ECONOMIC PROFITABILITY AND ON-FARM INCOME DIVERSIFICATION AMONG SMALLHOLDER COCOA FARMERS IN THE WESTERN AND ASHANTI REGIONS OF GHANA

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE IN AGRIBUSINESS

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DECLARATION

I, Nana Okyir Baidoo, author of the thesis titled "ECONOMIC PROFITABILITY AND ON-FARM INCOME DIVERSIFICATION AMONG SMALLHOLDER COCOA FARMERS IN THE WESTERN AND ASHANTI REGIONS OF GHANA" do hereby declare that with the exception of references duly cited, this thesis is a result of research solely conducted by me at the Department of Agricultural Economics and Agribusiness, College of Basic and Applied Sciences, University of Ghana, Legon from February 2020 to November 2024. This work has never been presented either in whole or in part for any other degree of this University or elsewhere.

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DEDICATION

This work is dedicated to Afia and Kofi, whose arrival has made me strive to be an even better version of myself. To my team of parents: Charlotte, Adwoa, Ashay, Del, Mandy, Aunty Yaa, Aunt Jemi, Appiah, Connie, Collins & Mimi, who have nurtured me even through my adult years to be as good a son, husband and brother as there can be, and to my family of friends who have supported me in diverse ways throughout this journey.

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ABSTRACT

Cocoa is of utmost importance to the economy of Ghana and to over 850,000 cocoa farming households who derive their livelihoods from cocoa production. In recent years, there has been an increase in diversification by cocoa farmers into other farm-based livelihoods with cocoa or out of cocoa into other competing perennial tree crops such as oil palm and rubber, often in pursuit of higher returns. Most studies focus on financial profitability and not economic profit, thus failing to estimate or ascertain if the opportunity cost of producing cocoa outweighs its benefits. Also, with the resources available to farmers, it is important to examine how efficient cocoa farmers are in using these resources to generate profit. Studies also examine the determinants of profitability and on-farm income diversification separately; however, it is important to establish if there is a relationship between on-farm income diversification and profitability. Theories such as the Resource Based View Theory of the Firm, Walker's Theory of Profit and Hawley's Risk Theory of Profit form the theoretical underpinnings of this study. This study sought to estimate the financial and economic profitability of cocoa farm plots in the Western and Ashanti regions of Ghana, estimate the profit efficiency associated with these cocoa farm plots and the factors affecting it as well as establish the relationship between the on-farm income diversification status of farmers and the profitability of their farm plots. For the study, data was collected from 402 farmers with 513 farm plots under the Cocoa4Future Project implemented in the Elembelle, Wassa Amenfi Central (Western Region) and the Afigya Kwabre North districts (Ashanti Region). Financial profit expressed as gross profit per hectare was GHS3,311.72 for cocoa farm plots in the Western region and GHS3,176.59 for plots in the Ashanti region. The observed difference in financial profit across different plot age groups was found to be statistically insignificant. The economic profit estimations indicate that cocoa production is generally economically profitable. However, farmers are worse off for producing cocoa over rubber for the Western region when cocoa trees are over 16 years old but are better off for producing cocoa over oil palm in the Ashanti region after cocoa trees are over 7 years old. However, sensitivity analysis shows that if farmers were to achieve on average a yield of 1000kg/ha, both financial and economic profitability would improve significantly by about 120%. The study also found that while generally cocoa farm plots were profit inefficient, cocoa farm plots in the Ashanti region were significantly more profit efficient as compared to cocoa farm plots in the Western region with estimated profit efficiency scores of 40.60% and 44.26% for the Western and Ashanti regions respectively. Also, it was found that for both regions, cocoa farm plots of diversified farmers were more profit efficient. Age and cocoa farm plots located in the Wassa Amenfi Central district as against Elembelle district, were found to have a significant effect on cocoa farm profit inefficiency. The study also found that higher profits are likely to be associated with diversified farmers. Based on the results, the study concludes that the benefits of producing cocoa, outweigh the opportunity cost involved. The study recommends improving strategies for the distribution of inputs such as seedlings, fertilizer and agrochemicals to farmers to help increase yields. Also, it is recommended that cocoa trees, especially hybrid varieties, be replaced after at most 20 years. To increase farmer profit efficiency, the study recommends encouraging the adoption of hybrid cocoa varieties and sensitization on proper hybrid cocoa plot management. Also, the study proposes encouraging farmers to diversify into other on-farm livelihoods with cocoa.

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LIST OF ABBREVIATIONS

ADB	Agricultural Development Bank
AfDB	African Development Bank
BCR	Benefit Cost Ratio
CAPI	Computer-Assisted Personal Interviews
CIMPS	Crop Input Market Participation Share
CMP	Conditional Mixed Process
COCOBOD	Ghana Cocoa Board
CODAPEC	Cocoa Disease and Pest Control
CRIG	Cocoa Research Institute of Ghana
Eqn	Equation
FAO	Food and Agriculture Organization
FASDEP	Food and Agriculture Sector Development Policy
FBO	Farmer-Based Organization
GCB	Ghana Commercial Bank
GCX	Ghana Commodity Exchange
GDP	Gross Domestic Product
GHS	Ghana Cedi
GIRSAL	Ghana Incentive-Based Risk-Sharing System for Agricultural Lending
GLSS	Ghana Living Standards Survey
GPRS	Growth and Poverty Reduction Strategy
GREL	Ghana Rubber Estates Limited
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
Ha	Hectare
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IRR	Internal Rate of Return
MLE	Maximum Likelihood Estimation
MoFA	Ministry of Food and Agriculture
MT	Metric Tons
NIB	National Investment Bank
NPV	Net Present Value
OLS	Ordinary Least Squares
ROPP	Rubber Outgrower Plantations Project
ROI	Return on Investment
SFM	Stochastic Frontier Method
SLF	Sustainable Livelihoods Framework
SPRING	Strengthening Partnerships, Results, and Innovations in Nutrition Globally
SRID	Statistics, Research and Information Directorate
UN	United Nations
UNCTAD	United Nations Commission for Trade and Development
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VRS	Variable Returns to Scale

CHAPTER ONE

INTRODUCTION

1.1. Background

Cocoa production in Ghana is of immense importance to local socio-economic development (Odoom, 2021a). Ghana is the second largest global exporter of cocoa and is a gold-standard holder for global quality. Cocoa contributed about 20.9 billion to the national gross domestic product (GDP) and 11.2% of total export earnings as of 2023 (Ghana Statistical Service, 2024). There are numerous direct and targeted uses of revenues from cocoa including the Ghana Cocoa Roads program, which is the biggest single-road investment program, with roads being constructed annually. The program aims to create better access to cocoa-producing communities for easier evacuation of cocoa produced. However, with the construction of these roads, numerous positive externalities, such as improvement in trade and access to social amenities in connecting districts, accrue to the communities involved. In the 2021/2022, the Government of Ghana allotted approximately GHS 400 million for the construction of cocoa roads, whilst earning GHS 12 billion from cocoa sale that season, representing about 3% of earnings (COCOBOD, 2025.; Government of Ghana, 2022). Another area cocoa revenues are applied to is the education sector. The Cocoa Farmers' Scholarship Scheme operated by the Ghana Cocoa Board (COCOBOD) as part of its social services to cocoa growers offers scholarships to farmers for the second-cycle education of their children. For the 3-year stream, COCOBOD typically sponsors 7,500 students, and for the 4-year stream, 10,000 students (COCOBOD, 2025.; Peprah, 2019).

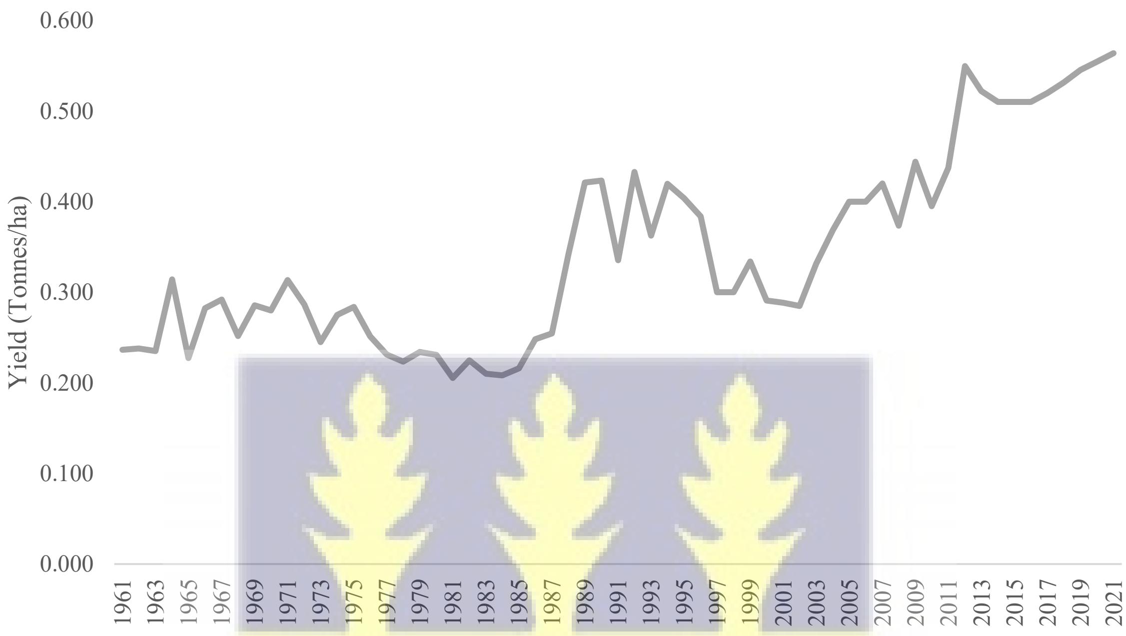
Cocoa production in Ghana is dominated by smallholder farmers with an average landholding of less than 4 hectares per farmer. These smallholder farmers are responsible for about 90% of total national cocoa production (Attipoe et al., 2020). More than 850,000 farmers – mostly smallholders – derive over 70% of their income from the cocoa business (Danso-Abbeam et al., 2014; Roldan et al., 2013). Cocoa is also estimated to provide income for about millions of Ghanaians and responsible for about two-thirds of total household income in most cocoa-producing households (Adesugba & Mavrotas, 2016). Given the foregoing, cocoa production is not only important to the Ghanaian at the macro level, but at the micro and household level too, as it is an important economic activity for many households and communities.

