 2011 that cocoa pollinators that were trapped were predominantly *ceratopogonid* midges as a result perform the analyses in their new work based on their

population. The goal in their study was to determine the dynamics of insect pollinators as influenced by cocoa production in Ghana. Using a small scale (1.6-4.0ha) of farmer managed cocoa farms from three cocoa growing areas that is Kunbease-Wuraponso, Abrafo- Ebekawpo and Edwenease in Ghana, their results showed that midges belonging to the cerataponogonidea and Cecidomyiidae families were the main cocoa flowers visitors after recording them for all the trapping methods applied in their previous work with the former being abundant. Their work also identified a positive relationship between standing plantain and cocoa pollination and thus recommended that an in-depth spatial cocoa-plantain inter-crop outlay should be investigated to help boost pollination of crop.

Besides ceratoponids, other insects have been observed to contribute to pollination although their contribution is probably very low; examples of such dipteran insects includes Cecidomiidae (also known as gall midges as depicted in the work of Frimpong et al., 2011), Chironmidae (non-biting midges), Drosophilidae (fruit flies), Sphaerocerideae (small dung flies) and Psychodidae (moth flies) (winder, 1977). Winder further indicated that Cecidomyiids which is commonly found in Cameroon and drosophilids commonly found in Ghana may also contribute to pollination.

The gap in cocoa yields have been reported to be as a result of many multiple factors such as inadequate phytosanitary practices, lack of improved varieties, low soil fertility, disease, pest and weed pressure etc. (Aneani and Ofori-Frimpong, 2013). But, there is an increasing evidence over the last decade that the present yield gap is as a result and can be linked to inadequate pollination. Although, it was in the early 1970's when the pollination gap was observed when it was found out that during the dry season there are few ceratopogonid pollinators available as well as the number of pollinated flowers as compare to the wet season (Winder, 1977). Groeneveld et al. (2010), accounted that in Sulewesi in Indonesia, a more direct proof was

observed in the pollination gap when cocoa trees were artificially pollinated (hand-pollination), there was an increased in optimum dry bean yield by 350 kg per ha when 40% of the flowers were hand-pollinated as compared to the number of dry beans yield obtained for the past 20 years with 10% natural pollination intensities. This shows that an increase in hand-pollination could lead to an increase in cocoa yield. Supporting the work done in Indonesia, Forbes (2017), also observed in his work done in North Queensland (Australia) that the addition of cocoa pod husks as pollinator breeding substrate also increase fruit set by 110 times more cherelles and produce 60 times more fresh fruit production yield. However, results from his work further indicated that performing hand pollination in fields where breeding substrate had already been added did not necessarily caused an extra increased in yield. A situation that shows that the breeding substrates had already increased the pollination intensities to obtain optimum levels. Hence, educating farmers on hand-pollination as well as understanding farmers perception on the use of these two approaches was the recommendations he made.

In a similar manner, a group of researchers from the University of Trinidad and Tobago, Waterloo Research Campus; Bridgemohan et al. (2017) gave an insight on cocoa floral phenology and pollination by observing its implication for productivity in the Caribbean Islands. Since cocoa midges [*Forcipomyia sp (Diptera: Carato-pogonidae)*] have been observed to be a major cocoa pollinator; they assumed that the number of fertilized pods and an increase in the number of beans may be the right approach in enhancing cocoa yield. By employing an insect survey through the use of suction traps, they estimated the dynamics of the midges population in three Caribbean territories. In addition to the evaluation of several naturally occurring substrates they also conducted separate studies on the cocoa floral and reproductive phenology. Their results showed a low insect population as determined by the suction traps ranging from 27.1 plus/minus 3.37 to 53.5 plus/minus 8.47 transect site. Their findings further indicated that most

trees maintained their floral prolificacy even though the pollination was low. However, with an increase of the midge pollinator population with augmentation of substrates of cocoa pods as well as banana pseudo-stem; a significant increase in new pods from < 10 pods/tree in the untreated areas to 49-76 pods/tree with substrate augmentation was observed. It is therefore evident that discarded cocoa pod after harvest provide a suitable feeding substrate and breeding site for midges likewise the augmentation of substrates of cocoa pods results in an increase new pods per tree.

It is observed that cocoa fruit set which correspond to an increase in cocoa yield is as a result of pollination success rather than nutrient limitation; a statement affirmed in the work of Groeneveld et al. (2010). However, knowledge gaps still exist in areas such as pollination ecology, pollinator agents as well as their potential for ecological intensification. Hence, we review limited knowledge on cocoa pollination that will help buffer current yield deficits.

According to Glendinning (1972); Wood and Lass (2008); Samarriba Chavez et al. (2010), about 125,000 miniature white and pink-purple nectar-guide flowers of 10>15mm diameter in clusters of 14>48 flowers cushions which are also known as cauliflowers are produced by cocoa trees along its main branches. Cushions are generally formed in an old leaf-axis of young healthy wood which have flower buds that requires about 30 days for it to emerge and mature (Wood and Lass, 2008). Wood and Lass (2008) further explained that the floral structure consist of one ovary that is female structure which is made up of five chambers that contains the ovules, five unfertile elongated staminodes, five sepals, five petals, and 10 stamens (male structure). The colour of flowers as well as the structure and volatiles are highly important for inducing pollinator visitation. For example, Young and Severson (1994) in their work indicated that pollinators are highly attracted to staminodes due to their colour and odor molecules in which

they produce. Their work which was done in Costa Rica further showed the effect of steam distilled oil properties and attractiveness to pollinators in nine genetically contrasting cocoa cultivars. In their work, classification of the cultivars were in three different clusters out of which one ancestral-type of cocoa formed one cluster alone with the highest molecular weight compound and attractiveness. Their findings showed the potential of native cocoa varieties for enhancing pollinators and pollination success due to the fact that in their observation, cultivars from artificial selection methods can be less attractive to pollinators those wild-types of cocoa cultivars.

However, Glendinning (1972) also indicated that cocoa flowering is driven by precipitation. He further explained that flowering in plantations in Ghana was low during the dry season which ru from the period of January to March and increases throughout April which is the raining period. The work of Omolaja et al. (2009); and Chumacero de Schawe et al. (2013), has observed similar flowering patterns. Falque et al. (1995) also indicated that flowering pauses in Ghana for Lower Amelonado are between June and November while Upper-Amelonado produces flowers throughout the year. But in the work done by Bos et al. (2007), it was observed that flower abundance also increase during harvesting, which suggest that pod removal can also trigger flowering and further implies that the tree allocate energy in flower production rather than fruit development.

