CHRISTIAN SERVICE UNIVERSITY COLLEGE

ASSESSING FARMERS' KNOWLEDGE AND SOCIOECONOMIC IMPACTS OF THE COCOA HAND POLLINATION PROGRAMME: THE CASE OF THE ATWIMA NKWABIAGYA DISTRICT, GHANA

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SEPTEMBER 2023

DECLARATION

Candidate's Declaration

I hereby declare that this dissertation is the result of my own original research and that no part of it has been presented for another degree in this University or any other University.

Candidate's Signature ……. Date …….

Name: Kenneth Ameyaw

Supervisor's Declaration

I hereby declare that the preparation and presentation of the dissertation were supervised in accordance with the guidelines on supervision of the dissertation laid down by Christian Service University College.

Supervisor's Signature ……. Date …….

Name: Dr. Charles Dwumfour Osei

ABSTRACT

Cocoa is one of Ghana's leading products, contributing significantly to the world market. In the past, Ghana held the top position as the leading cocoa producer, supporting millions of jobs in the cocoa sector. However, the current cocoa production has seen a decline attributed to various factors, including pest and disease infestations, poor maintenance, an ineffective extension system, and inadequate cocoa production practices. This study focuses on understanding farmers' knowledge and perceptions of hand pollination and its impact on cocoa yield and farm practices in the Atwima Nwabiagya district. Using structured questionnaire, 388 cocoa farmers were selected using the simple random sampling procedure. The descriptive cross-sectional design was employed. The data was analysed using both descriptive and inferential statistical approach. The findings revealed that Cocoa farmers in the Atwima Nwabiagya district had high knowledge level on hand pollination of cocoa. The finding showed that the adoption of hand pollination of cocoa leads to an increase in farmers' productivity/yield and increased annual earnings. Also, the results showed that the adoption of hand pollination had significant impact on their livelihoods. Farmers reported to possess high human, social, physical, natural, and financial capital after adopting hand pollination method. Finding from the study have implications for policy and practices cocoa pollination and production in Ghana. For instance, Government through COCOBOD must establish tailored credit and savings schemes, facilitate access to financial services such as micro-credit and agricultural loans to farmers who adopt hand pollination in order to enable them make necessary investments in their farms

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DEDICATION

I dedicate this thesis to my loving family, whose unwavering support and encouragement have been my source of strength throughout this journey.

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CHAPTER ONE

INTRODUCTION

Background of the Study

Based on global data projections, it is foreseen that cocoa production will exceed the five million-tonne mark by the culmination of the 2023 harvest season, as outlined in Shahbandeh's (2023) report. In the preceding crop cycle (2021/2022), the worldwide cocoa production stood at roughly 4.9 million tonnes, as per the findings of the Swiss Platform for Sustainable Cocoa (SPSC, 2022). The demand for cocoa primarily emanates from Western Europe and emerging economies across Asia. An interesting point to note is that sustainable sources contributed to approximately 8% of the total value in the global retail cocoa market in 2017. This noteworthy shift was predominantly fuelled by the increasing demand observed in Western Europe and North America, as emphasized in the research conducted by Voora et al. (2019).

Cocoa plays a vital economic role for many small-scale farmers in West Africa, a fact underscored by Abdullahi et al. (2021). In the past decade, West Africa has unquestionably solidified its position as the global leader in cocoa production. Countries such as Cote d'Ivoire, Ghana, Nigeria, and Cameroon, as highlighted in Shahbandeh's (2021) report, collectively account for more than 70% of the world's cocoa supply. Niether et al. (2020) have asserted that cocoa production in Africa, on average, has experienced a consistent annual growth rate of around 3% since the year 2000.

In Ghana, the cocoa sector serves as a vital source of livelihood for more than four million households, as highlighted by Iddrisu et al. (2020). Boadu & Boadu (2021) and Maguire Rajpaul et al. (2020) have further emphasized that the cocoa industry in

Ghana plays a pivotal role in sustaining the income of around 800,000 families and significantly contributes to the nation's foreign exchange earnings.

Recognizing the vital role of cocoa in Ghana's economy, the Ghana Cocoa Board (COCOBOD) initiated two crucial programs during the 2001/2002 and 2002/2003 growing seasons: the Cocoa Disease and Pest Control (CODAPEC) and the cocoa Hi-tech program. These initiatives aimed to saturate cocoa farms with insecticides and fungicides, provided to farmers at no direct cost, as documented by Dormon et al. (2004). Additionally, these programs sought to enhance soil quality. Alongside these efforts, the government of Ghana introduced hand pollination and the cocoa rehabilitation project under the Productivity Enhancement Programmes (PEPs).

Cocoa holds immense significance in Ghana, playing a pivotal role in the country's economic landscape. However, the cocoa sector in Ghana confronts various challenges, including declining yields attributed to aging trees, pest and disease outbreaks, and suboptimal agricultural practices. A key factor contributing to diminishing cocoa yields is poor fruit set, often linked to inadequate pollination. Research has demonstrated that pollination significantly influences farmers' income and crop production (Peixoto et al., 2022).

Hand pollination represents an artificial pollination method, involving the transfer of pollen from one cocoa tree to another's stigma. This technique is employed to enhance cocoa bean yield and quality. Studies by Akoa et al. (2021) and Wongnaa et al. (2021) have underscored the substantial benefits of hand pollination, including increased cocoa production and improved bean quality. However, it's essential to note that hand pollination is labour-intensive and necessitates specialized skills.

Research has been conducted on the impact of hand pollination in cocoa production in Ghana, with studies showing positive results. One study conducted in Ghana found that hand pollination increased the number of pods per tree by 50%, and the number of beans per pod by 20%. Another study in Ghana recounted that hand pollination increased cocoa harvests by up to 75% (Asante *et al.*, 2023).

In summary, existing literature indicates that hand pollination has the potential to be a successful approach for boosting cocoa production in Ghana. Nevertheless, its practical application necessitates a certain level of expertise and technical proficiency. This study aims to investigate farmers' familiarity with this pollination technique and evaluate its influence on cocoa production within the Atwima Nwabiagya district in Ghana.

Problem Statement

In order to boost productivity, good agricultural methods for cocoa include, among other things, managing shade, spraying, weeding, pruning, thinning, removing mistletoe, removing sick pods, and more. To prevent diseases and pest infestations as well as to provide a suitable reaction to specific outbreaks when they do arise, it is crucial to maintain a high standard of farm management (ICCO, 2008). Hand pollination serves as a complementary method to natural pollination, especially in regions where natural pollination is inconsistent or insufficient, with the aim of enhancing pod development.

To bolster cocoa productivity to levels exceeding 1000kg per hectare, the Government of Ghana and the Ghana Cocoa Board incorporated hand pollination as part of their productivity enhancement programs (PEPs). In 2017, COCOBOD initiated the Hand Pollination program on a national scale, marking the beginning of widespread

implementation of this innovative technique. The primary objectives are to boost yields and ensure a sustainable source of income for farmers. (COCOBOD, 2023).

Numerous studies have assessed the effects of various productivity enhancement programs on cocoa production. Some of the productivity enhancement studied include mass spraying (Abankwah, et al., 2010; Gyimah, 2019), and cocoa rehabilitation (Kwaw-Nimeson and Tian, 2019). Numerous short to medium-term interventions have been introduced to address the issue of low cocoa yield and productivity in Ghana. These efforts involve the application of farming technology guidance provided by the Cocoa Research Institute (CRIG) to farmers, with support from the Cocoa Health and Extension Division (CHED). Furthermore, ongoing initiatives include educational and training programs for farmers, focusing on sound agronomic practices. However, despite these proactive measures and the introduction of hand pollination, the issue of low cocoa productivity among Ghanaian farmers persists.

Hand pollination is a method of artificially introducing pollen from one cocoa tree to the stigma of another, in order to increase the yield and quality of cocoa beans. However, despite its potential benefits, the adoption of hand pollination is low among cocoa farmers in Ghana. The main reason is that hand pollination is a labour-intensive, costly, and requires technical skills. This problem is significant as hand pollination is part of the productivity enhancement programs introduced by the Government of Ghana and Ghana Cocoa Board to increase cocoa production and provide sustainable incomes for farmers.

While there have been prior studies in Ghana investigating farmers' perceptions and knowledge of hand pollination (Umeh et al., 2022; Nyamekye, 2021; Tham-

Agyekum et al., 2022), there remains a significant knowledge gap regarding farmers' perceptions and practical implementation of hand pollination in the country.

There is a growing body of research on hand pollination as a productivity enhancement program for cocoa, there is less research on how farmers' knowledge and perception of this practice influence their decision to adopt it. This is an important research gap to address, as it is essential to understand the factors that influence farmers' adoption of new technologies and practices. A more detailed understanding of farmers' knowledge and perception of hand pollination is essential for developing effective interventions to promote its adoption. For example, if farmers are unaware of the benefits of hand pollination, or if they believe that it is too difficult or expensive to implement, then targeted educational and training programs could be developed to address these concerns.

The current study aims to expand the existing literature on farmers' knowledge levels by focusing on the Atwima Nwabiagya district, which has not been previously explored. This district is of particular significance as it contributes significantly to the overall cocoa production in Ghana. Previous studies have examined knowledge levels in specific regions or districts within the country, but the focus of the Atwima Nwabiagya district in this study adds a valuable contribution to the understanding of cocoa farming practices. Also, little is known about the gendered disparity of knowledge and practice of hand pollination of cocoa in Ghana. The current study shed light on this dearth of knowledge. On this background, it is noteworthy to assess farmers’ knowledge and perception about hand pollination method in cocoa production.

Aims and Objectives

The aim of the study is to assess the impact of hand pollination on cocoa production among farmers in Atwima Nwabiagya district. The specific objectives of the study are:

i. To examine the knowledge level of farmers in practicing hand pollination method for increasing cocoa production output
ii. To investigate the Perceived impact of hand pollination programme on cocoa yield in Atwima Nwabiagya district
iii. To examine the perceived economic and social contributions of hand pollination programme to the livelihood of the cocoa farmers in the Atwima Nwabiagya district

Research Questions

i. What is the knowledge level of farmers in practicing hand pollination method for increasing cocoa production output?
ii. What is the Perceived impact of hand pollination programme on cocoa yield in Atwima Nwabiagya district?
iii. What are the perceived economic and social contributions of hand pollination programme to the livelihood of the cocoa farmers in the Atwima Nwabiagya district?

Significance of the Study

The significance of the study lies in its potential to improve the adoption and effectiveness of hand pollination as a method of increasing cocoa production in the Atwima Nwabiagya district.

By assessing the knowledge level of farmers on hand pollination and its impact on cocoa production, the study aims to identify the constraints facing the program and suggest ways to address them. This information will be invaluable to Ghana COCOBOD in revising their strategies for implementing the hand pollination program to make it more effective and beneficial to farmers.

In addition, the study will contribute to the existing body of knowledge on cocoa production in Ghana and other related areas by providing important literature on the impact of artificial pollination. This information will be useful to other researchers who may wish to conduct further research in this area.

The outcomes and suggestions derived from this study will have a valuable impact on various stakeholders, including policymakers, industry management, and participants in the cocoa sector. These findings can shape the decisions and actions of stakeholders, encouraging them to embrace the practice of hand pollination. Ultimately, the effective implementation of the hand pollination program is expected to result in higher yields and stable incomes for farmers in the Atwima Nwabiagya district. This, in turn, will contribute significantly to the expansion and prosperity of the cocoa industry in Ghana.

Delimitation of the Study

Geographically the scope of the present study is limited to the Atwima Nwabiagya district of the Ashanti Region of Ghana, and the results may not be generalizable to other regions or countries. Moreover, the study focused specifically on the use of hand pollination as a method for increasing cocoa yields and farmer income, and did not explore other pollination techniques that can affect cocoa yield.

Participation in the study was strictly voluntary and may reflect sampling bias and may not be representative of the broader population of cocoa farmers in the region.

Limitation of the Study

The study relied on self-reported data from farmers, which may be subject to bias or inaccuracies. Additionally, study did not control for other potential factors that may impact cocoa yields and farmers, income such as weather conditions or pest infestations. These omitted variables may confound the documented results, potentially affecting the validity of the findings.

Organization of the Study

The research was organized into five distinct chapters. Chapter one serves as the introduction to the study, encompassing the following elements: the study's background, the statement of the problem, research questions, the study's objectives, the hypothesis, justification for the research, and the study's scope.

Chapter two delves into an extensive literature review, synthesizing relevant research findings on the subject matter.

Chapter three elaborates on the methodology used and the research instruments selected to address the study's objectives.

Chapter four is dedicated to presenting the research results, visually represented through tables and graphs, aligning with the research questions and objectives.

Lastly, chapter five provides a summary of the study, draws conclusions, acknowledges the study's limitations, and offers recommendations for policy and suggestions for future research endeavours.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter of the study is dedicated to present the theoretical, empirical, and conceptual framework. The chapter discusses the theoretical perspectives to the study, gives an overview of cocoa production in Ghana, and presents give a brief accounts of trends in cocoa production in Ghana. The chapter further sheds light on the various actors in the production of cocoa, give a brief account on farm management practices that affect the production of cocoa as well as discuss the various pollination method at the disposal of cocoa farmers. The chapter gives an account of farmers' knowledge on hand pollination of cocoa, its effects on yield and livelihood.