In Ghana, cocoa is produced in seven (7) cocoa regions per COCOBOD's administrative classification, namely Eastern, Ashanti, Central, Brong-Ahafo, Western North, Western South and Volta Regions. Four administrative regions of these, namely the Western, Ashanti, Eastern and Brong Ahafo regions, account for 90% of the country's output (Danso-Abbeam & Baiyegunhi, 2019). Within all the cocoa regions, cocoa-producing communities are typically rural, with farming being the main economic activity undertaken (Oyekale, 2020). Thus, most livelihoods outside of cocoa farming are agrarian as well (Peprah, 2015). This means that these communities are often vulnerable to risks associated with agriculture, including climate change, inadequate access to financial services and primary production-related risks (Löwe, 2017).

Several factors have been identified as threats to the sustainability of cocoa crops, not only within Ghana but on a global scale. These include productivity-related issues such as soil fertility decline, low adoption of technology, low use of fertiliser and other agrochemicals due to increasing costs, adverse effects of climate change and low adoption of proper farm management practices (Amfo & Ali, 2020a; Aneani & Ofori-Frimpong, 2013; Peprah et al., 2020). In Ghana, yields are estimated to be between 400 to 550 kilograms/hectare (see Fig. 1.1), below the achievable yield of 1000 kilograms/hectare (1 tonne/hectare) as projected if best management practices recommended by the Cocoa Research Institute of Ghana (CRIG)

(Amponsah-Doku et al., 2022) are adopted, and far below the yield potential of 1,890 kilograms/hectare estimated by Aneani and Ofori-Frimpong (2013). This low yield below the projected achievable yields, together with other socioeconomic factors, account for lower-than-attainable incomes for cocoa farmers.

Figure 1.1 Yield (Output/ha) of Cocoa in Ghana from 1961 to 2021

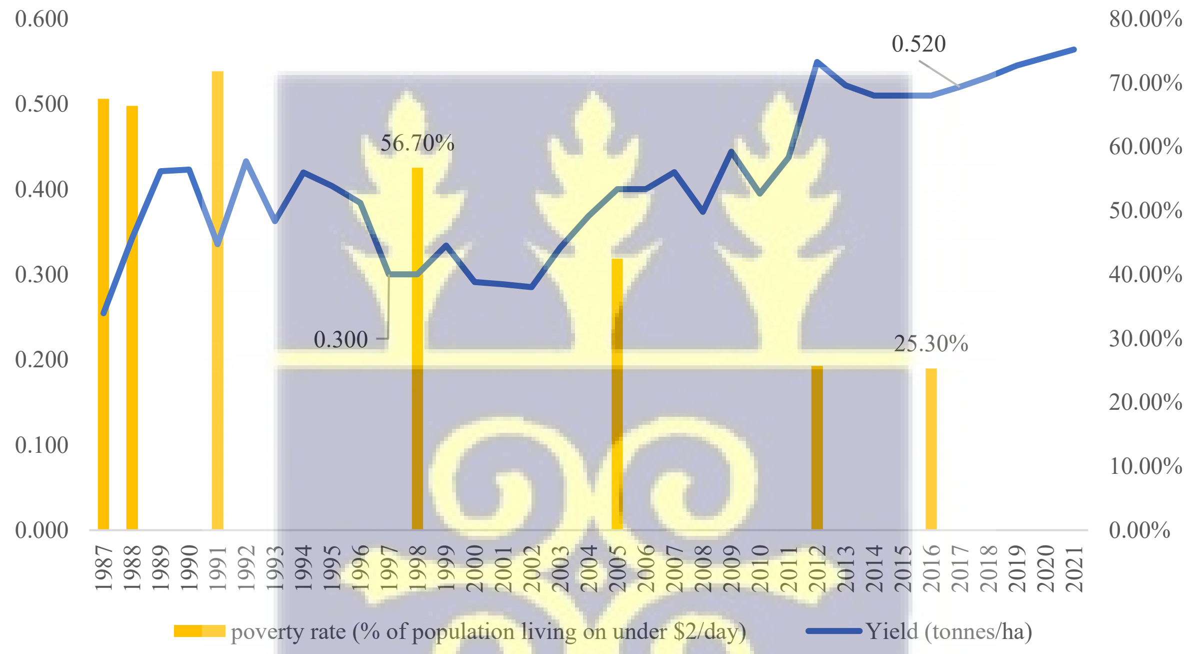


Source: Ghana COCOBOD, 2022

Historically, the focus of government policy in boosting production and yield in Ghana's cocoa sector has been towards improving crop health through programs targeted at disease and pest control, pollination, and hybrid seedlings (Maciej et al., 2021), plant and soil health. Two such programs are the Cocoa Disease and Pest Control (CODAPEC) and Mass Spraying Program, instituted in the 2001/2002 season and the revised Subsidized Fertilizer Program (Maciej et al., 2021). These programs have been successful to varying extents as they have been beset by both external and internal issues. After eight years of implementation of the "Free Fertilizer Program" between 2009 and 2017, the Management of Ghana Cocoa Board (COCOBOD) has had to reintroduce a revised Subsidized Fertilizer Program (COCOBOD Projects, 2023).

Despite the recorded setbacks in these programs, research by Breisinger et al. (2008) suggests that since its formation and current form, COCOBOD has contributed to a reduction in poverty levels among cocoa-producing households from 60.1% in the early 1990s to 23.9% in 2005. This is a greater decline in comparison to the overall national poverty rate, which fell from 51.7% in 1991/92 to 28.5% in 2005/2006, and 11.1% in 2020, coinciding with increased cocoa yields (Food and Agriculture Organization, 2023; World Bank, 2023). This correlation further highlights the importance of improvements in cocoa yields to poverty reduction (see Fig 1.2), not only in cocoa-growing households but also in the overall national poverty reduction

Figure 1.2 Poverty Rate and Cocoa Yields in Ghana (1987 - 2021)



strategy.

Source: Adapted from FAOSTAT and Ghana COCOBOD (2022)

Since 2005, the private sector has also been active in investing in interventions aimed at promoting the productivity and wellbeing of cocoa farmers. Institutions such as Mondelez, Esoko, Solidaridad, World Vision, Lindt-Sprungle, Cadbury and Rainforest Alliance Management Group have all directly invested or been involved in the delivery of direct cash payments, farmer training and input support (Felix, 2020; Onumah et al., 2023; Tham-Agyekum et al., 2024). These projects have had reported impacts on selected groups of farmers. For example, a study found that World Vision's Cocoa Life project interventions were very highly relevant to livelihood diversification, business development, financial literacy, microcredit facilities, and education within beneficiary communities (Odoom, 2021). Astrid et al. (2016) also found that Rainforest Alliance's certification of small-scale cocoa farmers in Ghana has a favourable impact on the yield, income, and improvement of certified farmers' natural and financial capital, among others. The commonality with these projects is the emphasis on increasing farmer profits or income leading to improved farmer welfare, including food security status and poverty alleviation. The achievement of this goal has more extensive ramifications on the global supply chain for consumer goods relying on cocoa as raw material. Any decline in productivity negatively impacts the sector (Odijie, 2018).

In Ghana, studies show a high level of livelihood diversification among cocoa farmers, related to low returns from cocoa (Yamoah & Kaba, 2022; Agyei-Manu et al., 2020). These consist of both on-farm and off-farm livelihoods diversification. On-farm livelihood diversification strategies such as other tree crop farming, including rubber, oil palm and citrus, strongly compete with cocoa for land as a factor of production (Aneani et al., 2016). Other on-farm livelihoods identified include livestock rearing and the production of food crops such as cassava and vegetables (Afriyie-Kraft et al., 2020; Bisseleua et al., 2018). In terms of off-farm diversification strategies, studies identify artisanal livelihoods such as tailoring and carpentry, as well as trading among others (Agyei-Manu et al., 2020). This transition is understandably motivated by farmers' need for food security and other welfare concerns (Lapeyre, 2004). This observed behaviour is driven by the prospect of making more profits. However, the decision to diversify or convert from cocoa farming to another tree crop or alternative land use is influenced by socioeconomic characteristics that are peculiar to individual farmers. Studies have shown that a low education level can be a barrier to entry into the non-farm sector for smallholder farmers (Khatun & Roy, 2012). Moreover, household heads with formal education are more likely to engage in non-farm alternative livelihoods (Agyei-Manu, 2020). As noted from Agyei Manu et al (2020), the ultimate motivation for either diversifying with cocoa or converting from cocoa to another livelihood is often the perception of higher profit. It is important, therefore, to ensure the profitability of cocoa farming as a business. Given the importance of addressing farmers' welfare requirements, it has also become necessary to examine the profitability of cocoa farms relative to other competing alternatives such as oil palm, rubber, and citrus. Whilst the importance of cocoa revenue to the country has been established, at the farmer level, this is outweighed by farmers' own welfare needs.

This study is situated within the framework of the Cocoa4Future (C4F) Project. C4F is a project which aims to make cocoa farmers in Ghana less vulnerable. The project is funded by the European DeSIRA Initiative and by the French Development Agency (2021-2025). The project brings together many partners jointly striving to place people and the environment at the core of tomorrow's cocoa production. Specifically, the C4F Project is focused on an implementation of a Cocoa Farm Monitoring system with five (5) main themes: (i) changes in the cocoa family farm characteristics; (ii) strategies for diversification; (iii) cocoa cycles and ecological change; (iv) social innovations around agroforestry, land tenure and child labour; and (v) public policy support tool to help the government of Ghana sustain cocoa production.