2.6 Farmers Perception in the Cocoa Industry

Pollination and pollinators have been observed to provide an important ecosystem service for human well-being. Hence, identifying and managing diversity of pollinators in the Ghanaian cocoa industry would have a significant impact on not just the conservation but also improve agricultural yields in terms of the quality and quantity on the farms. However, for there to be an

improvement of yield, understanding farmers' perception and knowledge on pollination services as well as the importance and dynamics of insect pollinators for agricultural production likewise other key management and production factors must be considered. This section reviews research works that has been done on farmers' perception and knowledge about key policies and its effect in the cocoa industry.

Agbongiahuoyi *et al*., (2014) examined the perception of Nigerian cocoa farmers to voluntary standard certification. Their studies employ the purposive sampling technique to select 80 farmers in Cross River and Osun States in Nigeria due to their exposure to cocoa certification. By applying structured interview for collecting data and analysing the data using descriptive statistics and correlation, they observed that majority which happens to be 87.5% of the farmers that took part of the interview were aware of the voluntary standard cocoa certification precisely the Rainforest Alliance and UTZ. Their results further indicated that 32.5% of the farmers claimed to have received training for certification from some UTZ label exporters and 67.5% believed that the Cocoa Transformation Agenda (CocTA) introduced by the Government will help them practice certification. But low perception towards cocoa certification was as a result of socio-economic characteristics such as age, farming experience, farm size and yield which had a probability of < 0.05 significant influence on farmers' perception. They therefore recommended that training farmers on cocoa certification as well as including the relevant factors (that is the socio-economic characteristics) in CocTA policies can help obtain sustainable cocoa production.

In another work by Frimpong-Anin et al. (2013), a survey on farmers and Agricultural Extension Officers awareness of pollination and the possible impact of farm practices on cocoa pollination due to the scarcity of information on farmers' knowledge on pollination and pollinator conservation was conducted. Their survey was carried out in three cocoa growing areas in Ghana

(Kubease-Wuraponso, Abrafo-Ebekawopa, and Edwenease) by sampling farmers and extension officers between the period of February, 2007 and January, 2010. By setting a pre-tested structured questionnaire, the general information on farmers' knowledge on pollination and pollinators of cocoa in particular were obtained. Their study made used of a total of 112 people from 97 farms for the interview. Their findings indicated that about 87.6% which happens to be majority of the respondents were ignorant of the general scientific concept of pollination due to their perception that pollination is one of the intrinsic physiological mechanisms of trees. Based on their results, 82.5% had believed that pollination was not necessary and as a result was not needed for fruit set. Only 12.4% of farmers' from their findings knew and understands the fundamentals of pollination. However, they observed that the farmers' knowledge and understanding of pollination did not influence the farmer's responses as to whether flowers can yield fruit without the activities of pollination. With respect to cocoa pollinators, only 5 out of 12 farmers were knowledgeable to know the identity of cocoa pollinators with those farmers having an in-depth understanding of the activities of the honey bee *Apis mellifera* and the sweat bee *Hypotrigona* sp. as the main insect pollinators that aid in pollination. Nevertheless, the farmers understanding of the role of midges as well as the understanding that cocoa pod husks were potential breeding substrates for cocoa pollinating midges were low. The results and findings showed in this study was not surprising since farmers educational status or level in the areas were the research was conducted is generally low. The study also did not relate farmer's knowledge on pollination to ascertain whether that affects cocoa yields.

Furthermore, Misganaw et al. (2017) gave an insight about the perception of farmers on the importance of insect pollinators, their current status, distributions and knowledge of the role of insect pollinators in a farmland habitat in gozamin district of Amara region, Ethiopia. By employing household surveys of 131 house hold heads, transect sampling, focus group

discussion, and direct field observation method, they were able to collect data for their study. They observed from their findings that most farmers precisely 94 which happen to be 77% of the respondents had no knowledge on pollination and the importance of insect pollinators. Also, more than half (76; (62.3%)) of the farmers also confessed that apart from the honeybee insect, they did not know any other insect pollinators. However, there were significant differences in their views since eighty-three (83) of the respondents could not identify the role played by honeybees and other insect pollinators in agricultural seed set. But 75 of the respondents from their findings showed an in-depth knowledge of the impact of agricultural input such as insecticides and herbicides in their role on insect pollinators' activities. Their findings further indicated that, most farmers were not interested in the activities of pollination and believed the activity would rather decrease yield due to their believe that with the application of insecticides and herbicides coupled with drought and deforestation, pollination process cannot achieve the required result they want. It can therefore be established that the awareness creation on the importance of pollination and pollinators is of urgent need for farmers to conserve pollinators.

2.7 Conceptual Reviews on Knowledge and Perception

Knowledge and perception has evidently become an important factor in our everyday activity. It has become the dominant field that shape the socioeconomic development of any country. This section reviews works that has knowledge and perception as the subject matter. For example, Ibegbulam, I. J. (2015), investigated the knowledge, perception and attitude of students in Nigerian to plagiarism. By using structured questionnaire which was self-administered by the researchers to the respondents, they were able to collect data for their study. Two hundred and eighty two (282) first year students in the Faculty of Business Administration were used as respondents. Analysing their result using frequency counts and percentages, they find out that the

knowledge of plagiarism among the students prior to they being taught the subject was very low. However, after exposure to the subject through teaching, there was a significant increase in their knowledge.

In a similar manner, Faronbi et. al. (2017) also assessed the perception, knowledge, and attitude of nursing students towards old age and care of the older adults and used it to examine the personal characteristics that could predict their attitude. By employing two hundred and eighty students (280) from learning institutions for nursing in Ile-Ife, Nigeria, they were able to collect data on perception, knowledge and attitude with the support of validated self-administered questionnaires. To derive their results, they made used of descriptive analysis and inferential statistics by using Statistical Package for Social Sciences. Their result showed 66.1% and 71.8% of the respondents respectively had a positive perception and attitude towards the care of elderly people. Furthermore, the findings depicted that taking care of older patients should go beyond the basic nursing care with 60% of the respondents also showing good knowledge of the essential clinical practice in the care for older patients. Attitude and perception showed a statistically significant association with OR = 1.11; p = 0.002 with the age category between 20 - 25 (OR = 0.45; p = 0.04). Moreover, attitude of the respondents and knowledge had no significant association between them. The study recommended that good knowledge towards the care of older patients should be encouraged for a better clinical outcome.