Theoretical Underpinnings

Technology Acceptance Model (TAM)

The Technology Acceptance Model, originating from the Theory of Reasoned Action and Planned Behaviour, was initially introduced by Davis in 1989 (Lala, G. (2014) Its primary aim at its inception was to provide a comprehensive explanation of the factors influencing the acceptance of computers. This model was designed to be a flexible framework capable of explaining user behaviour across various end-user computing technologies and diverse user populations while maintaining simplicity and theoretical robustness (Lala, G. (2014)). Over time, the applicability of the Technology Acceptance Model has expanded beyond the realm of computers to encompass a wide range of other technologies. These technologies now include telemedicine services (Kamal et al., 2020), among others, digital tools for educators (Scherer et al., 2019), mobile phone applications (Min, So, & Jeong, 2019), and e-learning platforms for students (Sukendro et al., 2020).

Davis' Technology Acceptance Model (TAM), which was introduced in 1989, remains one of the most widely employed research models for predicting how individuals will behave when it comes to adopting and embracing information systems and technology. TAM has undergone extensive examination and validation through numerous studies that delve into how people accept and engage with technology across various contexts within information systems (Tung et al., 2008).

Within the TAM framework, two pivotal factors play a crucial role in shaping individuals' behaviours related to technology usage: perceived usefulness and perceived ease of use. Perceived usefulness refers to the personal evaluation made by a potential user regarding the likelihood that using a particular application system will improve their job performance or overall quality of life. Conversely, perceived ease of use (EOU) can be described as the extent to which a prospective user expects that the target system will be user-friendly and require minimal effort (Lala, G. (2014).

According to the TAM model, the primary drivers that significantly influence the actual usage of technology are perceived ease of use and perceived usefulness, as highlighted by Rauniar et al. (2014). These two factors are subject to the impact of various external influences, with social, cultural, and political forces being the most common among them. Social variables encompass elements like language, skills, and facilitating conditions, all of which can affect a user's perception of technology. On the other hand, political factors encompass the utilization of technology in politics and during political crises, as observed by Zabukovsek and Bobek (2013). Within the TAM framework, attitude to use relates to how users evaluate the usefulness of a specific information system application. Behavioural intention, on the other hand, serves as a metric for gauging the likelihood that an individual will actually employ the application in question.

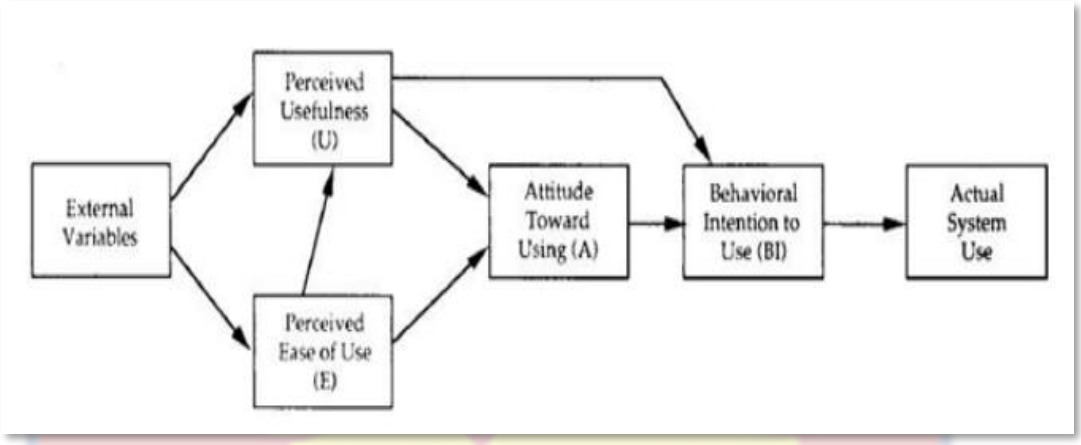

Figure 1: Technology acceptance Model (TAM)

Diffusion of Innovation Theory

In the late 19th century, the initial exploration of the dispersion concept was carried out by notable figures in the fields of sociology and anthropology. French sociologist Gabriel Tarde, as well as German and Austrian anthropologists and geographers like Friedrich Ratzel and Leo Frobenius, were instrumental in laying the groundwork for these early studies (Kaminski, J. (2011).

As agricultural technology continued to advance, researchers began delving into how independent farmers embraced innovative practices, tools, and hybrid seeds (Atela et al 2018). Notably, the work conducted by Ryan and Gross (2017) regarding the acceptance of hybrid maize seeds in Iowa marked a pivotal moment in the evolution of diffusion studies. Their research introduced a new paradigm that would go on to shape subsequent studies in this field.

Since its inception within rural sociology, the Diffusion of Innovations theory has found applications in a wide range of disciplines. These applications span across fields such as medical sociology, communications, marketing, development studies, health promotion, organizational studies, knowledge management, conservation biology, and complexity studies, as highlighted by Greenhalgh et al. (2018). Of

particular significance has been its utilization in examining the adoption of medications, medical procedures, and health communication strategies, as emphasized by Berwick (2003).

E.M. Rogers, an American scholar, introduced the Diffusion of Innovation Theory in 1962. At its core, this theory focuses on the dynamics of how an idea or product gains acceptance and spreads within a population or social system over time. When a new concept or invention is embraced, it leads people to alter their behaviors and practices from their previous routines. To make this transition, individuals must perceive the innovation as novel or ground-breaking (LaMorte, 2018).

The theory proposes a process where the adoption of an innovation does not happen instantaneously across a social system. Instead, it posits that certain individuals within the population are more inclined to accept the innovation earlier than others. Furthermore, the theory highlights the influence of specific personality traits on the speed at which people adopt new ideas or innovations. As LaMorte (2018) elaborates, Rogers identified five distinct adopter types in his research

- Innovators: These individuals are often the first to explore and experiment with new ideas or inventions. They possess a daring and adventurous spirit, actively seeking out novel concepts. Innovators require minimal motivation to engage with innovations, as their inherent curiosity drives them.
- Early Adopters: Early Adopters are opinion leaders within their communities. They readily take on leadership roles and are open to change. They are already aware of the need for change and are receptive to fresh ideas. Providing how-to guides and implementation information can effectively engage this group, as they do not require extensive persuasion.

- Early Majorities: While not leading the charge, the Early Majorities are among the first to adopt new ideas. They, however, require evidence of an innovation's effectiveness before embracing it. To engage this demographic, strategies frequently involve featuring success stories and providing data that highlights the practicality and benefits of the innovation.
- Late Majorities: Late Majorities are hesitant to change and typically wait until a significant portion of the population has already adopted an innovation. To engage this group, it is essential to provide information demonstrating the widespread adoption and successful implementation of the innovation.
- Laggards: Laggards are characterized by their strong adherence to tradition and resistance to change. They are the most challenging group to persuade and are highly conservative. Strategies to appeal to Laggards may involve presenting statistics, utilizing fear appeals, or leveraging pressure from individuals in other adopter groups.

Understanding these adopter categories is crucial for effectively introducing and diffusing innovations within a given population or social system. Each group's unique characteristics necessitate tailored approaches to facilitate the acceptance and adoption of new ideas or products.

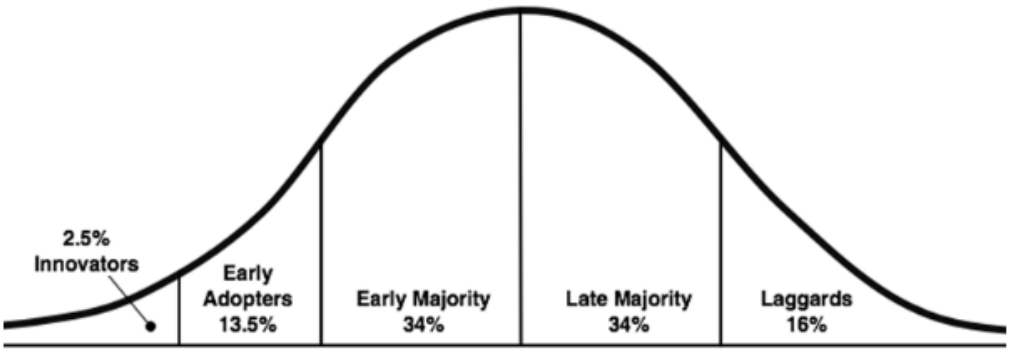

Figure 2: A Graphical Representation of Diffusion of Innovation Theory

The Diffusion of Innovation Theory, proposed by Everett Rogers, describes how new ideas, products, or technologies spread through a population over time. It breaks down the adoption process into five categories: innovators, early adopters, early majority, late majority, and laggards. Let's relate this theory to the adoption of hand pollination as a new technology by farmers using the provided percentage values.

Innovators (2.5%): Innovators are the first to adopt a new technology. In the context of hand pollination for farmers, this group might include those individuals or a small percentage of farmers who are highly innovative and eager to experiment with new agricultural techniques. They are likely to have a keen interest in the potential benefits of hand pollination, such as increased crop yields or better control over the pollination process.

Early Adopters (13.5%): Early adopters are the second group to adopt the innovation. These farmers are influential within their communities and are willing to take risks. They see the potential benefits of hand pollination and are willing to invest time and resources to learn and implement this new technique. Their adoption can influence neighboring farmers to consider hand pollination.

Early Majority (34%): The early majority is a larger group of farmers who adopt the innovation after a careful observation of its success and acceptance by the innovators and early adopters. They are more cautious in their approach and tend to adopt a new technology when it becomes more established and widely accepted within their community. These farmers may adopt hand pollination as they see their peers benefiting from it.

Late Majority (34%): The late majority consists of farmers who are skeptical of new technologies and innovations. They adopt hand pollination after seeing the

majority of their peers successfully implement it and observe positive outcomes in terms of crop yields and quality. Economic pressures or the need to remain competitive might drive this group to adopt the technology.

Laggards (16%): Laggards are the last to adopt the innovation. They are resistant to change and may only adopt hand pollination when it becomes an absolute necessity or a standard practice in the industry. Resistance to change, tradition, or limited resources may delay their adoption.

In summary, the graphical representation of the Diffusion of Innovation Theory for the adoption of hand pollination by farmers would show a slow initial uptake (innovators and early adopters), followed by a rapid increase in adoption as the innovation gains acceptance (early majority and late majority), and a slower uptake towards the end (laggards). The point at which the early majority starts adopting hand pollination is a critical turning point that influences the widespread adoption of this new technology within the farming community.

Overview of Cocoa Production in Ghana

According to COCOBOD (2019), the historical roots of cocoa can be traced back to the headwaters of the Amazon River in South America, where indigenous communities originally used it to create beverages and chocolate. The export of cocoa to Europe commenced during the 16th and 17th centuries, originating from South America. While the Spanish initiated substantial cocoa plantations in Brazil, the significant expansion of cocoa cultivation occurred with the arrival of Tetteh Quarshie, a native of Osu, Accra. In 1879, he returned from Fernando Po with Amelonado cocoa pods and established a farm in Akwapim Mampong, located in the Eastern Region.

Local farmers began acquiring cocoa pods from Quarshie's farm, subsequently establishing their own cocoa plantations. This led to the widespread adoption of cocoa cultivation, initially spreading from the Akwapim region to other parts of the Eastern Region. Although the Basel Missionaries had also been involved in cocoa cultivation in Aburi since 1857, it was Quarshie's introduction of Amelonado cocoa pods that truly accelerated the expansion of cocoa farming in the region.

Cocoa Production in Ghana

Cocoa holds significant economic importance in the equatorial region, which is characterized by abundant rainfall, with an annual average of approximately 1,250mm, and mean annual temperatures ranging from 25.50 to 26.50 degrees Celsius.

These climatic conditions create an ideal environment for cocoa cultivation, particularly in the West African regions along the Gulf of Guinea. Notable cocoa-producing countries in this region include Ghana, Nigeria, Ivory Coast, Cameroon, and Liberia (Schroth et al., 2016). Currently, Ghana stands as the world's second-largest cocoa producer, with Cote d'Ivoire being the only country ahead of it in cocoa production (Adjei et al., 2020).

In Ghana, the cultivation of cocoa is primarily concentrated in the nation's rainforest regions, specifically in Ashanti, Brong Ahafo, Central, Eastern, Western, and Volta. These regions experience annual rainfall ranging from 1000 to 1500mm, which creates optimal conditions for cocoa production (World Bank, 2020). The primary cocoa harvest season begins in October, followed by a smaller mid-crop season that commences in July. It's worth noting that the majority of cocoa production in Ghana is attributed to smallholder farmers who oversee plots of land typically not exceeding three hectares in size.

Trends in Cocoa Growth in Ghana

Since its inception in Ghana during the 19th century, the cocoa industry has undergone notable fluctuations. Kolavalli and Vigneri (2011) describe four distinct phases in the development of cocoa production in Ghana: an initial period of introduction and remarkable growth (1888-1937), followed by a phase of stagnation, succeeded by a brief but swift expansion after the country gained independence (1938-1964). Subsequently, there was a precarious period of near-collapse (1965-1982), only to be succeeded by a phase of recovery and expansion, commencing with the implementation of the Economic Recovery Programme in 1983.