1.2. Problem Statement

Within the theme of strategies for diversification, assessing the profitability of other crops (tree and food crops) outside cocoa fields has become germane, albeit not much empirical studies have been generated for policy focus. The profitability of cocoa farming, especially in Africa, is a well-researched area. In terms of methodology, most of the studies done have adopted the net present value approach (NPV), benefit-cost ratio (BCR) and the internal rate of return (IRR) as the metrics for analysing the profitability of farm plots in the cocoa sector in Africa (Norton & Nalley, 2013; Nunoo & Owusu, 2017; Nur Alam et al., 2020). Other studies have also analysed financial profitability by calculating the accounting net profits of cocoa farms (Oseni & Adams, 2013; Yahaya et al., 2015). These studies have yielded a great degree of disparity based on location, and the presence of interventions aimed at productivity improvement and certification. Beyond financial profitability analysis, there is little in terms of information on the economic profitability of cocoa in comparison with other alternatives. The concept of economic profitability here looks at analysing the profitability of a venture beyond financial metrics and taking into cognizance foregone alternatives which may have been available. In the case of cocoa farmers in Ghana, given the key resources used to produce cocoa, which are land, labour and capital, several tree crop alternatives exist. Oil palm, rubber, coconut and citrus are popular alternatives that may be ventured into at the expense of cocoa. There is little literature that delves into the question of whether cocoa farming as a business provides a profitable return above what can be achieved if the farmer had gone into the forgone alternatives mentioned. This analysis could provide the actual economic profitability of cocoa, beyond the financial profitability metrics that are often estimated in the literature.

Aside from estimating the profitability of cocoa farmers at the cocoa plot level, it is also important to estimate and understand the extent to which they are efficient in achieving the recorded profits given that profit is a function of revenue and cost. In Ghana, the cocoa marketing is a monopsony, which indicates that it is a market where there is only one buyer. By law, the Cocoa Marketing Company is the only buyer of cocoa. It achieves this through a network of Licenced Buying Companies (LBCs) which buy cocoa at set prices from farmers on its behalf. As the price of farmgate cocoa beans is set, farmers' revenues depend largely on their ability to boost the output available for sale. Profitability of farmers is based on how they can maximize output given the limited resources they have, and how they are able to minimize their costs to achieve the highest output possible. Literature indicates a gap between the current actual and achievable output levels per unit area for cocoa farms in Ghana, mostly from field trials conducted by research institutions under best practices (Aneani & Ofori-Frimpong, 2013; Brako et al., 2021). The Ghana COCOBOD estimates that yields of 1,000kg per hectare are possible under best practices (Amponsah-Doku et al., 2022). Other studies have also indicated achievable yields of between 550 kg per hectare and 600 kg per hectare (Danso-Abbeam & Baiyegunhi, 2018) for smallholder farmers. Given the constraints inherent in the profit maximization of cocoa farmers, it is important to understand how efficient cocoa farmers are in generating profits. However, there is very little in terms of studies done to ascertain how efficient farmers are in generating the profits they do. Most studies from the literature reviewed focus on technical efficiency, relating to the efficiency of output production (Danso-Abbeam et al., 2020; Danso-Abbeam & Baiyegunhi, 2019). It is important therefore to study the profits that are generated from these outputs, especially in comparison to what is attainable.

Whereas a number of factors are identified (Danso-Abbeam & Baiyegunhi, 2019; Onumah et al., 2013a; Onumah et al., 2013b) as affecting the production efficiency attainable by farmers, information on the factors that may account for possible variations in the efficiency with which farmers generate profits from cocoa farm plots is scanty. The key factors affecting production or technical efficiency may be socioeconomic, farm-specific and/or institutional variables

(Asante et al., 2017; Temoso et al., 2016; Onumah et al., 2013a; Onumah et al., 2013b). Some of these factors include farm size, frequency of pesticide application, gender of household head, education and non-farm income, among others (Asante et al., 2017; Temoso et al., 2016). From Asante et al (2017) and Temoso et al. (2016), it is established that increasing farm sizes may increase the technical efficiency of cocoa farmers. Also, increasing the frequency of pesticide application to between three and six times per season tends to lead to higher yields and higher technical efficiency, as controlling pests associated with cocoa improves the yield of cocoa trees. Furthermore, some studies show that there exists a gender gap in farmers' performance under the assumption of variable returns to scale (VRS), where male farmers are observed to be more technically efficient than their female counterparts (Danso-Abbeam & Baiyegunhi, 2020). Knowledge of these factors helps to create models that can assess the usefulness of interventions and advise on the design of interventions for the sector. In the same vein, it is important that the factors that affect profit efficiency also are identified and discussed. Given the difference in technology across the different cocoa regions and potential districts (Danso-Abbeam & Baiyegunhi, 2020), it is important to clearly understand which variables account for observed variations. However, there is little in terms of empirical studies that provide information on the factors that affect the profit efficiency of cocoa farmers. Moreover, it is even more difficult to find studies that address profit efficiency especially in the Ghanaian cocoa enterprise context and across different cocoa regions of Ghana. Given that the variation in technology may be traced to the different diversification options farmers are involved in, the diversification strategy with cocoa selected by a farmer must be studied to ascertain whether this is a factor that affects profit efficiency or otherwise. However, no studies have been found to have undertaken this investigation.

As on-farm diversification continues to become more common among cocoa farmers, it is important to investigate if this diversification has an impact on the profitability of cocoa or rather has an adverse impact on cocoa profitability. Two of the most widely investigated effects of diversification among farmers are increased food security and income (Adjimoti & Kwadzo, 2018). In terms of food security, a number of studies establish a relationship between food security and farmer diversification (Hashmiu et al., 2022). Recent studies show a positive link between cocoa cultivation, household crop income, and food security, contradicting previous literature that claimed cash crops reduce food security. This clearly highlights complementarities between cocoa, food crops, and cashew production (Hashmiu et al., 2022).

Farmers moving from staple food production into the production of cash crops in the last decade have been seen as worrying for food security outcomes despite their impact on income improvement (Douxchamps et al., 2016; Thanichanon et al., 2018). Thus, given this new paradigm, there is the need to investigate if despite the total household income increase, the profitability of cocoa farming as an enterprise is leading farmers to diversify into other farm and off-farm diversification strategies. Only a few recent studies have been conducted in this area (Afriyie-Kraft et al., 2020; Dzahini-Obiatey et al., 2020). Even beyond the problem of estimating the impact of profitability on farmers' decision to diversify, there is the need to understand whether diversifying into other strategies has an impact on farmers' cocoa enterprise profitability.

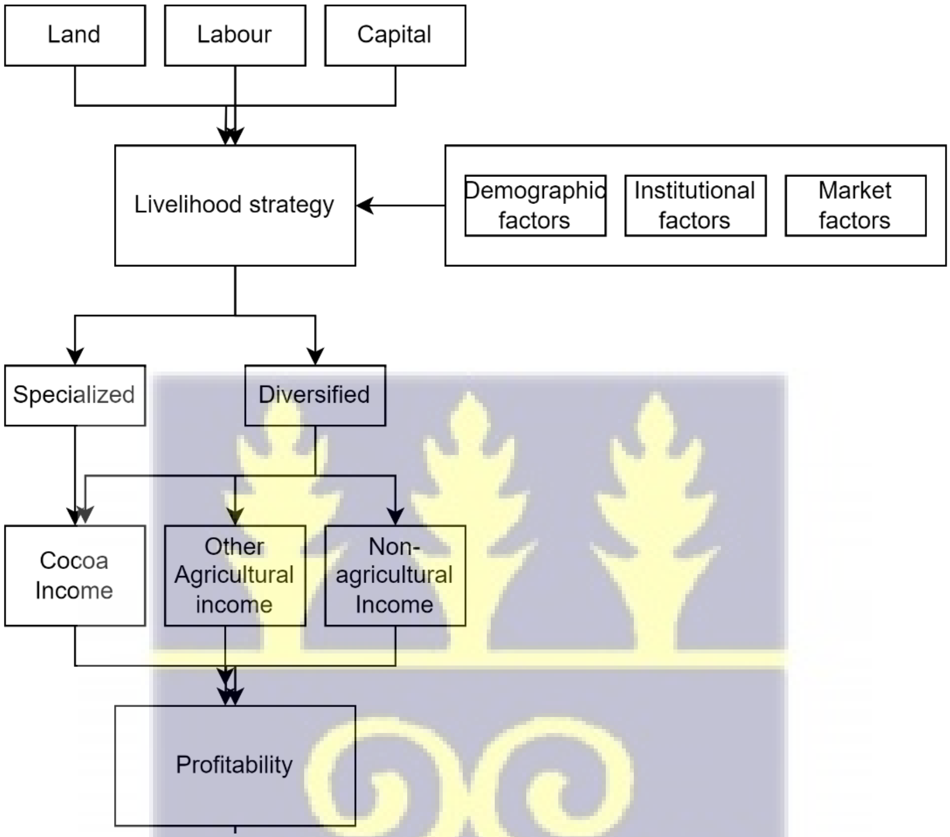
Studies show that diversified farming systems are generally more profitable than specialized systems (Sánchez et al., 2022). Sanchez et al. (2022) show that in a broad range of circumstances, diversified agricultural systems are not only more viable but economically advantageous than simplified ones. However, at the smallholder level, no studies were found to have been done that treat cocoa farming as a business unit and tests if diversification into other on-farm and off-farm enterprises will lead to more profitable cocoa enterprises. This is to examine whether diversification is a significant determinant of cocoa farmer profitability or otherwise. On the other hand, it is important to also understand if on-farm income diversification by cocoa farmers is influenced by profitability, that is, if profitability is also a significant determinant of on-farm income diversification into farm-based and off-farm income among cocoa farmers in Ghana.

Several factors are identified as influencing cocoa farmers' decision to diversify their income sources. Education level, age of the farm, access to credit, extension contact, information sources on climate change, and government support have been identified as some factors that influence diversification among cocoa farmers (Amfo & Ali, 2020a; Prazeres et al., 2023). Few studies have considered investigating the profitability of cocoa farms as a factor influencing farmers' on-farm income diversification behaviour or link the profitability of cocoa farmers to their on-farm income diversification status (Iritié & Djaléga, 2016). However, given the importance of profitability on the attractiveness of cocoa as an enterprise, it is important to investigate empirically if profitability is indeed a determinant of cocoa farmers' on-farm income diversification decisions.