For an effective intervention or policy to come to light, it is essential that the knowledge, perceptions and beliefs of the group be taken into consideration. With this in mind, Singh, S., (2012), developed a model that seek to study the socio-demographic profile of persons leaving with leprosy and also to explore their knowledge, perceptions and beliefs about the disease. Semi-structured questionnaires that made used of interviews were employed at various clinics

and care homes for affected persons in and around Chandigarh, India to derive data. Data collection through case study was also employed in their study. The result indicated that 64.9% of the respondents had the perception and knowledge that leprosy resulted from supernatural causes like karma, God's punishment from sin.

In the field of agriculture, many researchers have researched into factors that may enhance or constrain smallholder farmers' ability to either adapt or adopt to improved technologies or policies with the knowledge and perception of farmers recorded to be a key factor. Farmers' perceptions and knowledge about agriculture policies have been identified as the key aspect that facilitates their decision making processes. (Corbeels, et al., 2000; Sehoueto, 2006). This decision-making process depends on factors such as knowledge, perceptions and attitudes collectively referred to as intrinsic factors and also extrinsic factors such as the age, level of education, marital status, farming experience, farm size etc. (Baumgart-Getz, Prokopy & Floress, 2012; Knowler & Bradshaw, 2007; Reimer, et al., 2012).

Technological knowledge or knowledge on policies are often influenced by farmers' access to information (Prokopy, et al., 2008) and social networks in which the farmers interact (Greiner, et al., 2009). Getting information increases farmers' awareness and goes a long way to evaluate their capacity of existing policies (Lambrecht, et al., 2014). Hence, influencing the farmers' views (perceptions) about their practices and also prior experience.

The study done by Meijer et al. (2015) considered farmer's perception as the views they carry on a given technology in terms of their needs and prior experiences. Pulido and Bocco (2004) defined farmers perceptions as their expressions towards the causes and status of land degradation pertaining to their lands. In all these, it is seen that the perception a farmer carries depends on where his or her interest lies. Farmers' perception and adoption of various policies

have been widely studied (Ervin & Ervin, 1982; Pannell et al., 2006; Reimer et al., 2012). In all the studies, there is a similar conclusion that is been drawn that farmers' perception towards a technology or policy is attributed to their influence in the adoption behaviour of those policies or technologies. For instance, Reimer et al., (2012) found that farmers' perception of the conservation practices were powerful predictors of the adoption within two watersheds in the United States.

Though various aspects of perceptions towards technology and other policies has been widely studied, there is a dearth of literature about farmers perception and knowledge of hand pollination application and thus warranting further investigations.

CHAPTER THREE

METHODOLOGY

This chapter seeks to examine the methodology necessary to investigate the variables under study. Moreover, the research approaches which includes the study design, study area, target population, data collection instruments, sample and sampling techniques, reliability as well as the validity test of the instruments and the data analysis of the method will further be discussed in this chapter.

3.1 Research Study Design

According to Mouton and Marias (1988), research designs are based on information gathering technique and the nature of the problem that helps to arrange conditions for the collection and analysing of data in a way that gives meaning and understanding the research under study. The grouping of research methods according to Khan, 2012, is done in three ways, namely; qualitative, quantitative and mixed method. The method that has to do with accuracy, reliability and generalisation of results is what is termed “quantitative research” (Lewis and Thornhill, 2012). To achieve this, workable hypothesis and questions that leads or help to generalise the findings are developed; this is because it considers the use of collecting numeric data to exhibit the relationship between the theoretical aspect and research.

The qualitative research approach was explicitly defined by Kothari (2004), to be concerned with subjective assessment of postures, conduct and opinions. To implicitly define it, Dampson and Ofori, (2011), explained it to be the method that makes use of the technique of observation, case studies, interview guides that built on the subjective elements of the researcher into findings and conclusions. Morse and Niehaus, (2009), defined the mixed method as one that make use of both

the quantitative and qualitative approach and with this method it begins with the researcher setting hypothesis and then testing the hypothesis by quantitative methods and vice versa (Bryman and Bell, 2007). Hence, a research methodology could be defined as the researcher's choice about cases to study, the tools used for data collection and the strategies of data analysis that is used in planning and executing the research (Silverman, 2006). But, the choice of method to apply depends on the nature of the research under consideration. It was however argued by Morgan and Smircich (1980), the social phenomena that is being explored determines the quality of the research method. Base on the nature of the variables being studied, the positivists approach (quantitative research method) would be employed. Much emphasis is placed on the different constructions and meanings provided by the informants upon their experience in the cocoa production business.

The procedures which serves as a plan, blueprint to aid in data collection, measurement and analysis of data to carry out a research is termed as a study design (Neelankavil, 2007). The cross-sectional survey was use in our study based on the lesson learnt and the problem understudy. In cross-sectional survey data analysis from more than one case are required and used at a single time. It was explained further by Sauders et. al., (2012) to be the type of design that allows association and variations between variables that make use of quantitative data in their analysis.

3.2 Sampling Technique and Collection of Data

A primary data derived from the administering of structured questionnaires were used in the study. Through this approach applicable information from the farmers in the area of the Tafo Cocoa District of the Eastern region were obtained. Data on the characteristics socio-economic factors of cocoa farmers such as gender, the age of respondents, level of educational, migration

status of respondents, years of farming experience, family size of respondent etc. as well as information about the output level of cocoa and important factors such as the size of farm, input sources, land, labour, age class of sampled farm, variety of cocoa used, and farm practices were obtained.

The two widely used types of sampling technique by most researchers according to Babbie (2007) are the probability and non-probability sampling technique. In this study, this type of sampling technique was also employed to allow the sample to have a more representative of the population being used. Due to the difference in the size of workers in the selected farms, the quota was also employed to assist in determining what proportion was selected from each farm. The choice of selecting the farm was initially grouped into clusters due to the mutually homogeneous yet internally heterogeneous groupings of the farm. Afterwards, the simple random sampling was also adopted to guide in obtaining the exact workers from the selected farms to aid in conducting the research. The motivation behind adopting all this strategy was derived from the study of Zikmund, Babin, Carr and Griffin (2010), who indicated that it is generally not necessary to use or study all possible cases in order to understand a phenomenon under consideration.

3.3 Data Collection Instrument

Copper et. al., (2006) explained that when it comes to collecting of data, it ranges from a simple observation at one end or location to a more grandiose survey of huge population with the approach to select from in most cases depending on how the data was collected. Questionnaires, standardized tests, observation form, laboratory notes and other instruments such as calibration logs are examples of these approaches that is normally used to collect raw data. This study employed the questionnaires and interview approach to obtain data from respondents. This

approach was chosen because literatures on perception about farmers on most policies other than hand pollination adopt this method in data collection and it is also economical and reliable which further provides uniformity, although it is time consuming. The open- and closed-ended form of questionnaires were used with the open-ended questions giving respondents the opportunity to answer questions without any form of restriction while the closed ended form of questions give respondents an equally fixed alternatives to choose from.