During the era of rapid cocoa cultivation expansion in the Gold Coast (1888-1937), farmers from the Akuapem and Krobo tribes, residing in the Eastern region, introduced cocoa to the southern region in the mid-19th century. They made this move due to various factors, including declining global palm oil prices around 1885, a rise in rubber exports, land limitations in Akuapem, and the establishment of produce buying firms along the coast to facilitate trade in the newly introduced cocoa crop. These farmers relocated to Akyem, where they acquired land from local chiefs to start cultivating cocoa (Hill, 1963). This expansion of cocoa cultivation eventually reached the Ashanti and Brong Ahafo regions, solidifying Ghana's position as the world's top cocoa producer between 1910 and 1914.

The period following the phase of exponential growth is commonly referred to as the "stagnation and post-independence growth" phase, spanning from 1938 to early 1964. During this interval, cocoa production faced challenges stemming from pest and disease outbreaks, particularly affecting the Eastern region. Consequently, cocoa farmers shifted their cultivation to the Brong Ahafo region. Nevertheless, after Ghana's attainment of independence, cocoa production gradually increased, reaching a

remarkable peak of 430,000 tons, despite a decline in global cocoa prices from 1960 to 1962. Nevertheless, the government grappled with difficulties due to the global cocoa price slump, which eroded the liquidity reserves of the Cocoa Marketing Board (CMB) and led to reductions in producer prices. Notably, during this same period, in February 1966, the government was overthrown, resulting in significant challenges within the cocoa sector, as detailed by Kolavalli and Vigneri (2011).

Kolavalli (2018) points out that the decline in cocoa production began in 1965, triggered by a collapse in global cocoa prices. This phase persisted from 1964 to 1982 and witnessed around 20% of Ghana's cocoa being smuggled to Côte d'Ivoire between 1970 and 1980 (Bulír, 2002). Additionally, the aging of cocoa trees and the prevalence of diseases made cocoa farming unattractive to farmers, leading to a shift towards food crop agriculture (Amanor, 2010). As a result, cocoa production dwindled to as low as 159,000 tons in 1982/83.

In an effort to revitalize the sector, the government implemented various measures, including the establishment of the Cocoa Marketing Board (CMB), the introduction of bonuses for cocoa farmers, and an increase in producer prices. These initiatives marked the beginning of a new phase in the cocoa sector known as the "recovery and second expansion" phase, spanning from 1983 to 2008, as outlined by Kolavalli and Vigneri (2011).

Ghana's cocoa sector recovery was initiated through the implementation of the Economic Recovery Programme (ERP) in 1983. A critical component of the ERP was the Cocoa Rehabilitation Project, designed to rejuvenate the cocoa industry. This project introduced a pricing mechanism that raised cocoa farm prices in Ghana above those offered in neighbouring nations, discouraging cocoa smuggling. Furthermore,

farmers received compensation for the removal and replacement of cocoa trees afflicted with swollen shoot disease, which encouraged the planting of higher-yielding cocoa varieties. Consequently, cocoa production rebounded, reaching 400,000 tons by 1996, and productivity significantly improved from 210 to 404 kg/ha.

The growth of Ghana's cocoa production gained substantial momentum in 2001, partly attributable to elevated global cocoa prices and interventions by the Cocoa Marketing Board. These interventions included initiatives like the cocoa mass spraying program and subsidies for fertilizers. However, it's worth noting that some attribute this growth to cocoa smuggling from neighbouring countries, such as Ivory Coast, estimated to be between 120,000 and 150,000 tons in 2004. Despite occasional shortfalls, cocoa prices have demonstrated a consistent upward trend over time. Currently, Ghana's annual cocoa production averages around 900,000 tons, with peak years witnessing production levels reaching one million tonnes.

Actors of Cocoa Production in Ghana

Ghana's cocoa industry involves a broad spectrum of participants categorized into the public, formal, and informal sectors. COCOBOD serves as the public sector representative, overseeing export operations and input provisioning. The formal sector, which encompasses Licensed Buying Companies (LBCs), establishments specializing in cocoa-based food products, and cocoa beverage processors, operates under government regulations. The informal sector, as identified in the 2016 sixth round of the Ghana Living Standard Survey by the Ghana Statistical Service, comprises private traders, small-scale enterprises, and self-employed entrepreneurs. This diverse mix of participants collectively shapes the landscape of Ghana's cocoa industry.

Formal Actors

At the commencement of each cocoa season, COCOBOD extends loans to Licensed Buying Companies (LBCs) at reduced interest rates, earmarked specifically for compensating cocoa farmers. LBCs strategically seek to augment their market share by maximizing cocoa bean purchases and adjusting their cocoa production as necessary (Williams, 2009; World Bank, 2013). In pursuit of the market objectives in Ghana's cocoa industry, LBCs have devised an effective approach, with Public Buying Companies (PBCs) functioning as subsidiaries of the LBCs. PBCs are tasked with procuring approximately 35% of the country's cocoa beans and have earned a commendable reputation, garnering recognition as the foremost business in Ghana in 2011, outstanding monetary institutions and manufacturing enterprises.

Another vital player in the Ghanaian cocoa sector revolves around extension services and research. The Cocoa Health and Extension Division (CHED) collaborates with LBCs and various Non-Governmental Organizations (NGOs) to elevate cocoa productivity and annual crop yields through farmer training initiatives. CHED's training programs encompass both traditional and modern cocoa production techniques, as well as agronomic and forestry technologies. Furthermore, CHED imparts knowledge to farmers regarding weed, pest, and disease control measures aimed at enhancing crop yields. These endeavours find substantiation in studies conducted by Aneani et al. (2013) and the World Bank (2013). Additionally, the focal hub for cocoa production research in Ghana is the Cocoa Research Institute (CRIG). CRIG systematically conducts research across various facets of the production process, delving into cocoa species varieties, pest and disease dynamics, and the intricacies of cocoa cultivation in the country.

Informal Actors

In Ghana's cocoa market, informal participants include the food retail sector and consumers. The predominant retail landscape comprises grocery stores and open-air markets, with supermarkets constituting a minor portion, approximately 5% (MoFA and World Bank, 2008). Within these retail establishments, a wide array of cocoa-related products is accessible to consumers, encompassing locally manufactured and imported items such as chocolates, chocolate spreads, pastries, cakes, hair care products, candies, and cocoa powder for beverages.

International Market Actors

The primary global influencer in the Ghanaian cocoa market is the International Cocoa Organization (ICCO), headquartered in London. It consists of both cocoa-producing and cocoa-consuming nations. ICCO serves as a platform for international stakeholders to collaborate effectively in structuring and managing the global cocoa market for the mutual benefit of all parties involved. Since its establishment, more than 80% of cocoa-exporting countries have ratified the International Cocoa Agreement, which provides a framework for industry practices. ICCO member countries collectively contribute to 85% of global cocoa production and consume over 60% of the world's cocoa (icco-cooperation.org).

In addition to ICCO, international corporations such as Cadbury (now part of Kraft Foods) and Unilever, which heavily rely on cocoa in their food products, also wield significant influence in shaping the market.

Structure and Stability of Cocoa Flowers

According to Gutiérrez et al (2016), cocoa, a tropical woody species, serves as an example of an allogamous plant. Initially classified within the Sterculiaceae family,

cocoa was subsequently reclassified under the Malvaceae family. The primary cocoa groups include Criollo, often known as Fine Cocoa, and Forastero, also identified as Theobroma leiocarpa. These groups are differentiated by their fruit and seed characteristics, respectively. Furthermore, a third category, referred to as mixed or hybrid cocoa, has emerged and is believed to result from cross-pollination between the Forastero and Criollo groups (Nyamekye, E. 2021).

Historically, the majority of cocoa cultivated in the former Gold Coast belonged to the Forastero variety. However, over the past two decades, the Cocoa Shoot Virus Disease (CSSVD) Control Unit of COCOBOD has reported a distribution of cocoa types, with 17.83% being hybrids, 8.48% categorized as amelonado varieties, 58.52% representing Amazon varieties, and 15.17% comprising mixed varieties. Eskes (2001) estimates that the currently cultivated cocoa varieties account for about 30% of the total. Additionally, research conducted by Adomako and Adu (2000) indicates that 70% of cocoa trees are traditional populations, as farmers tend to favour them by saving seeds from trees that are likely to be inbred.

The process of cocoa cultivation remains relatively consistent across West Africa and typically involves the utilization of both primary and secondary forests for planting (Dguma et al., 2001). While there is a correlation between larger cocoa farms and plantations, it's important to note that size does not always translate to higher cocoa output. This trend has raised concerns about cocoa's adverse impact on tropical forests, particularly as expansion often occurs in undisturbed areas. This has prompted stakeholders and researchers to advocate for an alternative approach (World Bank, 2011; MES, 2002; Asare, 2006). The proposed solution centres on enhancing cocoa production by focusing on its flowers and optimizing their utilization through insect pollination.

According to Claus et al (2018), cocoa flowers possess distinct characteristics: they are small, grow directly on the trunk or branches (cauliflorous), and are hermaphroditic, containing both male and female reproductive parts. The unique structure of cocoa flowers, with five separate anthers set apart from the central stigma by a folded sepal, highlights the importance of pollinators in the pollination process. Although cocoa blossoms typically reach their peak during the early rainy season, Bos et al. (2007) have observed that cocoa flowers can be found year-round. As detailed by Lopez et al (2021) each cocoa tree produces approximately 125,000 flowers annually. However, it's worth noting that the abundance of flowers may vary among different cocoa genotypes, as mentioned by Snoeck et al (2016).

In Ghana, cocoa farms generally undergo a period of sporadic flowering from January to March during the dry season. As the rainy season begins in April, there is a notable increase in flowering activity. However, this intensity gradually diminishes, leading to minimal to no flowers during the peak of the main crop season. After the main crop is harvested, there is a resurgence in flowering intensity.

Anand et al. (2015) attributes this phenomenon to the dynamics of competition for space and resources, where an increase in developing pods on the tree leads to a decrease in flowering intensity and vice versa.

Several cocoa-producing countries have observed that seasonal changes can influence the flowering pattern of cocoa. This includes factors like flower production and pod setting, which are directly or indirectly affected by environmental conditions such as temperature and rainfall (Dyamond and Hadley, 2008). As noted by De Almeida et al. (2010), regions with distinct seasonal variations in rainfall and temperature may pose challenges for cocoa flower growth.

Overview of Hand Pollination of Cocoa

According to the Environmental and Social Management Report (2018), hand pollination in cocoa farming involves a deliberate and manual process of cross-fertilizing the male and female flowers of cocoa plants. This method is employed to complement natural pollination, especially in areas where natural pollination is either irregular or insufficient, with the aim of increasing pod development.

To support and enhance cocoa production, it is essential to have a comprehensive understanding of its pollination process. Cocoa plants rely on Forcipomyia midges, which belong to the Ceratopogonidae family, for the transfer of their adhesive pollen (Mena-Montoya, 2020). However, the population of these midges can be influenced by changes in rainfall patterns, leading to fluctuations in their numbers. To improve cocoa yields, it is crucial to take into account the ecosystem and enhance factors that positively impact cocoa production (Gockowski & Sonwa, 2010).

Pollination is a crucial ecosystem service that plays a vital role in cocoa yield. As highlighted by Bos et al. (2007), cocoa pollination has been a concern for over a century because approximately 90% of cocoa flowers drop off without proper pollination. The pollination process heavily relies on midges, which thrive in moist and humid environments. Several studies (Vera-Chang et al., 2016; Forbes et al., 2019; Toledo-Hernández et al., 2020) suggest that artificial pollination is a favourable solution to address the challenges associated with natural pollination. This method involves human intervention in the pollination process and is employed when natural pollination is insufficient. It is a mechanical process used to enhance the yield and quality of tree crops like cocoa (Forbes et al., 2017).

In June 2017, COCOBOD initiated a program to employ 10,000 young individuals on a contract basis for the purpose of pollinating approximately 19,200 hectares of cocoa farms in Ghana. Another 10,000 individuals were hired in 2017/2018, resulting in a total of 20,000 young workers dedicated to pollinating 38,400 hectares of farms. In selected cocoa farming areas, farmers received training in good agricultural practices aimed at increasing flower production. According to the Environmental and Social Management Report (2018), COCOBOD had plans to re-engage the 30,000 trained pollinators in 2019 to pollinate 57,600 hectares of cocoa farms. This pollination program, sponsored by COCOBOD, continued until 2021, at which point farmers had acquired sufficient training and experience to take over and manage the project independently.

Figure 3: Hand Pollination Process

Importance of Hand Pollination Technique

Hand pollination, as previously mentioned, is a method of pollination where pollen is manually or mechanically applied to the pistils of a flower, primarily used

when there are deficiencies in natural pollination (Pinillos & Cuevas, 2008). It can be employed exclusively, such as in the case of vanilla cultivation in Madagascar (Westerkamp and Gottsberger, 2000), or supplementary, as seen in the passionfruit cultivation in Brazil, where manual pollen application complements natural pollination (Silveira et al., 2012). Hand pollination is frequently utilized in plant breeding to exert precise control over parentage (Frankel & Galun, 2012).