1.3. Conceptual Framework

Figure 1.3 provides an overview of the concepts underpinning this research. The decision to go into cocoa farming is one made based on the availability of farm resources, which may include land, labour and capital to acquire or rent land, or in some cases inheritance of the land resource, and the expected income from the cocoa relative to other farm enterprises. From this foundation, farmers venture into cocoa farming as their primary livelihood strategy. Based on their socioeconomic characteristics and other factors, there is variation in the profitability of farmers/cocoa farm plots. To increase overall profitability, farmers may, again influenced by their unique set of socioeconomic characteristics, venture into other livelihood strategies, including agricultural income sources. However, this study argues that in addition to socioeconomic factors, on-farm income diversification status also influences the profitability of cocoa farmers enterprises.

Figure 1.3 Conceptual Framework of the Study



Source: Author's Construct, 2024

1.4. Research Questions

The research questions this study seeks to address are as follows:

1. What is the financial and economic profitability of cocoa farm plots in the Ashanti and Western regions of Ghana?
2. What is the profit efficiency of cocoa farmers in the Ashanti and Western regions of Ghana?
3. What is the relationship between on-farm income diversification and profitability of coco farm plots in the Ashanti and Western regions of Ghana?

1.5. Objectives of the Study

The main objective of this study is to assess the economic profitability of cocoa farm plots and the relationship between profitability and on-farm income diversification of cocoa farmers in the Ashanti and Western regions of Ghana.

The specific objectives of the study are:

1. To estimate the financial and economic profitability of cocoa farm plots in the Ashanti and Western Regions of Ghana.
2. To estimate the profit efficiency of cocoa farmers in the Ashanti and Western Regions of Ghana.
3. To determine the relationship between on-farm income diversification and profitability of cocoa farm plots in the Ashanti and Western Regions of Ghana.

1.6. Hypothesis Underpinning this Study

The associated hypotheses for this study are:

i. Cocoa farm plots in the Ashanti and Western Regions of Ghana are financially and economically profitable.

ii. Cocoa farmers in the Ashanti and Western Regions of Ghana are profit-efficient in their cocoa production operations.

iii. There is a positive covariation between profitability and on-farm income diversification and between on-farm income diversification and profitability among cocoa farmers in the Ashanti and Western regions of Ghana.

1.7. Significance of the Study

Given that this study focuses on not only the financial profits that are made by cocoa farmers but also on their economic profits, this study will give policymakers a better understanding of the welfare implications of cocoa farmers in a much broader context than previously known. The study's unique approaches, such as estimation of economic profits as opposed to just financial profit, provides a multidimensional perspective into the potential welfare of the cocoa farmer relative to other farmers and establishes whether cocoa farmers are better off allocating their land as a factor of production to another tree crop or cash crop.

Knowledge derived from this study will also inform policymakers on the decision to improve the welfare of cocoa farmers by providing an insight into how profitable cocoa farming is in comparison to other tree crop alternatives, which is often a key consideration in the decision to improve the producer price of cocoa set by the Ghana COCOBOD. Based on this study and its extrapolation, policymakers can decide to adjust producer prices of cocoa or adjust subsidies and tariffs on inputs for cocoa.

The study also provides evidence to ascertain the factors behind farmers' choices of alternatives to cocoa and even further provides information as to whether these on-farm income diversification strategies are more profitable and provide better welfare for the farmer.

Furthermore, the study provides the opportunity to practically explore the application of key methodological approaches to profitability, such as the consideration of opportunity cost in profitability estimation, which hitherto have not been commonly used by researchers. The successful completion of this study will charter a new frontier for future analysis of agricultural projects in developing countries.

Finally, this study addresses key objectives of the C4F Projects, especially with respect to understanding the profitability of cocoa farm plots and the influence of diversifying into other tree crops on cocoa farm plot profitability.

1.8. Organization of the Thesis

There are five chapters in this work. In the first chapter, the background information, the research problem, and the study's justification are all provided. A review of pertinent literature on the study's thematic areas are provided in Chapter 2. The methodology for the study is covered in Chapter 3. This comprises the theoretical frameworks as well as an explanation of the data collecting and analysis process, questionnaire design, and the demographic characteristics of the sample selected. The results are presented and discussed in Chapter 4. A summary of the study's findings, conclusions, and recommendations are provided in Chapter 5.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter reviews previous studies related to the cocoa sector. The chapter gives an overview of the cocoa sector in Ghana concerning how it is structured and the legal frameworks that have shaped the sector. The chapter proceeds to discuss the body of knowledge on profitability, diversification and tree crop production in Ghana. The chapter also reviews some empirical studies conducted in the areas relevant to this thesis.

2.2. Overview of the Ghanaian Cocoa Sector

In this section, the study reviews the legal and regulatory frameworks of cocoa production and trade (GoG, 1992 Constitution, GoG the Land Act 2020, Ghana Cocoa Board Act 1984); the history of commercial cocoa production in Ghana and challenges facing the cocoa sector.

2.2.1. Legal and Regulatory Framework for Cocoa Production and Trade

The Ghanaian cocoa industry is governed by a strong legal and regulatory system that includes a wide range of laws, regulations, and organisations. The numerous facets of the cocoa business are governed by this framework, which has been thoughtfully created and is consistently updated to ensure efficient operations, sustainable practices, and fair-trade principles.

The 1992 Constitution: The 1992 Constitution includes a chapter on Lands and Natural Resources, which categorizes lands into three types: Public Lands, Stool Lands, and Non-Public/Stool Lands. It is important to note that stool lands cannot be converted into freehold interests; the highest interest that can be acquired is a leasehold interest.

The Land Act, 2020 (Act 1036): According to Act 1036, there are six distinct types of land interests: allodial, customary law freehold, common law freehold, usufructuary interest, leasehold interest, and customary tenancy. The allodial title represents the highest level of land ownership and can be acquired through various means such as purchase or gift. Customary freehold interest is an absolute and inheritable interest that can be obtained from the holder of the allodial title. Two common forms of customary tenancy in Ghana are Abunu and Abusa. Abunu involves an agreement between a non-local farmer and a landowner, where the farmer cultivates the land and shares the harvest with the landowner. Abusa, on the other hand, involves a caretaker who maintains the farm and receives compensation in the form of a portion of the cocoa yield. These customary tenancy arrangements, including Abunu and Abusa, are prevalent among smallholder cocoa-farming families in Ghana. While the farmers do not acquire ownership rights to the land, these arrangements play a crucial role in the country's agricultural sector and cocoa production, which is vital to Ghana's economy.

Ghana Cocoa Board Act 1984 (PNDCL 81): The Act introduces the Ghana Cocoa Board (COCOBOD) as a replacement for the Ghana Cocoa Marketing Board. Its primary objectives include promoting the cultivation of cocoa, coffee, and shea, implementing pest and disease control programs for these crops, and managing the purchase, import, manufacturing, distribution, and marketing of inputs related to their production. Additionally, the Act aims to support scientific research to enhance the quality and yield of cocoa, coffee, shea, and other tropical crops, regulate the marketing and exportation of these crops, and promote their overall well-being.

COCOBOD plays a crucial role in determining the prices paid to cocoa, coffee, and shea producers. It is responsible for procuring cocoa beans, coffee, and shea from producers, providing financial compensation for their purchases, and facilitating the provision of seedlings, credit, and other necessary resources to farmers for establishing new farms or rehabilitating existing ones. The Act also establishes Licensed Buying Companies (LBCs) as the authorized entities for purchasing cocoa, while prohibiting others from marketing and exporting cocoa without certification from COCOBOD.

Furthermore, the Act outlines the administration and financial provisions of COCOBOD and grants the board the authority to appoint heads of its subsidiaries, including the Produce Buying Company Limited, the Cocoa Research Institute of Ghana, the Cocoa Marketing Company (Ghana) Limited, COCOBOD Plantations Limited, the Cocoa Processing Company, and other divisions.

2.2.2. History of Cocoa Production in Ghana

Commercial cocoa cultivation in Ghana has a rich history, with its roots traced back to Tetteh Quarshie, a blacksmith, who brought cocoa beans from Fernando Po (now Bioko) in Equatorial Guinea to his farm in the Eastern Region of Ghana in 1895. By the end of the 19th century, Ghana was exporting cocoa, and from 1911 to 1976, it held the position of the world's leading cocoa producer, contributing 30-40% of the global cocoa output (ISSER, 2010). Currently, Ghana’s production of cocoa averages about 700,000 tonnes per year and, together with Cote d’Ivoire, accounts for 60% of global cocoa bean production

Realizing the importance of cocoa to the livelihoods of farmers and the Ghanaian economy, the government took charge of the industry in the 1930s and established a buying monopoly for all cocoa produced in the country (Kolavalli & Vigneri, 2011). Despite its intention to `protect farmers from price fluctuations, the initiative did not always result in improved prices for them.

At present, approximately 1.6 million people are involved in cocoa cultivation in Ghana, with many more engaged in related industries. Cocoa is cultivated in six regions of the country. While it once accounted for about 66% of Ghana's foreign exchange earnings, its share has now decreased significantly owing to the discovery and export of oil and developments in the mining sector (Essegbey et al., 2012).

Ghana's cocoa production has experienced different phases, from its dominance in the 1950s and 1960s to a decline in the following decades, followed by rehabilitation efforts in the 1980s, 1990s, and 2000s (Ludlow, 2012). Other countries like Malaysia and Cote d'Ivoire surpassed Ghana during this time. However, the focus is not merely on Ghana's cocoa production ranking but rather on the country's management of the socio-economic aspects of cocoa production to maximize returns for its people.