The study partition the questionnaires used in obtaining data into five sections (A, B, C, D, E and F) that covers essentially the closed and open-ended twenty two (22) items. The first section takes into account the association, community and group of the farmer; section B covers the personal data of the respondent taking into consideration his/her personal details as well as details about the nature of the farm. Section C covers the adoption gaps while that of section D gathers information about farmers knowledge on hand pollination. With section E and F, the perception on hand pollination as well as the expenses made on the selected farms was respectively handled.

3.4 Reliability and Validity Test

Reliability test as defined by Dampson and Ofori (2011) is the generation of similar or same findings every time a method or instrument procedures measurements are repeated. One of the main goals in reliability test is to minimize errors and also bias. In this study reliability is enhanced by taking precautions when verifying information. For example, an assistant who was responsible for recording and carefully documenting interview answers to make sure that there was some level of uniformity was used. The questions were also designed and arranged in the simplest of terms to incorporate multiple ranking that adequately address the research questions.

The received data was also double checked to minimize the potential of misrepresentation and misunderstanding in order to increase the reliability and validity of the study.

3.5 Area of the Study

The Akim-Tafo municipality was the area in which the study was carried. Latitude 6 degrees 12'58.47"North and longitude 0 degrees 22'14.81"West is the domain in which it lies. The Akim-Tafo municipality lies in the North-western of the Eastern Region of Ghana. A total land area of about 752-kilometer square (290 sq mi) is being covered by the Akim-Tafo municipality. The municipality also lies within the wet semi-equitorial climate zone just as that of the tropics and also experiences a rainfall maximum pattern having a mean annual rainfall that ranges between 1275mm-1544 mm in the period of May to June (Akim-Tafo municipal report, 2014). It is reported to have one of the best vegetation forest type which covers almost 80% that stretch throughout the land. According to the 2010 Population and Housing Census, about 188,912 people reside within this municipality. More than half (about 62%) of households in the municipality are engaged in agriculture activities. The Ghana Statistical Service, 2014 report indicate that most households that are engaged in agriculture are involved in crop farming. The soil in the municipality is recorded to fall into the group known as ochrosols and is very fertile for cocoa, cocoyam, cassava and plantain cultivation.

3.6 Analytical Framework

The choices a farmer makes are mostly based on either assumptions or adopting a particular policy or technology that maximizes his or her utility. Most researchers normally use the discrete choice models to ascertain the choice a farmer makes in his or her desire to either use or not to use a particular policy. The two most used model to estimate farmer’s decision on a policy are the logistic regression which is normally called the logit and the probabilistic regression also

known as the probit model. In this case a dummy variable which is equal to one when a farmer chooses a particular policy and zero when otherwise are assigned to the dependent variable of these models. The difference between the logit and probit models is that while the error term distribution for the logit is assumed to have the distribution of a standard logistic, that of probit make use of the standard normal distribution (Bryan et al., 2009). The study adopted the probit model because it has the ability to resolve heteroscedasticity problems as well as estimate probabilities that lies between 0 and 1 (Asante et al., 2011). One major reason why this was also used was that it is easy to analysed in the sense that the properties of the normal distribution are easy to handle. Hence, if we assume that Y is a dependent variable which only two possible outcomes that is 0 and 1and being influenced by say X an independent variable, then we can define the probit model to take the form

$$P(Y = 1 |X) = P(Y^* > 0)$$

$$= P(X' \beta + \varepsilon > 0)$$

$$= P(\varepsilon > - X' \beta)$$

$$= P(\varepsilon < X' \beta) \quad \text{by symmetry of the normal distribution}$$

$$P(Y = 1|X) = \varphi(X' \beta) \qquad (1)$$

where P being the probability; the standard normal distribution that is obtained from the cumulative function denoted by φ and beta is the estimated parameter obtained from the maximum likelihood analysis. To further deduce the probit model as a linear function, we obtained

$$Y0= \beta0 + \beta i\, Xi + \cdots + \beta n\, Xn,$$

where the marginal effect is computed for Xi.

3.7 Empirical Model Description

In using the probit model for the study to determine their perception about the application of hand pollination on their farms, the probit model was specified as;

$$Y0 = \beta0 + \beta1\ X1 + \beta2\ X2 + \beta3\ X3 + \beta4\ X4 + \beta5\ X5 + \beta6\ X6 + \beta7\ X7 + \beta8\ X8 + \beta9\ X9 + \varepsilon$$

where the dependent variable is denoted by Y0 (with 1= application of hand pollination and 0 = otherwise), the coefficient constant term is given by β0; the coefficient of the independent variables are β1 to β9; the explanatory variables are X1 to X9 and the error term is ε. To further gain an in-depth knowledge of the study, an estimation of the frequency of hand pollination application was done using the tobit regression. This is due to the fact that not all farmers will be willing to use it. The frequency was assigned to zero for farmers who may wish not to apply the hand pollination approach. The Tobit model is a better choice when compared to the least square method, hence, it adoption. Moreover, with the least square estimate there is a censoring of bias. This model has been adopted by many researchers such as Tsafack (2007) and co to estimate various perceptions about the usage and application of certain policies as well as technology packages by farmers. The Tobit model is described as follows;

$$FPAi = FPAi \ \ if\ FPAi > 0,$$

$$FPAi = 0,\ otherwise.$$

$$FPAi = xi\ \beta + ui$$

with *FPAi* representing responses on the frequency of the hand-pollination application observed and the vector of the independent variable denoted by *x* while the vector that is assigned to the

parameters is denoted by β and the error term for which the distribution is randomly distributed is given by *ui*. In our empirical model, we specify the Tobit model for the study as

$$FPA = \beta 0 + \beta 1\ X1 + \beta 2\ X2 + \beta 3\ X3 + \beta 4\ X4 + \beta 5\ X5 + \beta 6\ X6 + \beta 7\ X7 + \beta 8\ X8 + \beta 9\ X9 + \varepsilon. \quad (3)$$

In the Equation (3); FPA denotes the frequency of the perception of hand pollination application, the constant term of the coefficient is given by β0, the independent variables coefficient are given by β1 to β9, the variables to be explained are X1 to X9 and the term that represent the error is represented by ε. With respect to the explanatory variables, gender is assigned with X1, age of the farmer is denoted by X2, the educational level of the farmer is assigned to X3, the years of experience the farmers has obtained is assigned to X4, the farm size corresponds to X5, the age of the farm is given by X6, the farmers group or membership of farmers in an organisation (FBO) is represented by X7, X8 denotes farm ownership and the assigned variable for farmers income is denoted by X9.