Hand pollination becomes necessary when there are limitations in the pollination process. Pollination limitations can result from insufficient pollen deposition in terms of quality or quantity or a complete absence of natural pollinators (Wilcock & Neiland, 2002). When there is a lower fruit set under natural conditions compared to manual pollination, it indicates the presence of pollen limitation (Holzschuh et al., 2012; Minarro & Twizell, 2015). These limitations can have adverse economic consequences and pose a threat to crop survival (Basu et al. 2011; Christmann, 2019). Hand pollination serves as a safeguard by enhancing or substituting natural pollination in situations or locations where natural pollinators are scarce or unreliable (Kiepiel, I. (2019). It is particularly valuable when conservation efforts for pollinators face constraints, whether due to urban environments (e.g., Baldock, 2020), time requirements (e.g., ecosystem restoration; Kremen & M'gonigle, 2015), lack of knowledge (e.g., in rural areas; Marques et al., 2017), or limited resources (e.g., in the Global South, Eardley, Gikungu, & Schwarz, 2009). Hand pollination emerges as a valuable management tool in these scenarios.

Cocoa primarily depends on insect pollinators for the pollination process, with the most significant pollinators being midges belonging to the Ceratopogonidae family, particularly the female members (Lane, 2012). In addition to ceratopogonids, other small dipteran insects have been observed visiting cocoa blossoms. These include

Cecidomyiidae (gall midges), Chironomidae (non-biting midges), Drosophilidae (fruit flies), Psychodidae (moth flies), and Sphaeroceridae (small dung flies). Occasionally, other insects like aphids, coccids, cicadellids (Hemiptera), thrips (Thysanoptera), and ants (Hymenoptera) may also visit cocoa blooms. However, their contribution to pollination is likely minimal, resulting in lower cocoa production yields.

Empirical Review

Farmers' Knowledge on Hand Pollination of Cocoa

This section of the chapter is dedicated to discuss the various empirical findings regarding farmers' knowledge and awareness of hand pollination techniques of cocoa.

The study by Nyamekye & Dansoh (2021) assessed the knowledge and perception of farmers on hand pollination of cocoa in the Tafo cocoa district in Ghana. Using 200 cocoa farmers from the district, the study found that about 90% of cocoa farmers were aware of hand pollination and understood its importance to cocoa yield. However, only 27% of the study's participants reported they use such methods in their cultivation process of cocoa. The study attributed this low practice to lack of knowledge and training on the technicalities involves in hand pollination, the high labour cost, and the general perception that natural pollination is sufficient. Similarly, using the mixed method approach, Umeh et al. (2022) investigated farmers' knowledge and practice on pollination and insecticide use in cocoa farming in Ghana. The findings showed that farmers had substantial natural pollination and how it impacts cocoa yield. However, only about 7% of the surveyed participants were aware of farm management practices such as hand pollination as a supplement to natural pollination process. The study concluded that there is a need for increased awareness and education among cocoa farmers about hand pollination techniques.

Wongnaa et al. (2022) study on the perception and adoption of artificial pollination technology in cocoa production in the Western and Ashanti regions of Ghana. The findings showed that 74% of cocoa farmers were aware of artificial pollination technology, with 46% reporting the use of the technique on their farms. The most commonly used artificial pollination technique was the use of a paintbrush, followed by the use of cotton swabs. Respondents of the study indicated the beneficial impacts artificial pollination had had on their cocoa yield. However, the study identified knowledge gap and high labour cost as hindrance to the adoption of these induced pollination procedures. Tham-Agyekum et al. (2022) found that about 89% of cocoa farmers in the western and Ashanti regions of Ghana were aware of hand pollination and adopted the practice. The study further asserted that farmers that adopted this technique reported a significant improvement in their cocoa yield and income, with 63% of farmers reporting an increase in yield and 74% reporting an increase in income.

Osterman (2021) investigated how on-farm experience shape farmers knowledge, perception of pollinators, and management practices in Mexico and Costa-Rica. The study found that farmers' knowledge and perceptions of pollinators were largely shaped by their on-farm experiences. Farmers who reported high levels of pollinator visitation on their farms were more likely to have a good understanding of pollination and to perceive pollinators as important for cocoa production. Hence, the study recommended that extension services should prioritize on-farm training and education on the importance of pollinators and the management practices.

The Impact of Hand Pollination on the Cocoa Production

The data on the mean percentage of pollination-to-fruit set ratio indicates that only 5-10% of the cocoa flowers develop into fruits, and many of them are not fully mature. This suggests that there are yield gaps in major cocoa-producing countries due

to limitations in pollination (Toledo et al., 2017). This low percentage is primarily attributed to the insufficient deposition of pollen onto the flowers, which affects effective pollination. Wanger et al. (2014) argued that addressing cocoa pollination issues could help overcome current yield shortfalls and contribute to climate-resilient and sustainable production methods. In smallholder farms in Indonesia, studies have shown that hand pollination of all blossoms on a tree increased yields by 2.6 times compared to natural pollination, regardless of fertilizer and pesticide inputs (Toledo et al., 2020).

In a randomized controlled trailed study by Toledo et al. on the effect of hand pollination on cocoa yields in agroforestry systems in Brazil, the findings suggest that hand pollination results in a significant increased cocoa yield. The findings showed that the average cocoa yield of 0.96 kg/tree, while the control group had an average yield of 0.31 kg/tree. Also, it was found that hand pollination had a positive effect on the quality of cocoa beans produced, with the treatment group producing higher-quality beans than the control group. Wurz et al. (2021) found that hand pollination increases crop yields (including that of cocoa). The study found that hand pollination can increase yield and improve quality of the cocoa beans. The study by Wongnaa et al. (2021) evaluated the impact of the adoption of artificial pollination technology on cocoa yield and income of farmers in Ghana. The results of the study suggested that adoption of artificial pollination was associated with increased cocoa yield and income of farmers. Particularly, farmers that adopted artificial pollination techniques had an average yield of 958kg per hectare whereas those that did relied solely on natural pollination process had an average yield of 719kg. Surprisingly, this study showed that the cost involves in adopting artificial pollination of cocoa was relatively inexpensive and required little technical know-how.

Gockowski et al. (2010) examined the impact of farmers' field school (FFS) program (which incorporated hand pollination) on cocoa production in the central and western regions of Ghana. The study found that FFS participation had a positive impact on cocoa production practices, yield, and income. FFS participants had higher cocoa yields (25% increase) and income (21% increase) compared to non-participants. FFS participants also reported using fewer pesticides and applying them at the right time, resulting in cost savings and reduced negative environmental impacts.

The Impact of Hand Pollination on the Livelihood of Cocoa Farmers

Several studies have outlined the beneficial impact artificial pollination of crops has on the livelihoods of farmers. For instance, Toledo et al. (2020) found hand pollination of cocoa increases farmer's income. Specifically, the study found that the average income per hectare was highest for the hand pollination treatment ($4,224), followed by the fertilizer treatment ($2,315) and the pesticide treatment ($2,065). Hence, the study concluded that hand pollination is a more effective and profitable method for increasing yield and income of farmers.

Tham-Agyekum et al. (2022) conducted a study involving 120 cocoa farmers from the Fanteakwa district of Ghana, revealing that hand pollination of cocoa had a positive impact on the livelihoods of these farmers. Specifically, the farmers reported an increase in cocoa yield, income, and food security as a result of hand pollination. Similar findings were reported by Wongnaa et al. (2021), who observed that the adoption of artificial pollination technology led to a 36% increase in cocoa yield, resulting in higher income for farmers. Interestingly, Wongnaa et al. also noted that farmers adopting this technology had improved access to extension services, credit, and market information, which further contributed to enhanced livelihoods.

Wanger et al. (2021) emphasized that manual pollination could significantly benefit major cocoa-producing countries like Ivory Coast, Ghana, and Indonesia. Their research suggested that manual pollination has the potential to triple farm yields and double farmers' annual profits in these countries. Additionally, it was proposed that manual pollination could increase global cocoa supplies by up to 13%.

Nyamekye & Dansoh (2021) asserted that although there are challenges associated with the adoption of hand pollination method, farmers reported increased yield and income after adopting hand pollination. Asare-Nuamah & Mandaza (2021) highlighted that the government of Ghana use artificial pollination method as a means to boost cocoa output and enhance the livelihoods of farmers. Akinrinola & Adeyemo (2018) established that adoption of agricultural technology such as yam minisetts technology has a positive impact on poverty reduction among farmers in Ekiti state, Nigeria. In conclusion, the literature posits a favourable impact of artificial pollination (technology) of cocoa on the livelihoods of farmers.

Conceptual Framework

The conceptual framework of the study describes the model of the study as well as its intended goal. The most desirable outcome in agriculture for a farmer is to obtain the highest crop yields and better-quality fruit and seeds while working with the available resources and ecological conditions. When farmers are involved in cash crop farming, getting a premium price for the produce is especially crucial. Two approaches are widely used to increase crop productivity. Using agronomic inputs, such as high-quality seeds and planting materials, as well as procedures to increase yields, such as providing good irrigation, organic manure, inorganic fertilizers, and pesticides, is the first strategy. The second approach makes use of biotechnological methods, like adjusting the rate of photosynthesis and biological nitrogen fixation. However, there

exists a third but relatively less known approach of enhancing crop productivity, namely, manual pollination.

Pollination is vital for completing the life cycle of plants and ensuring the generation of fruit and seed, whether they are agricultural crops or uncultivated plants. It is critical to understand the ecological process that occurs before fertilization and fruit or seed set. Without pollination, there would be no fertilization, no fruit or seed growth, and no crop for farmers to harvest. As a result, pollination is the most critical step in the life cycle of a plant. It is required for agricultural production, biodiversity conservation, and increasing farm and rural income. However, as noted in earlier sections, natural pollination is not adequate for high yield and quality produce. Hence, artificial pollination approaches such as hand pollination is crucial to enhance crop productivity as well as the livelihoods of farmers. The Figure 4 below depicts the conceptual framework employed for the study. The theoretical underpinnings of the TAM model highlights that the perceived value of a technology is directly associated with the actual use. In this context, the study asserts that farmer's knowledge of hand pollination of cocoa influences their adoption of the method which enhances crop yield and consequently improves the livelihoods of farmers.

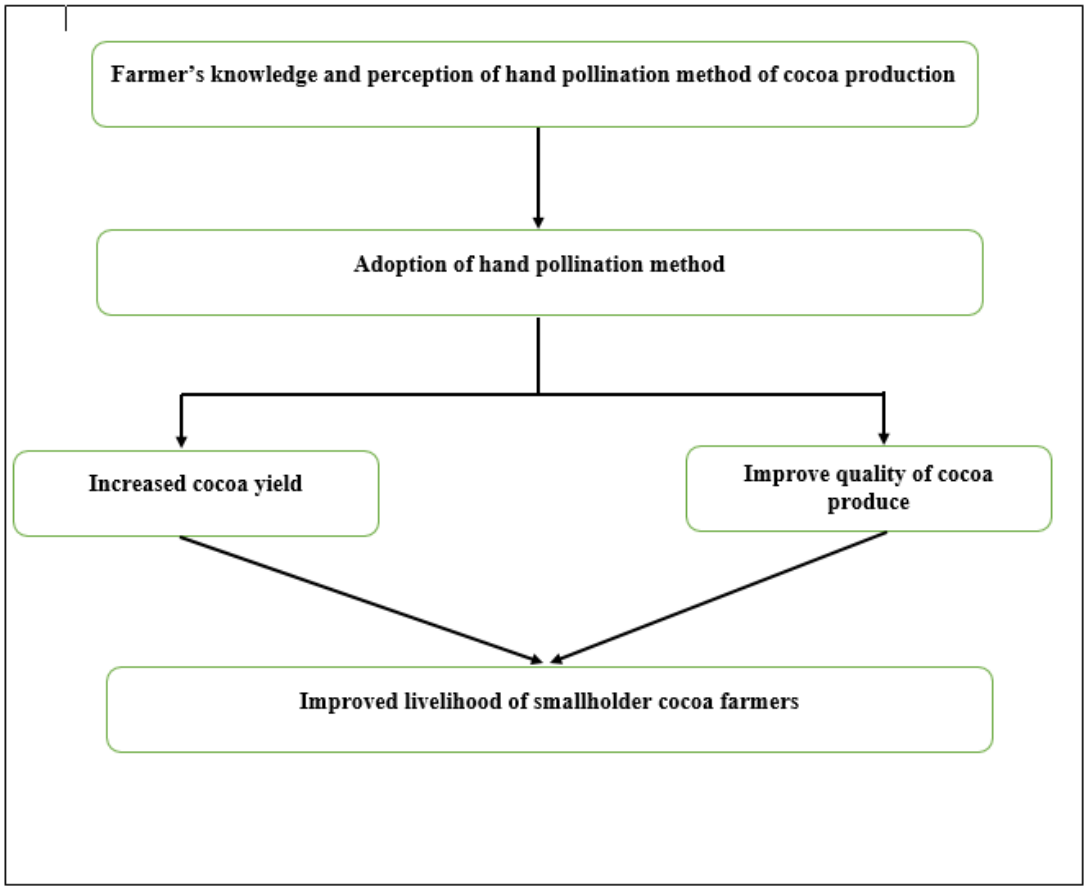

Figure 4: How Pollination Helps Farming and Benefits Rural Life

CHAPTER THREE

RESEARCH METHODOLOGY

Introduction

This section of the study describes the approaches and procedures employed to carry out the research. The methodology covers various aspects including the research design, study area, intended participants, approach to sampling and determination of sample size, methods of data collection and development of data collection instruments, handling and organization of data, analysis techniques, and the ethical considerations that will be upheld throughout the study.