2.2.3. Sector Challenges

After exploring the developments in the cocoa innovation system, certain key challenges deserve attention to gain a clearer understanding of the necessary policy options and strategies to achieve our objectives. Primarily, these challenges pertain to the policy cycles, including policy formulation and evaluation, as well as strategies to attract investment and enhance capacity development, all while leveraging Science and Technology. The Ghanaian cocoa sector confronts numerous challenges that significantly affect its productivity and long-term sustainability.

Ageing cocoa trees and low productivity: One of the primary challenges is the prevalence of ageing cocoa trees and low productivity resulting from inadequate farm management practices, ageing farmers, and limited access to improved planting materials (Gockowski & Oduwole, 2003). These factors contribute to diminishing yields and hinder the sector's ability to meet the increasing global demand for cocoa.

Deforestation: Moreover, the Ghanaian cocoa sector grapples with deforestation, which poses a significant threat to the environment and the long-term viability of cocoa production (Buck et al., 2020). Cocoa farming is frequently associated with forest encroachment and illegal activities such as land clearing, leading to habitat loss and ecological imbalances (Asante, 2022). The expansion of cocoa farms into forested areas not only contributes to deforestation but also exacerbates climate change effects.

Climate Change: Climate change poses another major challenge for the Ghanaian cocoa sector. Temperature increases, altered rainfall patterns, and a rise in the frequency of extreme weather events like floods and droughts have adverse effects on cocoa production (Aikpokpodion et al., 2019). These climate-related challenges disrupt flowering patterns, reduce pollination rates, and increase the susceptibility of cocoa trees to pests and diseases (Tetteh et al., 2020). Additionally, climate change impacts water availability, affecting irrigation systems and exacerbating the vulnerability of cocoa farmers to environmental shocks.

Pests and diseases: The Ghanaian cocoa sector also faces persistent challenges related to pests and diseases. Cocoa swollen shoot virus, black pod disease, and capsid bugs are among the most significant pests and diseases that affect cocoa production in Ghana (Dzahini-Obiatey et al., 2019). These pests and diseases cause substantial losses, decrease the quality of cocoa beans, and pose ongoing threats to the sector's productivity and profitability (Bowers et al., 2019)

Limited value addition in the Ghanaian cocoa sector: Furthermore, the limited value addition in the Ghanaian cocoa sector poses a challenge to its overall sustainability. The majority of cocoa exports from Ghana consist of raw cocoa beans, which limits the potential for higher-value processing and export of cocoa-based products (Afful-Dadzie & Owusu, 2017). Limited value addition restricts the sector's ability to capture a larger share of the value chain and hampers economic diversification and job creation.

Policy formulation, implementation, monitoring, evaluation and coordination: The cocoa sector stands out as an example of effective policy management, with well-defined policies and regulations guiding every stage of the cocoa production process, from planting to external marketing. These policies include increasing producer prices, disease and pest control programs, and the encouragement of good agricultural practices (GAPs) to enhance yield. The success of the policy management process has contributed to the cocoa industry's achievements, but there is still room for improvement.

One important area where significant policy action is needed is in encouraging local use of cocoa. Initiatives like the Ghana School Feeding Programme could be leveraged to incorporate cocoa products regularly into school menus, exposing children to cocoa consumption from a young age and creating a lasting market for processors. Such measures can foster cocoa consumption habits in future generations.

Beyond specific policy issues, the overall socioeconomic policy environment plays a vital role in supporting businesses and strengthening the cocoa value chain's competitiveness. African countries, including Ghana, face challenges in creating a conducive investment environment due to high costs and various infrastructural and utility deficiencies. Improving the investment climate by addressing issues like infrastructure, finance, governance, and the judicial system can spur significant growth in cocoa businesses and the private sector.

Research and Development: The Cocoa Research Institute of Ghana (CRIG) has the mandate for researching cocoa and native tree species with similar fat production to cocoa butter. It offers advice and information on cocoa production and related crops.

CRIG is renowned for its research and development of improved cocoa varieties and more productive farming techniques. However, it also researches cocoa products, leading to innovations such as cocoa butter soap, cocoa jam, cocoa vinegar, brandy, body pomade, and cosmetics. A number of these innovations have been adopted to be produced for the mass market by companies such as Kasapreko Co. Ltd., which produces cocoa brandy for both domestic and export markets (Buchgraber & Anklam, 2003)

Despite these achievements, there are challenges in bridging the gap between the research and industrial sectors. Generic constraints necessitate broad policy interventions to address dysfunctions, including investment policies to attract capital for commercializing research innovations like those developed at CRIG. Specific policy actions are needed to target cocoa sector innovations and integrate them into existing national programs. For instance, the Ghana School Feeding Programme could include cocoa beverages, creating a larger market for cocoa products. Opportunities abound for driving innovations in the sector through synergistic policy actions. Addressing these challenges will further enhance the success of Ghana's cocoa industry.

Global Threats: Ongoing technological advancements continue to highlight the importance of sustained research and innovation in Ghana and other cocoa-producing countries. The emergence of Cocoa Butter Equivalents (CBE) derived from sources other than cocoa, such as palm oil, shea, and mango kernels, poses a threat to the cocoa industry as it may reduce the volume of cocoa used in chocolate and other products. The European Union (EU) has already approved the use of up to 5% CBE in chocolates, which is projected to result in a decrease in total cocoa demand by approximately 200,000 tons.

The Cocoa Producers Alliance, consisting of 13 member countries, has voiced opposition to the approval of CBEs (Buchagraber & Anklam, 2003). However, their concerns were disregarded, and the approval became law in 2000. As a response, cocoa-producing nations must explore strategies to counter this threat. One strategy to reduce the cost-effectiveness of using CBE by chocolate manufacturers is to increase the production of cocoa. This necessitates greater reliance on science and technology in primary cocoa production, diversification of cocoa utilization to boost demand, and a concerted effort to promote cocoa consumption within the producing countries. These actions are crucial in safeguarding the cocoa industry and its economic significance.

Illegal small-scale gold mining ("galamsey") undermines cocoa farming in Ghana by converting cocoa plots into mine sites, degrading land and water, and pushing farmers out of cocoa-based livelihoods. Studies in cocoa-growing districts such as Amansie West and Atiwa show that galamsey clears vegetation and topsoil, causes severe soil erosion and deforestation, and contaminates streams used by cocoa farmers, resulting in declining yields and abandonment of farms (Donkor et al., 2024; Nunoo et al., 2023). Heavy-metal analyses in mining–cocoa landscapes further reveal elevated levels of mercury and other toxic elements in cocoa soils and beans, threatening bean quality and export prospects (Kokonu et al., 2025). Socio-economic work also shows that the relatively high short-term cash returns from mining lure cocoa farmers and labour away from cocoa, eroding long-term productivity and food security in cocoa communities (Appiah et al., 2024; Obodai, 2024).

These challenges collectively threaten the long-term viability of the Ghanaian cocoa sector and have significant implications for the livelihoods of cocoa farmers who heavily rely on cocoa as a source of income (Asante, 2022) Addressing these challenges is crucial for enhancing the sector's sustainability, improving farmers' welfare, and ensuring the continued contribution of cocoa to Ghana's economy.

2.3. Tree Crop Production in Ghana

Ghana's agricultural sector encompasses various subdivisions, including crops, livestock, fisheries, and forestry. The crop subsector alone constitutes a substantial 66.2% of the agricultural GDP (MOFA, 2011). This highlights the pivotal role played by the cultivation of tree crops, such as cocoa, oil palm, rubber, shea nut, and cashew nuts, in sustaining the economy, employment, and foreign exchange earnings (Limantol et al., 2016). These crops, as indicated by various sources (Boafo, 2019; Wolter, 2009; Asubonteng, 2018; Darfour, 2016), not only enhance food security by providing a stable source of nutritious fruits, nuts, and other products but also significantly support Ghana's export industry, particularly as a major global supplier of cocoa and other tree crop products.

Tree crops fall under the crop subsector, playing an integral role in the agricultural sector and contributing significantly to the country's economy. The production of tree crops in Ghana holds a substantial share in the agricultural sector, contributing to the nation's economic well-being, employment rates, and foreign exchange earnings.

The performance of Ghana's agricultural sector is intricately linked to various policies. The promotion of cash and export crops, with a positive impact on rural incomes and poverty reduction, has been recognized (Asuming-Brempong, 2013). Notably, tree crop production, including cashew nuts, cocoa, oil palm, and rubber, stands out as a significant driver of Ghana's agricultural sector (Boafo, 2019; Wolter, 2009; Asubonteng, 2018; Darfour, 2016). These tree crops not only make a substantial contribution to the country's economic development but also play a crucial role in overall social and economic progress.

The government of Ghana has been actively supporting and promoting the modernization and expansion of tree crop cultivation in the country. The government of Ghana has recognized the potential of the tree crop subsector and is actively working towards its development and expansion. The shift towards tree crop cultivation in Ghana is driven by various factors and is supported by the government to enhance agricultural productivity, income generation, and rural poverty reduction (Asante-Poku and Angelucci 2013; Angelucci 2013; MASDAR 2011; MoFA 2012). The government of Ghana acknowledges the importance of sustainable tree crop cultivation in promoting agricultural productivity, income generation, and poverty reduction, especially in rural areas.

The importance of these tree crops extends beyond economic contributions, providing both income and employment opportunities (Asante-Poku and Angelucci 2013; Angelucci 2013). Cocoa, in particular, stands out as a major cash crop, positioning Ghana as a leading global producer of cocoa beans (Asubonteng, 2018). The cultivation of cocoa involves the participation of numerous smallholder farmers, underscoring its significance in rural livelihoods and community development. As Ghana continues to navigate the complexities of its agricultural sector, the cultivation of tree crops remains a cornerstone, fostering economic resilience and sustainable development (Asubonteng, 2018).

Ghana's economy is deeply intertwined with the production of cocoa, making it one of the world's top producers and exporters of this highly sought-after commodity. The significance of cocoa production in Ghana's economy is evident in its contribution to foreign exchange earnings, employment rates, and poverty reduction. As a major cash crop, cocoa not only boosts Ghana's economy but also sustains the livelihoods of over 850,000 rural Ghanaian families and another approximately six million individuals who play a role in the cocoa production value chain (Danso-Abbeam et. al., 2018).