3.8 Description, Measurement and Expectations of Explanatory variables

This section incorporates the description as well as the measurements taking into consideration the previous knowledge we had on the expectations of the variables that were used and they are describe in Table 3.1. With respect to gender, male farmers were expected to apply the hand pollination approach more often and even at a higher rate than the females. According to Golden et al., (2010), females are more vulnerable when it comes to the application of certain policies in the agriculture sector. When it is comes to age, the most likely farmers to adopt the hand pollination were expected to be younger farmers compared to older men. Moreover, farmers who have more farming experience tend to adopt new policies easily compare to those who have

lesser experience likewise the higher level of education a farmer obtains is likely influence his or her adoption of the hand pollination approach since it is believed to cause an increase in yield.

Table 3.1 Explanation of variables

DESCRIPTION	**MEASUREMENT**	**Expectation**
Gender	If male then one, otherwise zero	Plus
Age	Calculated in years	Plus
Level of educational	For no formal education assign 1, 2 for basic education, 3 for SHS, and 5 for Tertiary.	minus
Years of farming experience	Calculated in years	minus
Farmers group or organisation	1 for yes and 0 otherwise	plus or minus
Farm size	h.a	Plus or minus
Farm ownership	1 = yes, 0 = otherwise	plus or minus
Average age of farm	Years	minus
Cocoa income	Ghana cedi	plus

CHAPTER FOUR

ANALYSIS OF DATA AND PRESENTATION OF FINDINGS

This chapter considers the results and analysis of the study. The chapter is further partitioned to incorporate the main sections under discussion and is presented as follows:

4.1 Farmers demographic Characteristics

In this section the analysis of the biographical information of the respondents are presented. Data was collected on the age, gender, educational level, marital status, and migration status. The total respondent amounted to 110 and presented below is the analysis over the total respondent.

The pie chart percentage distribution as shown in Figure 4.1 depicts the age distribution of the farmers. It can be seen that majority of the respondent (85 which represent 77.23%) are males and 21.23% which represent 25 respondents were female. This affirms the assertion that males prefer to enter into agriculture than females.

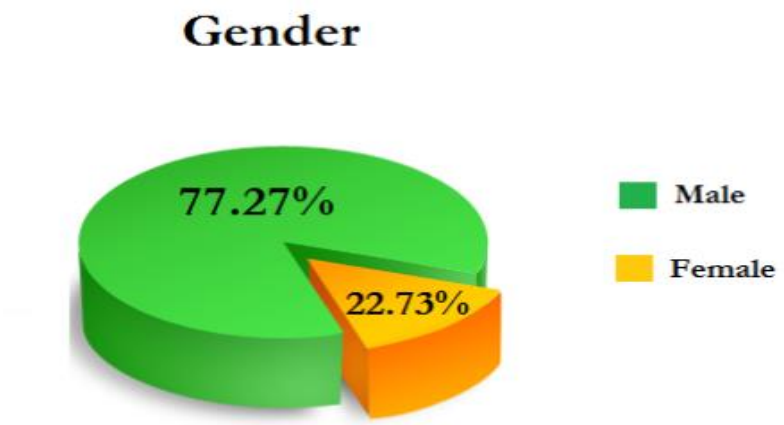

Figure 4.1 Percentage gender distribution of respondents

Furthermore, the high percentage score by the male respondents compare to their female farmers could also be attributed to the fact that males easily have greater access to farm land compared to the females. Moreover, the labour-intensive nature of cocoa farming which prevent majority of the women from entering into it is a factor why more males were recorded from the data.

In case of the migration status of the farmers, the data collected depicted that sixty six (66) which represent 60% of the respondents were natives from the Tafo Cocoa District while 40% which represent forty four of the respondents from the data collected were settlers as shown in Figure 4.2.

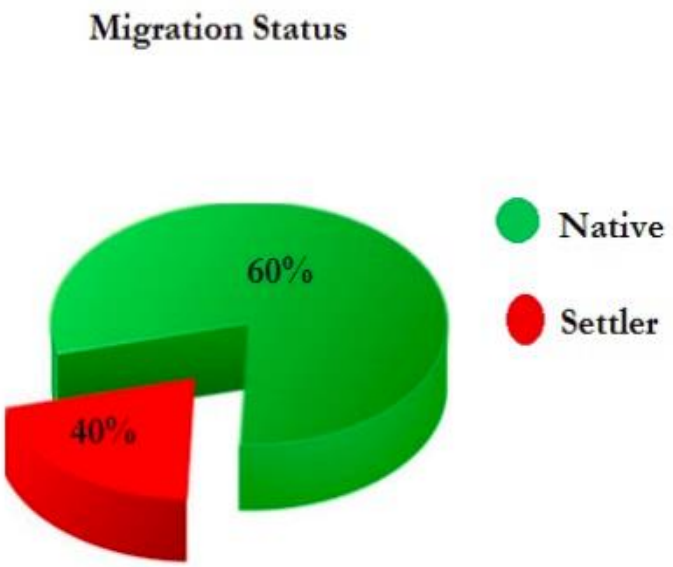

Figure 4.2 Percentage distribution of the migration status of respondents.

Educational level of respondents is as shown in Figure 4.3 below. It was observed that majority (62.73% representing 69 of the respondents) had at least basic level education, while just 4 respondents with a percentage score of 3.64% have tertiary education. 17 (15.45%) of the respondents were recorded to have obtained senior high school education and 12 (10.91)

respondents truthfully confess to have no level of education. Eight (representing 7.27%) of the respondent decided not to reveal their educational status due to personal reasons.