Study Design

Creswell & Creswell (2017) defined research approach as a systematic set of methods employed in conducting research, encompassing data collection, analysis, and the interpretation of findings. According to Creswell (2008), conducting research necessitates considering philosophical worldviews, choosing an inquiry strategy aligned with those worldviews, and determining appropriate research methods and procedures. Additionally, Saunders et al. (2019) assert that research design involves a comprehensive structure through which an investigation seeks to find answers to its research questions. This indicates that research design serves as a framework for collecting and analysing data to address issues relevant to the study's objectives. The quantitative approach was chosen for the underlying study. Specifically, the descriptive cross-sectional design will be utilized for the study. The descriptive cross-sectional design is a research design that is used to describe the characteristics of a population at a particular point in time. This design is appropriate as it allow the researcher to explore farmers' knowledge and perception of hand pollination without manipulating variables or influencing their responses (Thomas, 2020). Moreover, descriptive cross sectional

design is relatively easier and quick to conduct which makes it appropriate for a time-constraint study as this. However, this method does not aid in the establishment of cause-and-effect relationship (Gaille, 2020).

Study Area

The research area is situated within the Atwima Nwabiagya South district of Ghana, a part of the Ashanti Region. Specifically, this district spans longitudes 1045 to 2000' west and latitudes 6075' north. It is one of the 43 political and administrative districts in the Ashanti Region and shares its borders with Ahafo Ano South and Atwima Mponua Districts to the west, Offinso District to the north, Amansie-West and Bosomtwe-Atwima Kwanwoma Districts to the south, and Kumasi Metropolis and Kwabre Districts to the east. Geographically, it occupies the western part of the region and covers an area of approximately 294.84 square kilometers. The district's capital is Nkawie, as reported by the Atwima Nwabiagya Municipal Assembly in 2019.

In terms of topography, the district features an undulating landscape, with elevations typically around 77 meters above sea level. The terrain varies from gently sloping too steep in the highland areas. The climate in the district falls within a moist, semi-arid region, characterized by an annual rainfall range of 170 cm to 185 cm. This climate exhibits a primary rainy season from March to July and a secondary rainy season from August to mid-November. Temperature remains relatively stable, ranging from 27°C in August to 31°C in March, while the district experiences a high relative humidity, averaging around 93%.

As for vegetation, the district primarily consists of semi-deciduous forests. However, extensive human activities have led to the alteration and depletion of valuable tree species and other forest products in the area. Nevertheless, there are sizable areas

of protected forests, including the Gyemena, Tano Offin, and Owabi Water Works Forest Reserves. Figure 3.1 provides a visual representation of the district's map in Atwima Nwabiagya district.

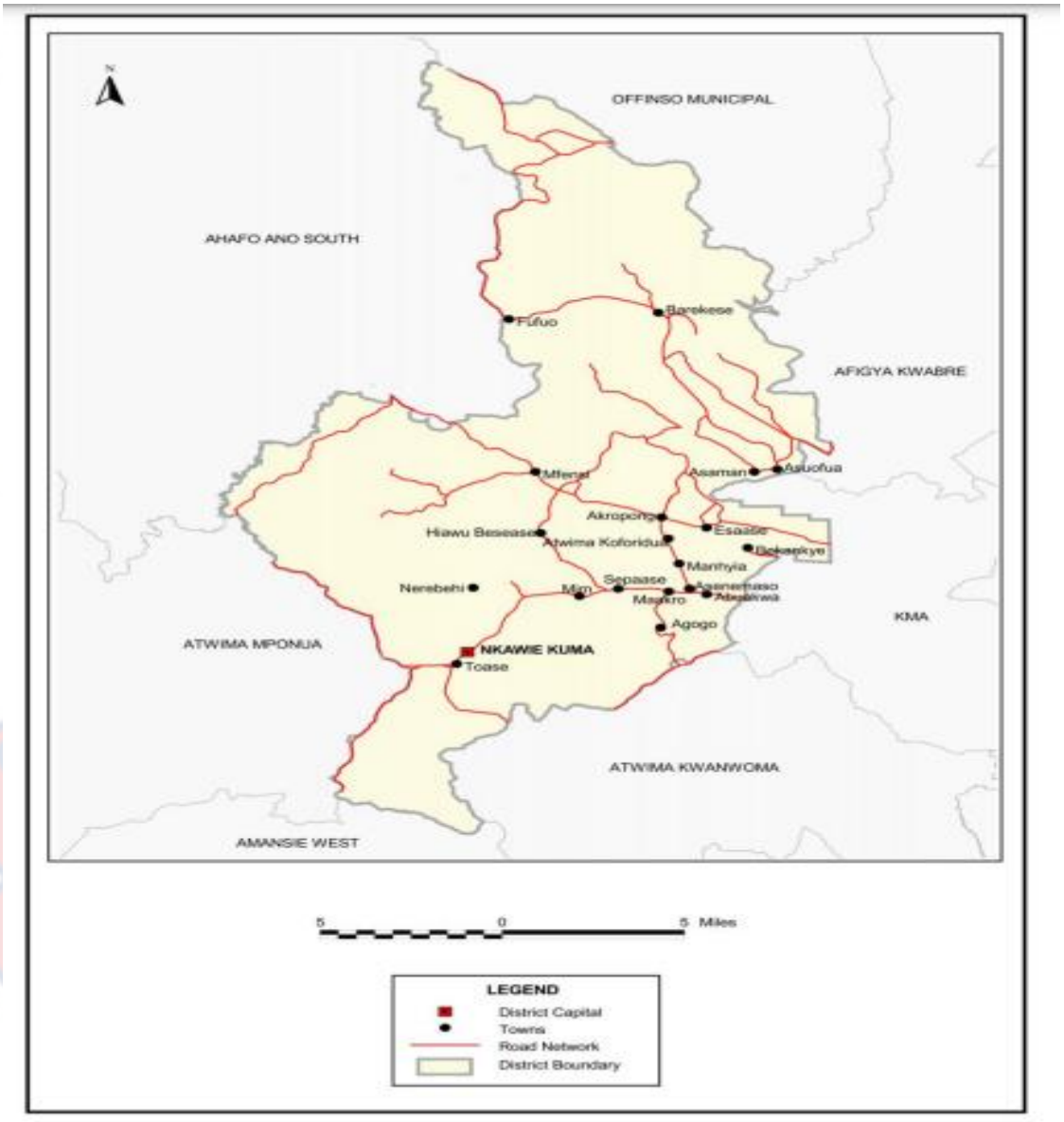

Figure 5: The District Map of Atwima Nwabiagya (PHC, 2010)

Population

In statistics, a population is a representative sample of a larger group of people (or even things) with one or more characteristics in common (Investopedia, 2023). According to Saunders et al (1997), the term ‘target population,’ can be taken to mean

all the members of the study as defined by its aims and objectives. The target population for the study are cocoa farmers in the Atwima Nwabiagya district. Records from the Ghana Cocoa Board (COCOBOD) suggest that there are 13411 cocoa farmers in the district (COCOBOD, 2021). The purpose of the study is to assess farmers' knowledge and practice of hand pollination of cocoa. Cocoa farmers are among the ideal group that directly apply hand pollination technique, they are appropriate to achieving the study's objectives.

Sampling Strategy and Sampling Size

As per Sharma (2017), sampling is a method used to systematically choose a smaller subgroup of items or individuals (a subset) from a given population, depending on the objective of the investigation, either for observation or experimentation. Amedahe and Gyimah (2002) define sampling as the process of selecting a portion of the population to represent the entire population. In this study, the researchers employed the simple random sampling technique to select cocoa farmers, ensuring that each individual had an equal chance of being included. This method was chosen for its ease and convenience, as well as its ability to minimize the influence of potential confounding variables.

Kenton (2022) defines a sample as a smaller, more manageable subset of a larger group. It is essential for the sample to accurately represent the population to generalize study findings. Samples are advantageous for data collection due to their practicality, cost-effectiveness, convenience, and manageability.

In this study, the researcher determined the scientifically appropriate sample size for data collection using Slovin's sample size determination formula, as outlined below.

$$n = \frac{N}{1+N(e)^2} = \frac{13411}{1+13411\ (0.05)^2} = \mathbf{388\ cocoa\ farmers}$$

Where n is the sample size,

N is the population size = 13411, and

e is the level of precision = 0.05.

The study therefore incorporated 388 cocoa farmers from the Atwima Nkwabiagya district.

Inclusion and Exclusion Criteria

The study comprised only cocoa farmers at the Atwima Nkwabiagya district. All cocoa farmers who had at least two years of farming experience were included and those with less than two years of experience were excluded from the study. Many scholars have outlined that farmers with two years or more have more information and experience than their counterparts with less than two years of experience. Also, cocoa farmers with no experience or practice with hand pollination method for cocoa production were also excluded.

Research Instruments

The primary data collection method employed in this study was the utilization of a structured questionnaire, serving as the cornerstone for gathering essential information. In line with Parfitt, J.'s (2013) definition, a questionnaire is a formal set of questions or statements meticulously designed to extract pertinent information from respondents, aligning with the research objectives. In this study, the questionnaire was instrumental in assessing the sentiments and attitudes of respondents towards statements related to various variables and their corresponding dimensions. This assessment was carried out using a 5-point Likert scale, known for its ordinal measurements spanning from 1 to 5, allowing respondents to express their level of agreement or disagreement, ranging from "strongly disagree" to "strongly agree."

The development of the questionnaire was a rigorous process, involving a comprehensive review of existing literature pertaining to farmers' perceptions of the hand pollination method and its potential impacts on productivity and livelihood. This literature review served as the foundation for crafting the questionnaire, ensuring that it included pertinent and contextually relevant questions to effectively address the research objectives. The questionnaire's construction aimed at collecting precise and insightful data, which would be pivotal for the subsequent analysis and conclusions of the study.

The questionnaire itself was structured into two primary sections to facilitate organized data collection. The first section was dedicated to gathering socio-demographic information from the study participants. This information would be instrumental in understanding the background and context of the respondents.

The second section of the questionnaire was more extensive and was further divided into three subsections, each focusing on distinct aspects or themes relevant to the research. The first subsection concentrated on evaluating farmers' knowledge and practice of the hand pollination method in cocoa production, with the questionnaire items being drawn from the work of Tham-Agyekum et al. (2022) and Nyamekye (2021). This allowed the study to delve into the extent to which farmers were familiar with and implementing the hand pollination method.

The second part of Section B aimed to collect information regarding the impact of the hand pollination method on cocoa productivity, a critical aspect of the study. This subsection sought to quantify the effects of the hand pollination method on cocoa yields and quality.

The final section of the questionnaire focused on the impact of the hand pollination method on farmers' livelihoods, a crucial dimension of the research. This section aimed to explore how the adoption of hand pollination influenced farmers' economic well-being and overall livelihoods.

The careful selection of items for these subsections drew from previous research, specifically Tham-Agyekum et al. (2022) and Wongnaa et al. (2021), ensuring that the questions were both relevant and validated in the context of the study. This approach enhanced the questionnaire's reliability and validity, ultimately contributing to the study's robustness and comprehensiveness in capturing the multifaceted aspects of the hand pollination method's impact on cocoa farming.

Data Handling and Analysis

The questionnaires were collected and then imported into MS Excel for the purpose of data cleaning and preparation. Subsequently, the cleaned data was exported to SPSS (Statistical Package for the Social Sciences) version 28 for the analysis phase.In this study, a combination of descriptive and inferential statistics was employed. Descriptive statistics, including measures such as the mean, standard deviation, median, frequency, and percentages, were utilized to summarize and present the characteristics of the collected data. These statistical measures provided a comprehensive overview of the data, allowing for a better understanding of the variables under investigation.