The unparalleled significance of cocoa to Ghana's economy is undeniable. Cocoa production is not only a major source of foreign exchange for the country, but it also constitutes a crucial component of the agricultural industry, employing a substantial portion of the population. In Ghana, cocoa production takes place in two main agroecological zones; deciduous and rainforest (MoFA, 2013). Cocoa is cultivated mostly by smallholders with farm sizes that average about 2 hectares (Barrientos et al., 2008). According to Ghana Commercial Bank, (2022), Ghana's cocoa production takes place in seven administrative regions: Ashanti, Brong-Ahafo, Eastern, Central, Volta, Western North and Western. This implies that cocoa production is spread across a total of 64 cocoa-growing districts, representing 1.2 million hectares of arable land. Cocoa output has fluctuated over the years. For instance, in the 2010/11 production year, the cocoa output was over one million metric tonnes (Ounmah et.al., 2013a). Subsequently, in 2018/19 cocoa output fell to 812,000 metric tonnes and then 771,000 metric tonnes in 2019/20. In the 2020–2021 crop season, Ghana accomplished a historic achievement by producing over 1 million tonnes of cocoa, an increase of around 45% (Ghana Commercial Bank, 2022).

Oil palm, another prominent tree crop, has a long-established history in Ghana. The oil extracted from palm fruits serves various purposes, including cooking and industrial uses (Osei-Amponsah, 2016). The oil palm industry, with its blend of smallholder farmers and large-scale plantations, plays a vital role in sustaining the country's economy. It provides employment opportunities to about 0.6 million households representing 3 million value chain actors and contributes about 1% to Ghana's economic growth (Agyei-Dwarko, 2021).

In Ghana, oil palm production takes place around the two forest zones, which are the semi-deciduous forest and rainforest zones, with high rainfall amounts of over 1200mm/annum (van der Vossen, 1969; Rhebergen et al., 2016). Within these forest zones, oil palm production can be found in the Ashanti, Brong-Ahafo, Eastern, Central, Volta, and Western regions (Ofosu-Budu, & Sarpong, 2013). Ghana is believed to have over 150,000 hectares of natural groves containing (Dura) oil palm, in addition to around 140,000 hectares owned privately, unorganized small plots and approximately 40,000 hectares in estates with smallholder and out-grower schemes (van der Vossen, 1969; Ofosu-Budu, & Sarpong, 2013). The overall estimated expanse of palm plantations in the country is reported to be 330,000 hectares (MoFA, 2010). In Ghana, oil palm production operates through two primary systems: (i) the large estate plantations, and (ii) smallholder private farms where the oil palm crop is intercropped with food crops during its establishment (Ofosu-Budu, & Sarpong, 2013).

Rubber, cultivated in plantations, is also an essential tree crop contributing to Ghana's agricultural diversity. It provides employment opportunities to over 7816 farmers (MoFA, 2017) and contributes to the country's economic growth (Tetteh et. al., 2021). Rubber cultivation in Ghana is strategically concentrated in regions that offer favourable climatic conditions for the growth of rubber trees. The Regions include the Western, Central, Eastern, and Ashanti regions (Tetteh et. al., 2021). The tree requires a minimum annual rainfall of 1,200 mm. The Western Region has emerged as a key hub for rubber production. This geographic concentration allows for efficient cultivation and centralized processing.

Cultivating natural rubber has emerged as a substantial income source for farmers in the forested regions of Ghana. Despite a history spanning over a century, there has been a notable surge in farmers' interest in rubber production over the past decade compared to the preceding 90 years (GREL News, 2012). In a bid to assist smallholder farmers in establishing clonal rubber plantations, the Ghanaian government launched the Rubber Outgrower Plantations Project (ROPP). This initiative, led by the Ghana Rubber Estates Limited (GREL), entails collaboration with two quasi-government commercial banks, the Agricultural Development Bank (ADB) and the National Investment Bank (NIB) (FAO, 2021).

Within the framework of ROPP, around 2500 hectares of new rubber plantations are established annually, providing tangible benefits to smallholder rubber farmers. Over the past decade (2006–2016), ROPP has supported over 7,815 farmers in cultivating 29,585 hectares of rubber, particularly in the Western, Western North, and Central regions of Ghana, with the primary goal of mitigating poverty (GREL Report 2016). The proliferation of rubber plantations has significantly augmented the incomes of smallholder farmers, making a substantial contribution to poverty reduction in rural areas (Lisa and Roble 2012).

Cashew nut production has witnessed growth, positioning Ghana as a notable player in the global cashew market (Danso-Abbeam et.al, 2021). This crop not only generates income for farmers but also plays a role in enhancing the country's economic standing. Cashew production is dominated by smallholder farmers with a farm size of not greater than 3 hectares. Thus, in Ghana, cashew is cultivated in the Bono, Bono East, Ahafo, Ashanti and Northern Regions (Dubbert, 2019). In 2019, Ghana played a significant role in the international market by supplying around 171,924 metric tons of nuts to the total global production. This highlights the importance attributed to cashew production in the region (Akyereko et al., 2022). The output of raw cashew nuts underwent significant expansion, increasing from 6.333 tonnes in 2003 to around 34.633 tonnes in 2006, and further escalating to 81.190 tonnes in 2008 (Sarpong, 2011). In 2015, Ghana exported about 232,834 tonnes, generating a contribution exceeding $200 million (MoFA, 2016).

Shea nut trees, native to the savannah regions of West Africa, including Ghana, contribute to the production of shea butter. This industry is particularly important for rural women, who are often involved in collecting and processing shea nuts. In the five northern regions of Ghana, it employs about 85% of rural women and also makes up about 70% of the income of rural households in northern Ghana (Adams et. al., 2016; Naangmenyele et.al., 2023). The shea tree is widespread throughout nearly the entire Northern Ghana region, spanning approximately 77,670 km2, and it plays a crucial role in supporting the livelihoods of about 900,000 rural women in the shea sector of northern Ghana (Kodua et. al., 2018; SNV, 2011). Shea trees can also be sparsely found around Western Dagomba lands, Southern Mamprusi, Gonjaland, Eastern parts of Nadowli, Sissala lands and Western parts of the Upper West Region especially Wechiau (GraphicShowbiz, 2021; Fobil, 2007). Additionally, some shea trees can be found in Bono, Bono East, Ahafo, Ashanti, Eastern and Volta regions in southern Ghana (FAO, 1988a; Fobil, 2007; Hatskevich et al., 2011; SNV, 2011).

In Ghana, shea butter production involves a combination of local, semi-mechanized, and automated processes. The main tasks in shea production encompass the collection of fruits and nuts, the transformation of nuts into butter, and the subsequent distribution and marketing of shea products. Predominantly managed by women, often serving as shea butter entrepreneurs, these operations cater to both local and global markets. Support for the processing of shea products has been extended by various entities such as export companies, non-governmental organizations (NGOs), development partners, and government initiatives. Shea derivatives, including both shea kernel and shea butter, have become marketable and entered the global market due to their export potential (Naangmenyele et.al., 2023).

Government-led initiatives, coupled with support from development partners, have been instrumental in promoting sustainable tree crop production. These efforts focus on improving agricultural practices, providing training to farmers, and promoting the use of modern technologies. The goal is to enhance productivity and ensure the long-term sustainability of tree crops, addressing issues such as deforestation and promoting agroforestry practices. In doing so, Ghana aims to strike a balance between tree crop cultivation and environmental conservation, fostering a holistic approach to agricultural development.

2.4. Livelihood Diversification

2.4.1. The Concept of Livelihood Diversification

Over the past few decades, there has been a growing body of research focused on the Sustainable Livelihoods Framework and its application to income diversification in small-scale fishery contexts (Ferrol-Schulte et al., 2013; Stacey et al., 2021). However, the interrelationship between livelihood diversity and diversification can sometimes be unclear and lead to conceptual confusion (Eriksson et al., 2020).

Livelihood diversification is a process through which households construct varied portfolios of activities and social support capabilities to improve their standard of living and resilience (Ellis, 1998). It goes beyond the narrow concept of income diversification and encompasses a broader view of social processes and outcomes that evolve (Ellis, 1998). The process of diversification can be influenced by planned interventions, resource management regulations, or socio-ecological changes such as changing market and climate conditions.

The goal of diversification is to achieve a pattern of livelihood diversity where there is an improved number of activities in the livelihood mix, aligning with the theoretical underpinnings of sustainable development that emphasize resilience and well-being (Biggs et al., 2012). However, the loose usage of the term "diversity" has resulted in different interpretations of livelihood diversification, leading to conceptual confusion (Eriksson et al., 2020; Stacey et al., 2021; Steenbergen et al., 2017).

In practice, achieving a diversified livelihood can take various pathways. For example, a rural fisher may achieve a diversified livelihood by improving current activities through technology, adopting new fish-based activities, or transitioning out of fishery into alternative or supplemental livelihood activities (Roscher et al., 2022). Within a household engaged in fishing-related activities, different members may pursue multiple enterprises within and outside fisheries or specialize in different enterprises or sectors (Allison & Ellis, 2001). The resulting patterns of livelihood activities through these diversification pathways can vary in their ability to support sustainable livelihoods in different contexts.

The increasing focus on the development of the rural off-farm economy has led to investigations into livelihood diversification. Livelihood diversification is a multidimensional concept that encompasses all alternative sources of activities to households to allocate their scarce factors of production (Ellis, 2000; Asravor, 2018). It goes beyond just economic activities to include other dimensions such as the household deployment of land and labour into various ventures.

Various aspects of livelihood diversification have been explored in studies (Nkegbe et al., 2018; Senadza, 2014; Dagunga et al., 2018; Asravor, 2018), including non-farm, off-farm, and on-farm diversification or cropland diversification. While on-farm diversification entails raising a variety of animal species or producing a variety of crop species, non-farm diversification refers to participating in alternative activities conducted away from the farm (Asravor, 2018). The non-farm sector also includes the wage-employed and self-employed sectors, where households run their enterprises or provide labour in exchange for income (Asravor, 2018).