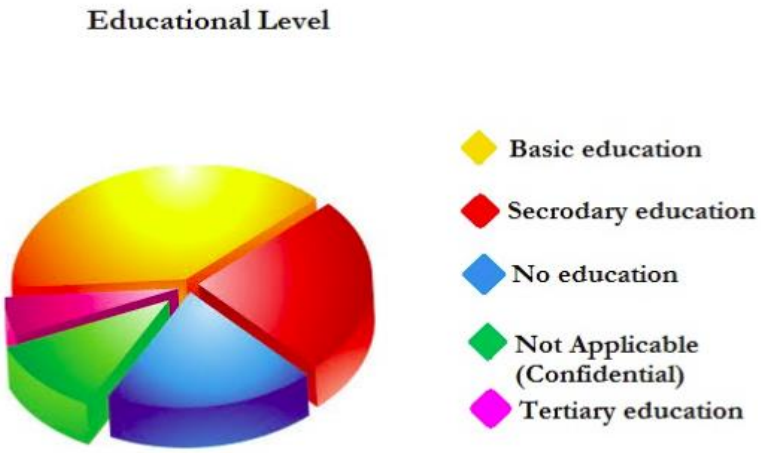

Figure 4.3 Percentage distribution of the migration status of respondents.

Table 4.1 further present the age and marital status of the respondents. Majority (86.1%) were observed to be above forty years old with the minimum (0.91%) observed to be eighteen years. The maximum age was found to be 97 years. The mean age from the data collected was 49 years and it was comparable with the national average age as described in the work of Danso-Abbeam et al., (2014). A positive correlation in the mean age would have a positive effect on productivity since there is a positive correlation between younger farmers and productivity because younger farmers are more energetic and creative. Married farmers were observed to be dominant from the data collected with a percentage score of 87.27% and also support the work done by Bammeke, (2003) who indicated that most farmers tend to marry in order to receive support from their spouse. The data further showed that 6.36%, 2.73% and 2.73% were respondent who were single, widowed and divorced respectively. Those who decided not to record their age were less than 1% percent.

Table 4.1 The demographic characteristics of respondents.

Variable	Description	Frequency	Percentage (%)
Age	18 – 25	1	0.91%
	26 – 30	3	2.73%
	31 – 35	5	4.54%
	36 – 40	6	5.45%
	above 40	93	86.1%
Marital Status	Single	7	6.36%
	Married	96	87.27%
	Widowed	3	2.73%
	Divorced	3	2.73%

Source: Field work (2018)

The data was further used to determine farmers' knowledge on hand pollination as well as whether they had ever hand pollinated their farm before this study was carried out. The results obtained for the farmers knowledge on hand pollination is depicted in Figure 4. From the Figure 4 below, it is observed that 74 respondents which represent 67.27% had no knowledge of what hand pollination is while 24.54% which also represent 27 respondents had an idea or knowledge on what hand pollination was. 8.18% (9 respondents) did not respond when asked whether they had an idea or knowledge about hand pollination.

With the usage or application of hand pollination in the farms of the respondents, 85 (77.27%) of the respondents admitted not to use the hand pollination on their farms with just 9 (8.18%) respondents been those that apply hand pollination in their farms. The remaining 16 respondents decided not to give their view as to whether they use or not the hand pollination in their farms.

Having obtained farmers/respondents view about their knowledge and usage of hand pollination (figure 4.4), the Probit model was used to determine the factors that might influence farmers decision on hand pollination application.

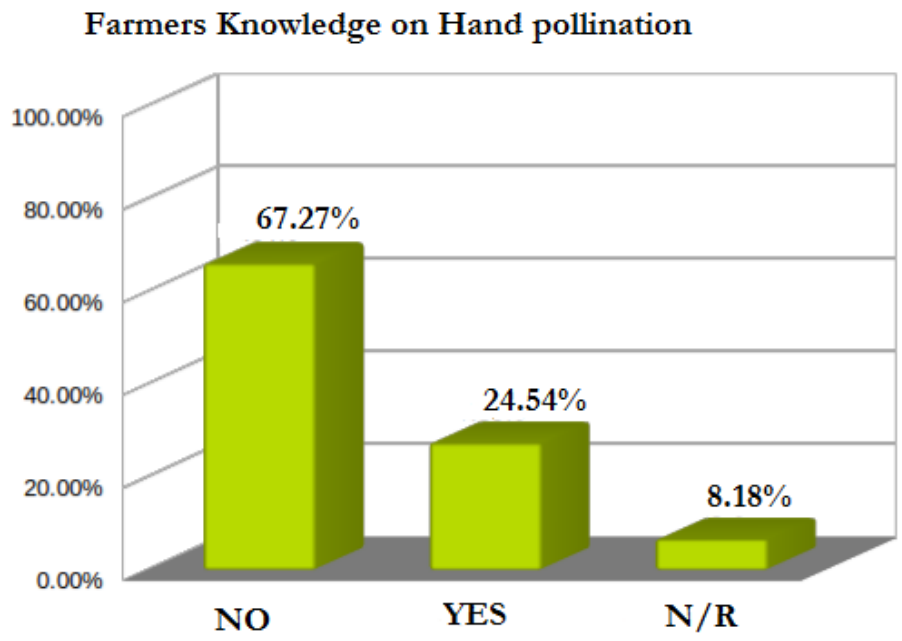

Figure 4.4 Farmer's knowledge on hand pollination

4.2 Statistical Associations Analysis

The probit results on the factors that influence cocoa farmers' knowledge to use hand pollination are presented in Table 4.2. The results as presented in the table shows that seven out of the nine variables described in chapter three were significant. The variables that were significant include gender, age, educational level, farming experience, farm size and cocoa income. Using the Chi square value of 76.15 derived from the wald test, the result showed that it was significant at 1% significant level with the log pseudolikelihood value of -61.00. X1 which represent gender was found to positive and significant at 5% confirming our a-priori expectation set at Table 1. This further shows that with males dominating the respondents, they are more likely to use hand pollination when their knowledge on it is enhanced. Female farmers might not necessarily apply hand pollination due to the fact that they have higher health risk when they come in contact with

other chemicals or strange grains as affirm by Goldner et al., (2010). Moreover, the study of Nkamleu and Adesina (2000) indicated that agricultural policies are mostly carried out by men than women.

At a statistically significant level of 1%, age represented by X2 was also found to be significant but had a negative influence on hand pollination. The result did not conform to the a-priori expectation set. This is because as the age of an individual (farmer) increases by 1 year, the probability that a farmer will adopt the hand pollination decreases. This result did not conform to the studies of other researchers such as Alavalapati et al. (1995), who in their study made the assertion that adopting a policy or technology is easily done by younger farmers compare to older ones. This could be attributed to the assertion that as farmers grow, they develop the experience in adopting other ways and means of increasing their productivity.

The level of education a farmer obtained was observed to positively influence his knowledge on hand pollination and was statistically significant at 5%. The result corresponds with the study done by Nkamleu and Adesina (2000). Hence, educated people will always have the desire to go in for policies or strategies that will give them maximum satisfaction and also provide them with the greatest of yield.