To achieve the first objective, a mean composite variable was generated from the 11-items intended to assess farmers' knowledge regarding hand pollination of cocoa. 95% confidence intervals was constructed to speculate the range of farmer's knowledge regarding hand pollination method. Mean and standard deviations of the

individual items were also assessed. A paired sample t-test was also utilized to compare the mean differences in farmer's income and yield before and after adopting hand pollination method. Descriptive statistics such as mean and standard deviation were used to assess the other research questions. Regarding the final objectives, mean composite variables were generated based on the items under each livelihood capital (i.e. physical, social, natural, and human). This mean composite was used to index the overall impact of hand pollination on the livelihood components of farmers. Statistical significance for this study was pegged at the 5% level

Ethical Consideration

Ethical considerations in research are a fundamental set of principles that shape the design and conduct of research, as highlighted by Bhandari (2023). Ethical conduct is a crucial element of research and involves treating the individuals who participate in the study with respect and consideration. There are four key areas of concern where the rights and dignity of research subjects must be safeguarded. These areas encompass consent, prevention of harm, protection of privacy, and avoidance of deception. In this study, ethical approval was sought from the COCOBOD district office in Nkawie, demonstrating the researcher's commitment to addressing these ethical issues during the research process.

CHAPTER FOUR

RESULTS AND FINDINGS

Introduction

This chapter presents the summary and discussion of the analysis of the field data. The chapter will be structured in four (4) subsections. The first section presents the demographic characteristics of the participants recruited for the study. The second section is dedicated to present the findings on farmers' knowledge level of hand pollination of cocoa at the Atwima Nwabiagya district. The third and last sections are dedicated to present the findings regarding farmers' perception on the impact of hand pollination on cocoa production and on their livelihood; respectively. Tables were used to present the study's findings.

Demographic Characteristics of the Respondents

Table 1 presents the demographic characteristics of the 388 respondents used in the study. From the table, it is evident that majority of the study's participants were male (69.7%) and about 30.3% of the respondents were female. Regarding the age composition of the selected participants, most of the respondents (30.6%) were aged 50-59years, followed by those aged 40-49years (28.7%), then those aged 30-39years (19.7%), and about 17.4% were above 59years. Respondents that are less than 30years had the least representation in the sample selected for the study (approximately 3.6%). Regarding their educational background, most participants had JHS and primary school qualifications (about 29.8% and 25.6%; respectively) and about 25.6% had no formal education. Only 8.8% of the respondents had tertiary education.

The majority of participants (75.9%) were married, followed by widows (12.7%), and only 6.7% were single. The data on household size revealed that the most of respondents lived in households with 5-6 members (34.7%) or 3-4 members (33.7%).

In terms of the labour force within the households of the participants, the highest number had 1-2 members (43.3%), followed by 3-4 members (35.7%), and 5-6 members (18%). Most of the farmers recruited owned 3 to 4 acres of farmland (30.1%), followed by those that own about 1-2arcreas (22.8%), and those that own 5-6acres of farmland (21.7%).

Regarding their farming experience, it is observed that about 33.4% of the participants had 21-30years of farming experience, 30.8% had 10-20years of farming experience, 19.4% had 31-40years of experience, and 8.8% had less than 10years of experience. Only about 7.5% of the participants had more than 40years of farming experience. It is also observed from the data that most of the respondents (29%) earned an annual income of about GH¢ (10001-15000), followed by those that earn about GH¢ (15001-20000) (28.7%), and about 17.8% earned about GH¢ (5001-10000) annually. Only 5.7% of the participants earned less than GH¢5000 annually. Almost all the participants (99.5%) had access to agriculture extension services and 90.2% of the participants had received formal training on hand pollination.

Table 1: Demographic Characteristics of the Respondents

Demographic characteristics		Frequency	Percentage
Respondent's sex			
	Male	269	69.7
	Female	117	30.3
Age			
	Less than 30	14	3.6
	30-39	76	19.7
	40-49	111	28.7
	50-59	118	30.6
	More than 60	67	17.4
Highest educational level			
	No formal education	99	25.6
	Primary	99	25.6
	JHS	115	29.8
	SHS/Technical/Vocational	39	10.1
	Tertiary	34	8.8
Marital status			
	Single	26	6.7
	Married	293	75.9
	Divorced	13	3.4
	Cohabiting	5	1.3
	Widow	49	12.7
Household size			
	1-2	52	13.5
	3-4	130	33.7
	5-6	134	34.7
	7-8	37	9.6
	9-10	11	2.8
	More than 10	22	5.7
Household labour force			
	1-2	166	43.3
	3-4	137	35.7
	5-6	69	18.0
	7-8	8	2.1
	9-10	3	0.8
Cocoa farm size (acres)			
	Less than 1	12	3.1
	From 1 to 2	88	22.8
	From 3 to 4	116	30.1
	From 5 to 6	84	21.7
	From 7 to 8	54	13.9
	From 9 to 10	20	5.2
	Above 10	12	3.1
Farming experience			
	Less than 10	34	8.8

	10-20	119	30.8
	21-30	129	33.4
	31-40	75	19.4
	More than 40	29	7.5
Annual income			
	Less than 5000	22	5.7
	5001-10000	69	17.8
	10001-15000	112	29.0
	15001-20000	111	28.7
	20001-25000	35	9.1
	Greater than 25000	37	9.6
Have access to agriculture extension service			
	Yes	381	99.5
	No	2	0.5
Received training on hand pollination			
	Yes	348	90.2
	No	38	9.8

Source: Field Data (2023)

Farmers' Knowledge Level and Practice of Hand Pollination Method in Cocoa Production

One of the study's objectives was to evaluate the knowledge and agronomic practices related to the hand pollination method among cocoa farmers in the Atwima Nwabiagya district. Table 2 provides a summary of the findings pertaining to this specific inquiry. Based on the results presented in Table 4.2, it can be inferred that majority of the selected cocoa farmers at the Atwima Nwabiagya district have high knowledge level regarding hand pollination of cocoa as indicated by (Mean=4.4, SD=0.034). Moreover, the 95% confidence interval suggests that the true population mean likely falls between 4.29 and 4.42, indicating a substantial understanding of cocoa hand pollination practice among cocoa farmers in the district.

The study revealed that 90.2 % of cocoa farmers in the Atwima Nwabiagya district possess a high level of knowledge regarding hand pollination. Similarly,

Dansoh and Nyamekye (2017) discovered a high knowledge rate of 70% among cocoa farmers in the Eastern Region of Ghana. Gyamfi et al. (2021) reported a rate of 75% in the Eastern Region, while Konadu and Dansoh (2022) found 78% in the Brong-Ahafo Region of Ghana.

Contrastingly, Adjei-Nsiah and Asare-Bediako (2020) identified a knowledge level of 65% among cocoa farmers in the Western Region of Ghana. Danso-Abeam and Amponsah (2019) reported 67% knowledge rate in the Ashanti Region of Ghana.

The variations in knowledge levels among different districts may be attributed to varying access to information and training on hand pollination. Districts with more extension officers and supportive organizations tend to have higher knowledge levels among cocoa farmers. Additionally, the increasing adoption of hand pollination technology is likely contributing to improved knowledge levels over time, as farmers share their experiences and insights with one another.

Collectively, the studies underscore that a majority of cocoa farmers in Ghana possess a basic understanding of hand pollination. However, further efforts are needed to enhance education and training on hand pollination, thereby elevating knowledge levels and promoting wider adoption of this beneficial technology.

In relation to the understanding and practices of cocoa farmers in the Atwima Nwabiagya district regarding hand pollination, the study's results can be summarized as follows:

For the belief that hand pollination can be conducted on cocoa plants that lack flowers, the majority of participants disagreed (Mean=1.6, SD=0.054). Similarly, most respondents did not consider a stick as the optimal tool for pollinating cocoa flowers, with a mean score of 1.3 (SD=0.045). Additionally, participants disagreed with the

notion that pollen grains from a single cocoa tree can effectively pollinate all the cocoa trees on a farm, with a mean score of 1.3 (SD=0.044). Respondents also disagreed with the idea that hand pollination is feasible on flowers that have not yet fully opened, with a mean score of 2.6 (SD=0.077). Conversely, a consensus emerged among the participants that the best time for hand pollination is in the afternoon, as indicated by a mean score of 4.7 (SD=0.043). These findings, along with the mean values, shed light on the level of knowledge and practical insights possessed by cocoa farmers in the Atwima Nwabiagya district concerning the hand pollination method.

Majority of them perceived that hand pollination of cocoa is more effective than natural pollination (Mean=4.4, SD=0.053) and that hand pollination is effective in increasing cocoa yield (Mean= 4.3, SD=0.060). These findings suggest that farmers in the district are highly knowledgeable regarding hand pollination. For instance, most of the farmers recognized that hand pollinating cocoa tree without flower is futile and waste of resources. Moreover, most of the respondents were aware that using stick is less precise in hand pollinating cocoa flowers mainly due to the small and complex nature of the cocoa flower. Even more convincingly, majority of the participants realized that afternoon pollination is advantageous as it allows for flowers to fully open, ensuring successful pollination. The findings align with those of Tham-Agyekum et al. (2022), who conducted a study in the Ashanti Region of Ghana. Their research revealed that cocoa farmers in this region possessed a solid foundational understanding of hand pollination. Nevertheless, certain aspects of knowledge, such as the optimal timing and quantity of pollen application, required improvement. Importantly, the study highlighted the positive impact of hand pollination on cocoa yield.

Similarly, Toledo-Hernández et al. (2023) conducted a study in the Brong-Ahafo Region of Ghana and found that cocoa farmers there exhibited a high level of

knowledge regarding hand pollination. However, their ability to adopt this practice was hindered by challenges related to access to training and necessary resources. Significantly, this study also confirmed the positive impact of hand pollination on cocoa farmers' income levels.

In contrast, Dansoh and Nyamekye's (2017) study in the Eastern Region of Ghana reported a moderate level of knowledge among cocoa farmers regarding hand pollination. Interestingly, despite their moderate knowledge, adoption rates of the technology remained low. The study identified several influencing factors, including access to training and resources, perceived benefits, and risk aversion, which affected cocoa farmers' willingness to adopt hand pollination.

Collectively, these studies suggest that cocoa farmers in Ghana possess a foundational understanding of hand pollination, but there is still room for improvement. Enhancing education and training on hand pollination could prove instrumental in increasing knowledge levels and encouraging greater adoption of this technology among cocoa farmers in the country.

Regarding the agronomic practices of hand pollination, it is observed that most of the selected farmers weed their farms before carrying out hand pollination (Mean=3.6, SD=0.078). Also, it is observed that majority of the farmers pruned (Mean=4.2, SD=0.058), sprayed (Mean=4.8, SD=0.035), and fertilized (Mean=4.7, SD=0.035) their farms before carrying out hand pollination exercise. These results demonstrate the farmers' commitment to adopting comprehensive agronomic practices in their cocoa farms. The results highlight farmers' recognition of the significance of proper farm management practices alongside hand pollination underscoring their commitment to maximizing cocoa production.

The study by Kuyah et al. (2021) found that good agronomic practices, such as weeding, pruning, spraying, and fertilizing, can potentially increase cocoa yield. The other three studies found that cocoa farmers in Ghana have a good understanding of the importance of hand pollination and are adopting this practice on their farms.

Overall, the studies suggest that cocoa farmers in Ghana are committed to adopting good agronomic practices in their farms, including hand pollination. This is a positive development, as it is likely to help cocoa farmers increase their production and incomes.

Table 2: Farmers Knowledge and Practice of Hand Pollination of Cocoa

Statement	Mean	SD	Confidence Interval
Farmer's Knowledge			
i. Hand pollination can be done on cocoa without flowers	1.6	0.054	1.47-1.68
ii. The optimal tool for pollinating cocoa flowers is a stick	1.3	0.045	1.18-1.36
iii. The most suitable time for pollinating my trees is during the afternoon	4.7	0.043	4.65-4.81
iv. Pollen grains from a single cocoa tree can suffice to pollinate all the trees on my farm.	1.3	0.044	1.25-1.42
v. I can engage in cocoa flower pollination without the need to wait for them to fully open.	2.6	0.077	2.47-2.78
vi. I believe hand pollination is an effective method in increasing cocoa yield	4.3	0.060	4.15-4.38
vii. I believe hand pollination is more effective than reliance on natural pollination	4.4	0.053	4.32-4.53
Practices of hand pollination			
i. I weed the farm before carrying out the pollination exercise	3.6	0.078	3.48-3.79
ii. I prune the farm before carrying out the pollination exercise	4.2	0.058	4.07-4.31
iii. I spray the farm with insecticides before carrying out the pollination exercise	4.8	0.035	4.72-4.86
iv. Fertilize is applied to the farm before carrying out hand pollination exercise	4.7	0.035	4.66-4.79

Source: Field Data (2023)

The Impact of Hand Pollination on Cocoa Yield

The study also sought to ascertain farmers' perception on the impact hand pollination has on cocoa productivity. The results are presented in Table 4.3. Inferred from the Table, majority of the respondents agreed that hand pollination has had significant impact of the yield on the cocoa production (Mean=4.81, SD=0.027). Also, majority of them highlighted that hand pollination improves the quality of cocoa beans produced (Mean=4.29, SD=0.047). Moreover, most of the respondents reported that hand pollination reduces the amount of time it takes for cocoa pods to mature (Mean=3.95, SD=0.071) and majority of them perceived that hand pollination increases the number of cocoa pods per tree (Mean=4.85, SD=0.026).

With a corresponding mean of (Mean=4.74, SD=0.033), majority of the respondents highlighted that hand pollination results in higher percentage of mature cocoa pods compared to natural pollination and most of them also perceived that hand pollination leads to the reduction in pest and diseases in cocoa farm (Mean=4.14, SD=0.057). Majority of the participants suggested that hand pollination increases the overall productivity of cocoa farms.