Off-farm diversification entails engaging in alternative economic activities outside one's farm, while on-farm diversification refers to diversification within the boundaries of the farm (Asravor, 2018). These dimensions capture different aspects of livelihood diversification and highlight the dynamic mechanisms that rural households employ to handle risks and improve their well-being (FAO, 2015). Empirical studies have shown regional variations in the extent of livelihood diversification, with the Northern belt of Ghana exhibiting less diversification compared to the southern belt (Asravor, 2018). However, evidence suggests increasing diversification of livelihoods among resource-poor households in northern Ghana (Dzanku, 2015; Senadza, 2014).

In conclusion, the concept of livelihood diversification within the sustainable livelihoods' framework provides a nuanced understanding of the multiple dimensions and pathways through which households construct diverse portfolios of activities to improve their livelihoods. It encompasses more than just income diversification and recognizes the importance of social processes, resilience, and well-being. Diversification can be achieved through various pathways and can vary in its implications for sustainable livelihoods depending on the context and specific activities pursued. Continued research and conceptual clarity are essential to further advance our understanding of livelihood diversification and its implications for rural development and resource sustainability.

Also, the literature reviewed clearly defines on-farm income diversification on-farm as diversification occurring within the boundaries of a farm (Asravor, 2018). Also, the various types of on-farm diversification are highlighted as being raising a variety of animal species or producing a variety of crop species. For this study, on-farm income diversification studied include tree crop production, food crop production and livestock rearing.

2.4.2. Drivers of Livelihood Diversification: Pull versus Push Factors

Diverse elements, which can be roughly divided into push and pull factors (Agyeman et al., 2014; Dagunga et al., 2018), are what propel livelihood diversification. Push factors are unfavourable circumstances that force households to engage in multiple activities outside the farm, whereas pull factors are favourable conditions or opportunities that draw households to allocate their labour or capital to a particular livelihood activity (Dimova & Sen, 2010; Bezu & Holden, 2014). According to Lay and Schüler (2008), these elements can also be categorized as opportunity-led or survival-led drivers of diversification.

Social capital, education level, farm size, productive assets, extension contacts, membership in farmer-based organizations, attendance at field demonstrations, credit accessibility, savings groups, and market proximity are some examples of pull factors for livelihood diversification (Dagunga et al., 2018; Asravor, 2018). Social capital, defined as shared knowledge, norms, and networks within a group, plays a crucial role in influencing the likelihood of households engaging in diversification (Ostrom, 2000; Polman & Slangen, 2008). Higher levels of social capital, characterized by trust and social networks, can positively influence the decision to diversify livelihood activities, as it provides access to resources, information, and support.

In contrast, push factors represent the harsh conditions that compel households to diversify their livelihood activities either for survival or to mitigate risks and shocks. These factors include migration to urban areas during dry seasons, economic instability such as price fluctuations, pest and disease outbreaks, climate change impacts like drought, land fragmentation, and asset depletion (Asravor, 2018; UNCTAD, 2015). These adverse circumstances create a necessity for households to explore alternative income-generating activities to sustain their livelihoods and cope with challenges.

In addition to opportunity-led and survival-led factors, other individual and institutional factors also influence livelihood diversification. Age, gender, household headship, and experience have been found to significantly affect the decision to diversify livelihoods (Ackah, 2013; Agyeman et al., 2014). Institutional factors, such as per capita income, can also play a role in shaping diversification patterns. For example, Agyeman et al. (2014) observed a negative and statistically significant effect of household income per capita and age on income diversification in the Western region of Ghana.

By understanding the pull and push factors that drive livelihood diversification, policymakers and development practitioners can design interventions that support and enhance opportunities for diversification, while addressing the underlying constraints that push households to engage in multiple livelihood activities. Creating an enabling environment with access to social networks, education, financial services, and market proximity can facilitate the transition to more diversified and resilient livelihood strategies. Additionally, measures to address economic instability, improve agricultural practices, and promote sustainable resource management can help reduce the necessity for survival-led diversification.

2.4.3. Livelihood Diversification versus Specialization

The literature on agricultural development can be broadly categorized into two main approaches: market-based agricultural/livelihood specialization and market-based agricultural/livelihood diversification. The former approach emphasizes promoting farm specialization to increase production and effectively participate in the market, while the latter focuses on shifting from monoculture to multiple crop varieties and engaging in various livelihood activities to meet diverse market demands (Bellon et al., 2020; Evenson & Gollin, 2003).

Livelihood specialization refers to the process of reducing diversity and increasing production in a selected product or activity while maintaining other production levels (Czyżewski & Smędzik-Ambroży, 2015). Proponents argue that specialization enhances productivity, efficiency, and competitiveness through the utilization of comparative advantage (Juszczyk, 2009; Stepien, 2007). They believe that specialization can lead to higher economic performance in agriculture (Czyżewski & Smędzik-Ambroży, 2015).

However, there is a growing recognition of the need for livelihood diversification, particularly due to the risks and uncertainties associated with agriculture, including climate change impacts (UNCTAD, 2015; Dagunga et al., 2018). Livelihood diversification, both within and outside of agriculture, is seen as a strategy for addressing challenges related to food security, nutrition, and poverty alleviation (FAO, 2012). Studies have shown that diversification can reduce poverty and improve household well-being (Tafesse et al., 2015). For example, increasing crop diversity has been found to reduce the likelihood of households being poor and to contribute to poverty reduction (Michler & Josephson, 2017).

While literature on livelihood specialization focuses on the Ricardian theory of comparative advantage, which seeks to maximize returns, the literature on livelihood diversification emphasizes portfolio theory, which suggests that "risk-averse households can minimize production risk through diversification" (Michler & Josephson, 2017). Studies in northern Ghana have found a positive relationship between crop diversification and both food consumption and income from sold crops, indicating that diversification can be beneficial

(Bellon et al., 2020). However, more comprehensive studies are needed to determine the optimal extent and mix of livelihood diversification and specialization for households.

In summary, the literature on livelihood diversification and specialization highlights the debate between these two approaches to agricultural development. While specialization can lead to increased productivity and competitiveness, diversification is seen as a strategy to mitigate risks, address challenges, and reduce poverty. The optimal approach may depend on various contextual factors, and further research is needed to provide a more nuanced understanding of the benefits and trade-offs associated with each approach.

2.4.4. The Impact of Livelihood Diversification

Ghana is among the developing nations where much research has been carried out to examine the benefits of income diversification. The influence of different income diversification strategies on the welfare of rural households in Bangladesh was studied by Salam et al. (2019). Their research showed that the welfare of households was significantly and favourably impacted by participating in non-farm activities in addition to farming. It is crucial to remember that the district-level sample size restricts the findings' applicability to the entire country.

Similarly, Asfaw et al. (2019) investigated the correlation between income diversification strategies and household welfare using panel data from Malawi, Niger, and Zambia. Their results indicated that the positive effect of income diversification strategies was more pronounced among the poorest households, while it decreased and even turned negative towards the higher income spectrum in all three countries.

Bellon et al. (2020) conducted a case study on an agricultural research-for-development initiative in northern Ghana to investigate the advantages of diversification over specialization in the Ghanaian setting. The study discovered that while livelihood diversification greatly increased the welfare of smallholder farmers in the area, it was more advantageous than specialization. It is crucial to recognize that this study was restricted to the northern region of Ghana and did not offer a thorough evaluation of the advantages of livelihood diversity over specialization across the board.

Another study in Ghana by Mensah (2014) explored the relationship between livelihood diversification, proxying it by the number of livelihood activities, and household food consumption in rural areas. The findings revealed a significant positive effect of livelihood diversification on household food consumption.

Nkegbe et al. (2018) investigated the complementarity or competition between non-farm activities (a form of diversification) and agricultural commercialization in Ghana using data from the Ghana Living Standards Survey. Their results indicated that non-farm participation complemented agricultural commercialization by increasing the probability and quantity of farm produce sold. However, it is important to note that their study primarily focused on non-farm participation and did not comprehensively examine livelihood diversification.

Ayana et al. (2022) conducted a study on the determinants of livelihood diversification and identified several significant predictors. Among the 14 determinants examined, level of education, dependency ratio, access to irrigation, and household urban linkage were found to have a positive relationship with the diversification of livelihoods. On the other hand, household age, sex, road distance, credit access, and household media access were found to be insignificant predictors. The study also explored the associations of landhold size, livestock holding size, extension contact, cooperative membership, and total household income with household diversification of livelihoods. Surprisingly, none of these factors showed any significant association with the diversification of livelihoods in real conditions on the ground. Ultimately, the Simpson Diversity Index results indicated a lack of diversification and instead suggested a tendency towards specialization in livelihoods.

Research in the past decade has increasingly focused on livelihood diversification strategies and choices, with studies conducted by Gebru et al. (2018), Abdiassa (2017), and Kramer et al. (2019). While there has been a growing body of literature on livelihood strategies and choices, there appears to be a lack of recent research specifically focused on irrigation scheme farmworkers in South Africa. Adopting the sustainable livelihoods framework, this study aimed to deepen the understanding of poverty and its underlying causes in rural Africa through empirical studies.

Different factors influence the choice of livelihood diversification strategies at the farm and off-farm levels. These factors can be broadly characterized by personal and household attributes, farm or plot characteristics, and socioeconomic factors, as highlighted by Gebru et al. (2018) and Kramer et al. (2019). For instance, advanced age and access to agricultural training were found to have a negative impact on livelihood diversification activities, as discussed by Wondim (2019), Kassegn, and Endris (2021). Younger farmers, who are relatively better educated and have better access to technologies, tend to seek alternative livelihood opportunities.

The study also emphasized the essential role of women in agriculture in Africa. Women constitute more than half of the agricultural workforce in sub-Saharan Africa and contribute significantly to food production. However, persistent gender inequality limits women's access to resources, training, and agricultural benefits, as highlighted by Kassegn & Endris (2021) and Lui et al. (2020).