Farming experience and average age of farm also had a positive influence on hand pollination application. This shows that as a farmer gains a year experience in its operations, the probability of hand pollination use also increases. Like the number of years, a farmer has cultivated his/her land also has an influence on hand pollination use. Because, farmers with more experience and very normal average age for their farm are expected to have better skills as well as have access to new information about ways to improve productivity.

Though farm size was significant at 5%, it negatively influenced hand pollination use. This conformed to the a-priori expectation which shows farm size decreases the probability to use hand pollination. The result was in line with Anim-Frimpong (2011). This was not surprising because without the help of technologies, farmers with large farm size will be discouraged to personally hand pollinate their farm.

Lastly, cocoa income was also significant at 5% and had a positive relationship with hand pollination use. When farmers receive a greater share for their produce as a result of hand pollinating their farm, they would be encouraged.

Table 4.2 Result from the probit model on the factors that influence hand pollination application among cocoa farmers.

Description	**Coefficient**	**Standard Error**	**P value**	**Marginal Effect**
Gender	0.758	0.309	0.014	0.044
Age	-0.824	0.300	0.001	-0.061
Level of Educational	0.115	0.016	0.000	0.004
Farming experience	0.371	0.146	0.011	0.014
Average age of farm	-0.09	0.022	0.000	-0.004
Size of Farm	-0.988	0.300	0.001	-0.061
Cocoa income	0.681	0.298	0.022	0.046
Farmers group	0.233	0.304	0.443	0.0008
Farm ownership	0.498	0.340	0.144	0.019
Constant	-3.000	4.000	0.468	
Diag statistic				**Value**
Log likelihood				-61.00
chi square of wald test				76.15
P>chi square				0.000
R square				0.4

Source: Field Survey (2018).

4.3 Tobit results on the farmer's perception of hand pollination application

The Tobit regression result is presented in Table 4.3. At 1% level of significance, the model was observed to be significant with a log likelihood value of 397.00. The variables which significantly influenced the perception farmers had on hand pollination application are farming experience; educational level; farm size; farmers group; cocoa income; and average age of farm.

Table 4.3 Result from the Tobit model on the factors that influence farmer's perception on hand pollination application among cocoa farmers.

Variables	**Coefficient**	**Standard Error**	**Probability value**
Gender	0.500	0.610	0.500
Age	0.661	0.169	0.000
Level of Educational	0.007	0.020	0.746
Farming experience	-2.233	0.301	0.000
Farm size	-1.093	0.322	0.001
Average age of farm	-0.050	0.012	0.000
Farmers group	-0.657	0.277	0.019
Farm ownership	-0.457	0.305	0.136
Cocoa income	-0.867	0.430	0.045
Constant	14.900	3.940	0.000
Diagnostic statistic			**Value**
Log likelihood			-397.00
Probability > F			0.000
R square			0.300

From Table 4.3, it was observed that the years of experience a farmer obtained was statistically significant at 1% although it had a negative relationship with the perception farmers had on hand pollination. This implies that as a farmers experience increases by at least one year, the negative perception of applying hand pollination reduces. However, there was a positive relationship between the level of education and farmers perception of hand pollination. The statistically

significant was at 1% and although this did not follow the a-priori expectation which was set in chapter three that educational level of farmers would have a negative influence on the perception of hand pollination, this result could be as a result of insect proliferation on those farmer's farms.

Farmer's group or membership association was observed to be statistically significant at 5% and negatively influence farmers' perception of hand pollination. This result was not surprising because as farmers become members of farmer based organisations, their awareness on hand pollination increases. This affirm the reasons why government and stake holders normally encourage or call for farmer based organisations to be formed in order to increase reliable source of information to farmers.

The size of the farm a farmer has was observed to be statistically significant at 1%. This shows that farmers with large size of farms will be interested in looking for strategies to help increase yield. Cocoa income was surprisingly seen to have a negative influence on the perception of hand pollination application. Though it was statistically significant at 1%, the results rather seek to indicate that farmers perception do not increase about the application of hand pollination as a result of higher income from sale of cocoa.

Finally, having observed from the results obtained that the farm size of the farmer has an influence on the knowledge and perception of farmers on hand pollination application; the Pearson Chi-Square was used to test the relationship between the farm size and it effect on output or yield of cocoa. A value of 10.01 obtained from the chi-square test with an associated p-value of 0.0001 was obtained and it showed that the test was statistically significant at 5%. This implies that an increased in the production of cocoa might somehow depend on the size of the farm. This is because when a larger size farm is hand pollinated, there is the likelihood of an increase in output per unit area.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter captures the summary, and conclusions that arose from the findings of the study and also set some recommendations based on the conclusions that were drawn from the study.

5.1 Summary

The difference in perceptions and knowledge of pollination has been a major obstacle in farmer-researchers collaboration and cooperation which is a necessity for sustainable management of pollination services. The goal of the study was to ascertain cocoa farmer's knowledge and perception of hand pollination and its effect on their practices. The demographic background of farmers in the Tafo district in the Eastern region of Ghana was studied. The study was sampled among 110 farmers and farmers' perceptions and knowledge were investigated. The findings showed an extremely low and gender biased with males dominating the cocoa farming industry. The cocoa farming industry was also observed to increase with age with the minimum age found in the study to be eighteen years and about 86% representing the majority of them aged 40 years and above. Respondents from the study revealed that majority of farmers within the Tafo district has obtained at least basic level of education but just a few had tertiary education. The probit model also showed that the factors that influence farmers knowledge on the application of hand pollination includes gender, age, educational level, farming experience, farm size and cocoa income while that of the tobit model shows the factors that influences farmers perception of hand pollination application. Farm size was also observed to correlates positively with the output or yield of cocoa since a larger farm size will lead to majority of the trees been hand pollinated but will only be possible if and only if the farmers knowledge and perception is increased.

5.2 Conclusion

The role of cocoa in the Ghanaian economy is very well acknowledged in this study and various other studies such Dormon et. al. (2004) and Vigneri (2008) although, its production relative to crop yield at the expense of less expensive and novel policies such as hand pollination application is of great concern. This is because the yield of cocoa per hectare in Ghana is low compared to the other major producers (MoFA, 2003). The study commenced with the understanding and identification of gaps that exist in the studies done on hand pollination. It was then followed by a survey in the Tafo district in the eastern region. Even though the argument of the findings of this study shows that hand pollination is one significant area that should be given the needed attention in order to enhance productivity, the results indicated that there is a huge gap to fill given the potential that can be achieved by both researchers and farmers. This study has shown that although there is much knowledge on other policies such as weeds, pests and diseases control, application of fertilizers, farm maintenance etc., the knowledge and perception farmers had on the application of hand pollination is very minimal. The analysis shows farmers decision to apply hand pollination on their farms would be greatly influenced by the gender of the farmer, age of the farmer, years of experience the farmer has in the industry, educational level of the farmer etc. In addition, the significant variables or factors that influence the knowledge and perception of farmers in their quest to apply hand pollination were years of farming experience, average age of the farm, the farm size, farmers group or membership of farmers based organisation.