Table 3: Farmers Perceived Impact of Hand Pollination on Cocoa Productivity

	Statement	Mean	SD
i.	Hand pollination has a significant impact on the yield of cocoa production	4.81	0.027
ii.	Hand pollination improves the quality of cocoa beans produced	4.29	0.047
iii.	Hand pollination reduces the amount of time it takes for cocoa pods to mature	3.95	0.071
iv.	Hand pollination increases the number of cocoa pods per tree	4.85	0.026
v.	Hand pollination results in a higher percentage of mature cocoa pods compared to natural pollination	4.74	0.033
vi.	Hand pollination leads to the reduction in pests and diseases in cocoa farms	4.14	0.057
vii.	Hand pollination increases the overall productivity of cocoa farms	4.78	0.036

Source: Field Data (2023)

The study also sought to compare the differences in cocoa production when farmers were relying on natural production and when they were using hand pollination. Tables 4 and 5 present these findings. From Table 4.4, it is observed that the minimum bag of cocoa produced when farmers relied on natural pollination was 1 and when they relied on hand pollination was 2. Also, the maximum cocoa produced when they relied on natural pollination was 60 and the maximum when they used hand pollination was 90bags. Evidently, it is observed that higher yields were produced when farmers used hand pollination as compared to when they relied on natural pollination.

Table 4: Comparing Output Levels before and after the Hand Pollination Programme

Natural Pollination vs Hand Pollination	Minimum	Maximum
Quantity of bags produced through natural pollination	1	60
Quantity of bags produced through the implementation of hand pollination	2	90
Discrepancy in the number of bags produced	1	30

Source: Field Data (2023)

A paired t-test was then utilized to ascertain whether the mean differences in production when farmers relied on natural pollination and hand pollination was due to chance or not. From Table 5, it is observed that around 12bags of cocoa were produced when farmers relied on natural pollination and about 22bags were produced when they used hand pollination of cocoa. The average variance in the quantity of bags generated under natural pollination and hand pollination was 9.55 (with a standard deviation of 8.32), yielding a p-value of 0.00. This indicates a statistically substantial distinction between the bags produced through natural pollination and those resulting from hand pollination.

These results indicate that opting for hand pollination is a more advantageous option in terms of yield, particularly regarding the production of cocoa bags, when compared to exclusively depending on natural pollination. Several studies have shown the significant role artificial pollination methods including hand pollination play in maximizing the yield of cocoa produce (Donald, 2004; Wongnaa et al. 2021; Kassie et al. 2009; Forbes et al. 2019; Tham-Agyekum et al. 2022). For instance, Kassie et al. (2009) asserted that artificial pollination enhances agricultural productivity, provides environmental benefits, and lowers production costs.

Additionally, as reported by Wongnaa et al. (2021), farmers observed an increase in yield when they embraced cocoa hand pollination. It is widely acknowledged that agricultural innovations play a pivotal role in augmenting overall farm production. Irrespective of the degree of adoption of artificial cocoa production, Forbes et al. (2019) have affirmed that it leads to substantial enhancements in output.

Despite the benefits of hand pollination, there are some challenges that need to be addressed in order to increase its adoption. One challenge is the cost of hand pollination. Hand pollination is a labor-intensive process, which can make it expensive for farmers. Another challenge is that some farmers may not be aware of the benefits of hand pollination or may not know how to do it properly.

Governments, development organizations, and the private sector can play a role in addressing these challenges. For example, governments can provide subsidies to farmers to help them cover the cost of hand pollination. Development organizations can provide training on hand pollination to farmers. And the private sector can develop new technologies to make hand pollination more efficient and affordable.

Table 5: Paired Sample T-Test (Production)

Variable	Obs	Mean	Std. err.	Std. dev.	Lower bound	Upper bound
Bags produced before reliance on hand pollination	388	12.21	0.741	11.598	10.748	13.667
Quantity of bags produced through the implementation of hand pollination	388	21.76	1.174	18.383	19.444	24.071
Diff		-9.55	0.532	8.318	-10.596	-8.502
	Degrees of freedom = 374 t- statistic = -17.967 Pr(|T| > |t|) = 0.00000					

Source: Field Data (2023)

The Perceived Economic Contribution of the Hand Pollination Programme to Cocoa Farmers' Livelihood.

This subsection is dedicated to addressing the study's objective of examining the impact of cocoa hand pollination on the livelihoods of cocoa farmers. The analysis commences by investigating how hand pollination of cocoa affects the annual income of cocoa farmers in the district.

A paired sample t-test analysis was conducted to compare the average annual income of farmers before and after adopting the hand pollination method for cocoa. As outlined in Table 4.6, the average annual income earned by cocoa farmers before relying on natural pollination was approximately GH¢ 1143, whereas the average annual income after implementing the hand pollination technique was GH¢ 1732.47. This indicates that farmers in the district experienced a substantial increase in their income, with an average gain of GH¢ 589.47 after embracing hand pollination. This difference is statistically significant at the 1% level, suggesting that hand pollination is a more financially rewarding choice for income generation compared to natural pollination. The implementation of hand pollination has resulted in a noticeable upswing in income levels for cocoa farmers.

The research by Wongnaa et al. (2021) shown that the earnings of farming households that used artificial pollination grew. It was also shown that adopters made, on average, between GH¢ 2756.84 and GH¢ 11074.38 higher earnings. Artificially pollinating the entire tree, according to Gupta et al. (2017), also resulted in a 161% increase in net income. Tham-Agyekum et al. (2022) found that adopting hand pollination technique increased farmers yearly earnings by about GH¢5268-50160 in the Nkawkaw cocoa district, Ghana. The aforementioned findings can be used to validate the findings of the current study.

Table 6: Paired Sample T-Test (Production)

	Obs	Mean	Std. err.	Std. dev.	Lower bound	Upper bound
Annual income after using hand pollination method	374	1143	1.553	2.5448	1011	1722
Annual income after relying on natural pollination	374	1732.47	0.798	0.0514	1575	1889
Difference		589.47	1.553	0.0048	8201	1431
	Degrees of freedom = 373					
	t- statistic = 7.2447					
	Pr(|T| > |t|) = 0.00000					

Source: Field Data (2023)

The Perceived Socio-economic Contributions of the Hand Pollination Programme to Cocoa Farmers' Livelihood Assets.

Thereafter, the study also sought to ascertain the perceived change in cocoa farmers' livelihood after adopting hand pollination technique. Five dimensions of livelihood indicators were assessed here. The summary of this analysis is presented in Table 7.

From Table 4.7, regarding the human acquisition dimension, it is evident that majority of the farmers perceived they have accumulated higher human capital through the utilization of hand pollination technique with a corresponding mean of 4.37. More specifically, majority of the farmers asserted that hand pollination has solidified their interest in cocoa farming (Mean=4.55, SD= 0.887). Majority of the farmers reported that hand pollination has increased their experience in cocoa production in the district (Mean=4.17, SD=0.903). Furthermore, a significant number of respondents emphasized that they gained substantial knowledge through the training they received on hand pollination, with a mean score of 4.56 (SD= 0.825). This increase in knowledge

has boosted the enthusiasm and dedication of farmers to cocoa farming, as they have seen improvements in their yields. The study's results suggest that training on hand pollination can lead to increased knowledge, enthusiasm, and dedication among cocoa farmers, which can boost their yields. This is consistent with the research conducted by Danquah et al. (2015), which found that training can enhance the competencies of individual farmers in performing specific psychomotor skills, such as hand pollination.

Regarding the physical capital gained by adopting hand pollination technique, the finding showed that majority of the participants reported they were able to purchase new farm tools (Mean=4.41, SD=0.987), new household gadget (Mean=4.42, SD=0.986), and new farm inputs (Mean=4.59, SD=0.896). This clearly shows that the adoption of hand pollination improves the livelihood of farmers by increasing their acquisition of physical capital (Mean=4.47). This is expected as it is established earlier that the usage of hand pollination method improves farmers income level, hence, they are able to procure new household and farming gadgets. In line with the results, Bosompem et al. (2011) and Anthony et al. (2014) found that asset acquisition within a household significantly impacts farmers' livelihoods. Additionally, the level of livelihood diversification among cocoa farmers is also influenced by the extent of asset acquisition.

The findings also indicated that hand pollination leads to improved likelihood by increasing farmers' ability to secure natural capital as indicated by the mean perception index of 4.48. With a mean of 4.6 (SD=0.908), majority of the farmers experience increased cocoa yield after adopting hand pollination. Similarly, majority of the farmers highlighted that they were able to cultivate higher acreage of farmland (Mean=4.18, SD=1.168) and majority of them indicated that hand pollination has helped them expand their cocoa farm (Mean=4.09, SD=1.162). This implies that hand

pollination positively affects farmers' livelihoods by improving their access to natural capital; increasing cocoa yields, expanding farmland cultivation, and leading to higher agricultural output. The study conducted by Tham-Agyekum et al. (2022) also highlighted a significant financial benefit of hand pollination, indicating that it can effectively double farmers' annual profits. This finding aligns with the study you referenced, which similarly suggested that hand pollination can result in higher prices for farmers, underlining the economic advantage of adopting this practice.

On the other hand, Toledo-Hernández et al.'s (2023) study revealed an even more substantial impact of hand pollination, indicating that it can triple farm yields. While this exceeds the result mentioned in the study, which suggested an increase in cocoa yields, it's important to consider the regional variation and diverse conditions under which these studies were conducted.

In summary, both studies affirm that hand pollination is a valuable process capable of significantly enhancing the livelihoods of cocoa farmers. However, the extent of this impact may vary based on several factors, including the specific region, the type of cocoa farming system, and individual farmer circumstances. Understanding these variations is crucial for effectively implementing hand pollination techniques and maximizing its benefits across cocoa farming communities.

Table 7: Perception of Change in Farmers' Livelihood

Perception Statement	Mean	Std. Dev.	Index
Human Capital			4.37
i. Hand pollination has solidified my knowledge in cocoa farming	4.55	0.887	
ii. Hand pollination has increased my experience in cocoa production in the Atwima Nwabiagya district	4.17	0.903	
iii. I have learnt a lot through the training on hand pollination of cocoa	4.56	0.825	
Physical Capital			4.47
i. I have been able to purchase new farm tools for my farm	4.41	0.987	
ii. I have been able to purchase new household gargets	4.42	0.986	
iii. I have be able to purchase my own farm inputs	4.59	0.896	
Natural Capital			4.48
i. Hand pollination has helped me expand my cocoa farm	4.09	1.162	
ii. I have experienced increased cocoa yield from year to year	4.60	0.908	
iii. I am able to cultivate higher acreage of farm land	4.18	1.168	
Financial Capital			4.49
i. I have been able to pay all my outstanding debts	4.54	0.859	
ii. I can now afford my children's school fees	4.61	0.824	
iii. I can now afford three square meals for my family	4.60	0.803	
iv. The implementation of hand pollination has led to increased access to credit facilities for me	4.23	1.097	
Social Capital			3.93
i. Hand pollination has helped to improve the social status of cocoa farmers in the Atwima Nwabiagya cocoa district.	4.18	0.942	
ii. I enjoy being a member of a farmers' association	4.61	0.853	
iii. I have been invited or likely to be invited to community development administrative meetings	2.97	2.974	

Source: Field Data (2023)

The findings also indicated that farmers experience enhanced livelihoods with increased financial capacities following the adoption of hand pollination techniques (Mean=4.49). Specifically, majority of the farmers reported that they have been able to pay all their outstanding loans (Mean=4.54, SD=0.859), afford their children's school fees (Mean=4.61, SD=0.24), and afford three square meals for their family

(Mean=4.60, SD=0.803) after adopting hand pollination technique of cocoa production. Moreover, majority of the participants highlighted that hand pollination has led to increased access to credit facilities (Mean=4.23; SD=1.097). Bosompem et al. (2011) found that cocoa farmers had the option to set aside some of their earnings for later usage. This is as a result of their access to agricultural credit from banks and microfinance organizations. This corroborates with the findings of the current study.

Lastly, the study also indicated that farmers experienced enhanced livelihood with increased social prestige following the adoption of hand pollination techniques with a corresponding mean of 3.93. More specifically, majority of the farmers reported that hand pollination has helped improved their social status in the district (Mean=4.18, SD=0.942) and majority of them also reported they enjoy being part of farmers' association after adopting hand pollination technique. This suggests that hand pollination not only positively impacts farmers' economic well-being but also boosts their social recognition and integration within their community.

The study by Tham-Agyekum et al. (2022) found that hand pollination can help farmers to increase their yields and incomes. However, it also found that hand pollination does not necessarily boost farmers' participation in community development administrative meetings. This could be due to a number of factors, such as the lack of time or interest among farmers.

One possible explanation for this difference in results is that the two studies were conducted in different districts of Ghana. It is possible that social norms and practices related to hand pollination vary between districts. Another possible explanation is that the two studies used different methods to measure the social benefits of hand pollination.