It is expected that with the application of the findings (that is more education given to farmers about hand pollination) the production of cocoa not just in Ghana but West Africa and the world as a whole would increase in terms of yield per hectare without necessarily expanding the acres

used in the farming of cocoa. The findings when employed by the Extension Unit of the Ministry of Food and Agriculture would help farmers incorporate hand pollination in their practice of cocoa cultivation and would go a long way to increase production.

5.3 Recommendations

The study has brought to light and has also added to literature about the knowledge and perception cocoa farmers had on the application of hand pollination. From the findings of the study, the following recommendations are made:

1. Women are to be encouraged to enter into cocoa farming.
2. Majority of farmers in the Tafo Cocoa District seems to have some basic level of education; hence, importance should be placed on periodically educating farmers on the appropriate farming techniques to be employed.
3. The formation of farm-based associations should be encouraged in order to help increase the awareness of information.
4. COCOBOD needs to encourage cocoa farmers to adapt to techniques such as hand pollination that will increase production and also minimize excessive land expansion.

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APPENDIX A:

KWAME NKRUMAH UNIVERSITY OF SCENCE AND TECHNOLOGY (KNUST)
(MASTER SCIENCE OF PROJECT MANAGEMENT)

HAND POLLINATION BASELINE DATA COLLECTION INSTRUMENT

CONSENT NOTE:

This survey is being conducted by Emmanuel Nyamekye in partial fulfillment of MSc. Project Management to assess the knowledge and perception of cocoa farmers' in the Tafo Cocoa District of the Eastern Region. This will also serve as baseline information on beneficiaries for the hand pollination project run by the Cocoa Health and Extension Division. All information will remain confidential and will only be used for the intended purposes of this project.

Thank you

SECTION A: QUESTIONNAIRE DETAILS

DISTRICT……. DATE OF INTERVIEW……. QUESTIONNAIRE NUMBER……..

REGION…… ENUMERATOR NAME……COMMUNITY……..

FARMER GROUP NAME…… IS FARMER INVOLVED IN PROJECT Yes ( ) No ( )

SECTION B: FARMER & FARM DETAILS

1. Name of cocoa farmer: ……
2. Farmer I.D…….
3. Phone number:……..
4. Sex: a. Male [ ] b. Female [ ]
5. Age (years):……
6. Migration status: a. Native [ ] b. Settler [ ]
7. Marital status: a. Single [ ] b. Married [ ] c. Widowed [ ] d. Divorced [ ]
8. Literacy level: a. None [ ] b. Basic education [ ] c. Secondary [ ] d. Tertiary [ ]
9. Household size: Number of adults (> 18yrs) …….. Number of children…….
10. Number of cocoa farms:……

11. Total farm size (Ha): ……

12. Location of sampled farm……

13. Farm size of sampled farm……. (Measured by GPS)

14. Average age of sampled farm (s) (Years):……..

15. Age class of sampled farm…….

16. Farm ownership: a. Abunu Share cropper [ ] b. Abusa Sharecropper [ ] c. Owner operator (No sharecropping) [ ]

17. Variety of cocoa: a. Hybrid [ ] b. Amazon [ ] c. Mixed [ ]

18. How many bags of cocoa did you harvest over the last 12/24 months (From selected farm)

Year	Bags harvested	Kilograms (kg)
May 2015-May 2016		
May 2016-May 2017		

* Check passbook for selected farm

SECTION B: ADOPTION OF GAPs

Which of the following GAPs have you practiced in the last 12 months?

Practices	*Did you do the following*	*Frequency*	*Area of farm applied*				*Period*											
			25%or less	*Up to 50%*	*up to 75%*	*100%*	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
Pruning																		
Weeding																		
Fertiliser use (Granular)																		
Fertiliser use (Liquid)																		
Insecticide application																		
Fungicide application																		
Harvesting																		

SECTION C: KNOWLEDGE ON HAND POLLINATION

Did you know about hand pollination before the project? a. Yes [ ] b. No [ ]

19. Have you ever hand pollinated your farm before the project? a. Yes [ ] b. No [ ]

20. What is your knowledge on hand pollination?

Knowledge statement	**Strongly agree (1)**	**Agree (2)**	**Neutral (3)**	**Disagree (4)**	**Strongly disagree (5)**
Hand pollination can be done on cocoa without flowers					
I can pollinate cocoa flowers without waiting for it to open					
A stick is the best instrument to pollinate flowers					
When I pollinate my flowers I do not need to apply GAPs					
The best time to pollinate my trees is in the afternoon					
Pollen grains can be collected from only one tree to pollinate all the trees in my farm					
I can pollinate flowers that are brown in colour					

SECTION D: PERCEPTION ON HAND POLLINATION

21. What are your perceptions on hand pollination

Perception statement	**Strongly agree (1)**	**Agree (2)**	**Neutral (3)**	**Disagree (4)**	**Strongly disagree (5)**
Hand pollination is a difficult activity					
I will waste my money if I pay for hand pollination					
I will earn more money pollinating my farm					
Hand pollination will reduce the harvest from my farm					
My trees may die if hand pollinated					
Hand pollination is time consuming and a waste of my time					

SECTION E: EXPENSES ON SELECTED FARM

How much money did you spend on sampled farm operations over the last 12 months?

INPUTS	***QTY***	***Unit Price***	***Total cost***
Fertilizer Granular (Bags)			
Liquid (LTRS)			
Fungicide			
Insecticide			
Basket/Rubber			
Drying mat			
Harvesting equipment			
Cutlass			
Other			
Other			
Other			

Activity	***Unit cost/day***	***Labour units***	***Total amount spent***
Weeding	***GHC***		**GH¢**
Pruning Inc mistletoe removal	***GHC***		**GH¢**
Spraying fungicide	***GHC***		**GH¢**
Spraying insecticide	***GHC***		**GH¢**
Fertilizer application	***GHC***		**GH¢**
Harvesting, fermentation and drying	***GHC***		**GH¢**
Transportation to LBC	***GHC***		**GH¢**
TOTAL SPENT			**GH¢**