Overall, the studies suggest that hand pollination can have a positive impact on cocoa farmers' livelihoods in both economic and social terms. However, the extent of the social benefits may vary depending on the district in which the study is conducted and the methods used to measure social benefits.

Summary of the Chapter

This chapter was dedicated to present the findings of the analysis of the study. The study focused on investigating the impact of hand pollination on cocoa farmers' livelihoods in the Atwima Nwabiagya district. The chapter is structured into several subsections, each addressing specific research questions. The first subsection examines the demographic characteristics of the participants, revealing insights into the composition of the study group. The next section delves into farmers' knowledge and practice of hand pollination. The findings show that a high level of knowledge regarding hand pollination exists among farmers in the district. Farmers are well-aware of the appropriate techniques and timings for effective hand pollination. Their commitment to comprehensive agronomic practices, such as weeding, pruning, and fertilization, underscores their dedication to maximizing cocoa production.

The third section of the study explores the impact of hand pollination on cocoa yield. Farmers overwhelmingly perceive hand pollination as significantly boosting cocoa production. They believe it leads to increased cocoa pod yield, better quality beans, shorter maturation times, and a decrease in pests and diseases. The comparative analysis between natural and hand pollination confirms that the latter yields higher cocoa output, which aligns with prior research. Lastly, the chapter probes into the perceived economic and social benefits of hand pollination. Farmers credit hand pollination with increased annual income, and they report the ability to purchase tools and inputs. There's a consensus that this method enhances their human and physical

capital, expanding both farming skills and resources. Moreover, the findings showed that hand pollination of cocoa had a positive impact on farmer's social and financial capital.

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATION

Introduction

This chapter provides a concise summary of the study's findings, draws conclusions based on these findings, and offers recommendations. Additionally, it underscores the implications of the research.

Summary of Findings

The study aimed to investigate the impact of hand pollination on cocoa production in the Atwima Nwabiagya district. Specifically, the study assessed farmers' knowledge on hand pollination method of cocoa production. The study also sought to investigate the impact of hand pollination on cocoa production and on the livelihood of cocoa farmers. The study utilized the quantitative research approach to address the research questions in the study using 388 cocoa farmers from the Atwima Nwabiagya district.

Majority of the respondents were male, had JHS educational attainment, and married. About 30.1% of the respondents owned 3-4acres of farmland. Most of the respondents had 21-30years of farming experience and about 29% earned about GH¢ 10001-15000. Almost all the participants had access to extension service and 90.2% of them had received formal training on hand pollination method. The results showed that majority of farmers had high knowledge level regarding hand pollination of cocoa (Mean=4.4, SD=0.034). The finding further showed that hand pollination method increases cocoa productivity and the income earned by cocoa farmers at the Atwima Nwabiagya district. In similar vein, the findings portrayed the significant role hand pollination played in improving the livelihood of cocoa farmers as it enhances their human, physical, natural, social, and financial capital.

Conclusion

In conclusion, based on the outcome of the regression analysis, the researcher wishes to present theses concluding remarks.

The results revealed that farmers in Atwima Nwabiagya district have high knowledge level regarding hand pollination of cocoa as well the agronomic practices required for effective hand pollination. The results highlight the importance of targeted education and training initiatives to enhance farmers' understanding and adoption of hand pollination practices. The study establishes that hand pollination positively impacts cocoa productivity and the income earned by cocoa farmers. The findings underscore the economic benefits of hand pollination as it leads to increased cocoa yields and improved financial capabilities for farmers. Additionally, the research reveals that hand pollination contributes to the overall livelihood enhancement of cocoa farmers and positively influencing various aspects of their well-being. The findings of the study emphasizes on the significance of hand pollination as an effective and economically beneficial method in cocoa production.

Recommendations

The following recommendations were deduced from the findings of the study;

First, Government and Ghana Cocoa Board must ensure continual promotion of training and extension services. To enhance farmers' knowledge and understanding of hand pollination techniques, it is crucial to invest in targeted training programs and extension services. These initiatives should be designed to reach a wide range of farmers, focusing on those with lower educational attainment and limited farming experience. The provision of accessible and practical training on hand pollination can

significantly improve the knowledge and adoption of innovative agricultural technologies that boost productivity.

In addition, most farmers are aged and may not have the good eye sight to perform the pollination themselves. Therefore, Government and COCOBOD must train youth with good eye sight to assist farmers who cannot pollinate their farm. These skilful youth pollinators should be trained in entrepreneurship development and assisted in establishing community base service enterprises capable of offering pollination services to farmers who cannot pollinate their own farms

Moreover, the Ghana Cocoa Board should put measures in place to strengthen and encourage the formation of cocoa farmers association or cooperatives, establish partnership with these cocoa farmer co-operatives and encourage them to release some of their members to participate in the hand pollination exercise. This collaboration will help access a larger pool of farmers and ensure their active involvement.

Furthermore, to boost the adoption of artificial pollination practices among farmers in the district, the Ghana Cocoa Board (COCOBOD) must establish special incentive or subsidies for farmers who adopt hand pollination practices.

Lastly, Government through COCOBOD must establish tailored credit and savings schemes, facilitate access to financial services such as micro-credit and agricultural loans to farmers who adopt hand pollination in order to enable them make necessary investments in their farms.

Suggestions for Further Study

Every study has some limitations; thus, it makes sense to evaluate the results of this study in the context of such constraints. The study was limited to one district in Ghana's Atwima Nwabiagya, which calls into question its generalizability. Future

research that takes into account choosing more districts from the cocoa production regions might prove more illuminating. Second, the focus of this research was solely on farmer's perception of the practice and its impact on their perceived livelihoods. Future studies may consider studying the underlying factors that influence farmer's decision to adopt hand pollination method of cocoa production. Moreover, future research may evaluate gender dynamics within cocoa farming and how the adoption of hand pollination might influence gender roles, opportunities for women in farming, and overall empowerment.

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APPENDIX

QUESTIONNAIRE

Dear Sir/Madam,

I am a student from the Christian Service University College (CSUC) and as part of the requirement for the fulfilment of a postgraduate programme, it is a necessity to embark on a research work. I am conducting a research on Farmers' Knowledge and Socioeconomic Impacts of the Cocoa Hand Pollination Programme in the Atwima Nwabiagya district, Ghana. I would like to request your assistance in filling out a structured questionnaire that I have developed for this study. The questionnaire will take approximately 20-30 minutes of your time.

The purpose of the study is to carefully assess how the adoption of hand pollination of cocoa by farmers in the district affected their livelihoods as well as their crop productivity. Your participation will provide invaluable information that will inform policies that will improve the living standards of farmers, particularly cocoa farmers in Ghana. Please answer the following questions truthfully and to the best of your knowledge. All information collected will be kept confidential and used only for the purposes of this research study.

SECTION A: DEMOGRAPHIC QUESTIONNAIRE

1. Sex

   A. Male **[ ]** B. Female **[ ]**

2. Age

   A. Less than 30 **[ ]** B. 30-40 **[ ]**

   C. 40-50 **[ ]** D. 50-60 **[ ]** E. More than 60 [ ]

3. Marital status

   A. Single [ ] B. Married [ ] C. Cohabiting [ ]

   C. Divorced [ ] D. Widow [ ]

4. Respondent Level of Education

   A. No formal education [ ] B. Primary [ ]

   C. JHS [ ] D. SHS/Technical/Vocational [ ] E. Tertiary [ ]

5. Household size

   A. 1-2 [ ] B. 3-4 [ ] C. 5-6 [ ]

   C. 7-8 [ ] D. 9-10 [ ] D. More than 10 members [ ]

6. Household labour force

   B. 1-2 [ ] B. 3-4 [ ] C. 5-6 [ ]

   C. 7-8 [ ] D. 9-10 [ ] D. More than 10 members [ ]

7. Cocoa farm size (ha)

   A. Less than 1 [ ] B. From 1 to 2 [ ] C. From 3 to 4 [ ]

   D. From 5 to 6 [ ] D. From 7 to 8 [ ] E. From 9 to 10 [ ]

   D. Above 10 [ ]

8. Farming experience

   A. Less than 10 years [ ] B. 10-20 years [ ]

   C. 20-30 years [ ] D. 30-40 years [ ] E. More than 40 years [ ]

9. Annual household income (cedis)

   A. Less than 5000 [ ] B. 5001-10000 [ ] C. 10001-15000[ ]

   C. 15001-20000 [ ] D. 20001-25000 [ ] E. Greater than 25000 [ ]

10. Do you have access to agriculture extension services

    A. No [ ] B. Yes [ ]

11. If yes, how many times do you receive extension training services in a year?

    A. 1-2 [ ] B. 3-4 [ ] C. 5-6 [ ]

    C. 7-8 [ ] D. 9-10 [ ] E. Above 10 [ ]

12. Have you been trained on the method of hand pollination of cocoa

    A. No [ ] B. Yes [ ]

PART I: FARMERS PERCEPTION OF HAND POLLINATION OF COCOA (K & P)

Please kindly evaluate the following statements and circle only one score for each of the statements based on your experience and understanding of hand pollination of coca (Scale: 1– Strongly disagree; 2 – Disagree; 3 –Neutral; 5 – Strongly Agree

S/N. ITEMS	Response				
Farmer's Knowledge					
1. Hand pollination can be done on cocoa without flowers	1	2	3	4	5
2. A stick is the best instrument to pollinate flowers	1	2	3	4	5
3. The best time to pollinate my trees is in the afternoon	1	2	3	4	5
4. Pollen grains can be collected from only one tree to pollinate all the trees in my farm	1	2	3	4	5
5. I can pollinate flowers that are brown in colour	1	2	3	4	5
6. I believe hand pollination is an effective method in increasing cocoa yield	1	2	3	4	5
7. I believe hand pollination is more effective than reliance on natural pollination	1	2	3	4	5
Practices of hand pollination					
8. I weed the farm before carrying out the pollination exercise	1	2	3	4	5
9. I pruned the farm before carrying out the pollination exercise	1	2	3	4	5
10. I spray the farm with insecticides before carrying out the pollination exercise	1	2	3	4	5
11. Fertilize is applied to the farm before carrying out hand pollination exercise	1	2	3	4	5

PART II: THE IMPACT OF HAND POLLINATION OF COCOA PRODUCTIVITY

Please kindly evaluate the following statements and circle only one score for each of the statements based on your experience and understanding of hand pollination of coca (Scale: 1– Strongly disagree; 2 – Disagree; 3 –Neutral; 5 – Strongly Agree

S/N. ITEMS	Response				
1. Hand pollination has a significant impact on the yield of cocoa production	1	2	3	4	5
2. Hand pollination improves the quality of cocoa beans produced	1	2	3	4	5
3. Hand pollination reduces the amount of time it takes for cocoa pods to mature	1	2	3	4	5
4. Hand pollination increases the number of cocoa pods per tree	1	2	3	4	5
5. Hand pollination results in a higher percentage of mature cocoa pods compared to natural pollination	1	2	3	4	5
6. Hand pollination leads to the reduction in pests and diseases in cocoa farms	1	2	3	4	5
7. Hand pollination increases the overall productivity of cocoa farms	1	2	3	4	5

8. How many bags of cocoa did you produced during the usage of natural pollination?

……

9. How many bags of cocoa did you produced after the usage of hand pollination?

……

PART II: THE EFFECT OF HAND POLLINATION ON THE LIVELIHOODS OF FARMERS

Please kindly evaluate the following statements and circle only one score for each of the statements based on your experience with hand pollination of coca (Scale: 1– Strongly disagree; 2 – Disagree; 3 –Neutral; 5 – Strongly Agree

S/N. ITEMS	Response				
Human Capital					
1. Hand pollination has solidified my knowledge in cocoa farming	1	2	3	4	5
2. Hand pollination has increased my experience in cocoa production in the Atwima Nwabiagya district	1	2	3	4	5

3. I have learnt a lot through the training on hand pollination of cocoa	1	2	3	4	5
Physical Capital					
4. I have been able to purchase new farm tools for my farm	1	2	3	4	5
5. I have been able to purchase new household gargets	1	2	3	4	5
6. I have be able to purchase my own farm inputs	1	2	3	4	5
Natural Capital					
7. Hand pollination has helped me expand my cocoa farm	1	2	3	4	5
8. I have experienced increased cocoa yield from year to year	1	2	3	4	5
9. I am able to cultivate higher acreage of farm land	1	2	3	4	5
Financial Capital					
10. I have been able to pay all my outstanding debts	1	2	3	4	5
11. I can now afford my children's school fees	1	2	3	4	5
12. I can now afford three square meals for my family	1	2	3	4	5
13. The implementation of hand pollination has led to increased access to credit facilities for me	1	2	3	4	5
14. My savings has increased now	1	2	3	4	5
Social Capital					
15. Hand pollination has helped to improve the social status of cocoa farmers in the Atwima Nwabiagya cocoa district.	1	2	3	4	5
16. I enjoy being a member of a farmers' association	1	2	3	4	5
17. I have been invited or likely to be invited to community development administrative meetings	1	2	3	4	5

18. What was your income during the usage of natural pollination?

……..

19. What was your income after the usage of hand pollination?

…….....