The level of education within a household was found to have a positive relationship with livelihood diversification strategies, as educated individuals possess better skills, experience, and knowledge. The number of dependents in a household was also found to have a positive influence on welfare and the ability to secure livelihoods through diverse employment opportunities.

Access to irrigation and land leasing in irrigation schemes were identified as factors that enable farmers to address climate change-related risks and generate surplus income for off-farm diversification activities, as discussed by Gebru et al. (2018) and Olumeth et al. (2021). However, the association between land size and diversification was found to be mixed, with studies by Barbier et al. (2014) and Kassem et al. (2021) indicating a negative relationship.

Marital status was found to have a positive influence on livelihood diversification and income levels, as noted by Etuk et al. (2018). Market access was also identified as a significant contributor to livelihood diversification and income levels generated from off-farm business activities, according to Felkner et al. (2022). Farming experience was found to influence livelihoods, with an increasing number of years in farming leading to a decreased probability of diversification, as highlighted by Samuel & Sylvia (2019). The type of employment, such as on-farm or casual work, also influenced the livelihood strategies of farmworkers, as analyzed by Scoones et al. (2019) and Sharaunga & Mudhara, 2021).

These studies provide valuable insights into the effects and relationships associated with livelihood diversification in Ghana and other developing countries. However, more comprehensive research is needed to better understand the extent of the benefits of livelihood diversification over specialization and its implications for household welfare and poverty alleviation on a national scale. Understanding the preferred livelihood strategies of rural households and the underlying variables that shape their diversification decisions is crucial for appropriate development strategies, monitoring and evaluation, and the potential for replication in different contexts. It is important to consider these factors to promote sustainable alternative livelihood strategies, particularly among farmworkers, and address the challenges and opportunities associated with livelihood diversification.

2.5. Financial Profitability Measurement Metrics in Cocoa

Profitability measurement metrics play a crucial role in assessing the financial performance of businesses in the cocoa industry. These metrics enable cocoa producers, traders, and processors to evaluate the efficiency and effectiveness of their operations, make informed decisions, and identify areas for improvement.

Several studies (Kongor et al., 2018; Ketema et al., 2021; Yahaya et al., 2015), as will be discussed subsequently in this chapter, have estimated the profitability of cocoa farmers or cocoa farm plots in Ghana using financial profitability measurement metrics such as return on investments (ROI), the profitability of an investment by comparing the net profit generated to the amount of capital invested to assess the effectiveness of their capital allocation and investment decisions; gross profit margin (the percentage of revenue that remains after deducting the direct costs associated with cocoa production, calculated by dividing the gross profit by revenue that identify opportunities for optimizing their cost structure and enhancing profitability; net profit margin, the percentage of revenue that remains as net profit after deducting all expenses, including overhead costs and taxes, a metric that allows cocoa businesses to evaluate their operational efficiency, cost-control measures, and revenue-generation capabilities; return on assets (ROA), a metric that evaluates how efficiently a company utilizes its assets to generate profits by dividing the net profit by the total assets; return on equity (ROE), calculated by dividing the net profit by the shareholders' equity to represent the return earned on their investment; and Break-even analysis which helps in assessing the minimum sales volume required to cover all costs and achieve profitability. By analyzing the break-even point, cocoa businesses can gain insights into their cost structure, pricing strategies, and sales targets necessary to achieve profitability. These financial profitability measurement metrics provide valuable insights into the financial health and profitability of cocoa businesses. By analyzing these metrics over time and comparing them to industry benchmarks or historical performance, cocoa producers can make informed decisions, identify areas for cost reduction, optimize pricing strategies, and enhance overall profitability. However, it is important to note that the availability and relevance of specific financial profitability measurement metrics may vary in the cocoa industry, depending on the context and the level of data transparency within the sector.

Kongor et al. (2018) conducted a study of constraints for future cocoa production in Ghana. The study estimated the gross profit of farmers per hectare for 731 cocoa farmers in all six cocoa-growing regions in Ghana. The findings indicate that cocoa yield and profitability were extremely low, averaging 234 kg ha^{-1} and Gh¢ 568 (about $150) per hectare, respectively. The study found that farm management measures, including the control of capsid and black pod disease, fertilizer use and farm size had a significant impact on profitability.

Yahaya et al., (2015) conducted an economic analysis of cocoa production in the Eastern Region of Ghana. The study estimated the gross and net profit as well as gross production value for four groups of cocoa farmers in the eastern Region of Ghana. The study found that farmers had a gross production value of GHS1.49, meaning that cocoa farmers made a profit of GHS0.49 per unit of cost spent.

Ketema et al., (2021) conducted a study of small-scale cocoa farmers in Ecuador, a country with more than 100,000 families depends on cocoa.

Based on a data collection containing farm-level economic information from 172 cocoa growers in northwest Ecuador, the study used multiple regression analysis, net present value (NPV), benefit-cost ratio (BCR), and descriptive statistics to analyze the profitability of cocoa farm plots. The results show that it is not profitable to produce cocoa in northwest Ecuador (average NPV of -248 USD per ha, mean BCR 0.73). The study area's cocoa production profitability was found to be significantly influenced by the length of membership in the corporate sustainability program, the share of cocoa revenue, the number of family labourers per hectare, the total area under cocoa production, the variety of cocoa produced, and the use of fertilizer.

These studies indicate that, predominantly, the measures of profitability commonly used in studies in the cocoa sector include gross profit, net profit, NPV, BCR and ROI. However, none of the studies reviewed take into account the implicit cost or forgone alternative of producing cocoa. This presents a knowledge gap in the body of knowledge on the profitability of cocoa farming, especially in the face of competing alternative tree crops.

2.6. Definition of Economic Profit

Economic profitability refers to the measure of a business's ability to generate profits after considering both explicit and implicit costs (Dobrovič et al., 2022). Explicit costs are the direct, tangible expenses incurred by a business, such as wages, rent, utilities, and raw materials. On the other hand, implicit costs are the opportunity costs associated with using resources in one way instead of their next best alternative use (Hofmarcher et al., 2020). These implicit costs may include the foregone income from alternative investments or the value of the owner's time and effort put into the business. To accurately measure economic profitability, both explicit and implicit costs need to be considered. This can be done by deducting all costs, explicit and implicit, from the firm's income (Orea & Steinbuks, 2017). This measure, known as economic profit, provides a comprehensive view of a business's financial performance by considering the true costs of production and the foregone opportunities of using resources in other ways (Walsh et al., 2021).

Economic profit considers all costs, both explicit and implicit, to accurately measure a business's profitability. This measure provides a more realistic picture of a business's financial performance, as it considers not only the direct expenses but also the opportunity costs associated with resources (Akpinar, 2020)

In conclusion, economic profit is a crucial measure of a business's financial performance because it incorporates both explicit and implicit costs. By deducting all costs, including imputed rents on owned land, imputed costs of unpaid family labour, and imputed interest on capital invested in fixed and working capital, economic profit provides a comprehensive view of a business's ability to generate profits. It accurately captures the opportunity costs associated with using resources in a particular way instead of their next best alternative use. This measure is essential for businesses to make informed decisions, optimize resource allocation, and assess the true profitability of their operations. In conclusion, economic profit is a comprehensive measure of financial performance that considers both explicit and implicit costs.

2.6.1. Evaluating Economic Profitability with Explicit and Implicit Costs

Evaluating the economic profitability of a business requires a thorough consideration of both explicit and implicit costs. Explicit costs are the direct expenses that can be easily quantified and include items such as wages, rent, utilities, and raw materials. These are costs that require a monetary payment and are essential for the day-to-day operations of the business (Mugera, 2013).

Implicit costs, on the other hand, are the opportunity costs associated with using resources in a certain way instead of their next best alternative use. These costs do not involve a direct monetary payment but still need to be taken into account when assessing the true profitability of a business (Iseli & Weber, 2007).

Evaluating economic profitability requires considering both explicit and implicit costs. To evaluate economic profitability, it is essential to include both explicit and implicit costs. By including explicit costs, such as wages and rent, and implicit costs, such as the opportunity cost of capital and the time and effort put in, businesses can obtain a comprehensive measure of their financial performance. This comprehensive measure, known as economic profit, goes beyond just looking at the direct expenses and takes into account the full range of costs associated with production (Wąs et al., 2019).

Economic profit provides a more accurate representation of a business's true profitability because it captures not only the monetary expenses but also the opportunity costs of utilizing resources in a certain way. This allows businesses to make more informed decisions regarding resource allocation and to understand the impact of their choices on overall profitability.

When evaluating economic profitability, it's important to consider the concept of opportunity cost. Opportunity cost refers to the value of the next best alternative foregone when a particular choice is made. By including opportunity costs in the calculation of economic profit, businesses can capture the full picture of the potential benefits that could have been obtained from alternative uses of resources (Wąs et al., 2019). Additionally, when evaluating economic profitability, it is crucial to consider whether a gross or net version of the opportunity cost is being used. A gross version includes only implicit costs, while a net version includes both implicit and explicit costs. This distinction is important because it determines the level of detail and accuracy in the assessment of economic profit. Therefore, accurate evaluation of economic profitability involves considering both explicit and implicit costs, including the opportunity cost of utilizing resources in a certain way instead of their next best alternative use.

Moreover, it is essential to acknowledge any competitive disequilibrium in the optimal alternative when calculating opportunity costs. If the optimal alternative is not chosen, the opportunity costs should include the optimal profit forgone. This can be achieved by adding the incurred expenditure and the highest net benefit forgone as opportunity costs (Du et al., 2022).

2.7. Factors Affecting Profitability of Cocoa Farms in Ghana

The profitability of cocoa production in Ghana is influenced by a combination of technical and socioeconomic factors. Several studies have examined these factors and their impact on cocoa profitability in the country.

Productivity/Yield: Higher yield levels positively affect the profitability of cocoa farms. This is supported by a study conducted by Owusu-Ansah et al. (2016), which found that improved farm management practices, such as regular pruning, weeding, and proper application of fertilizers, significantly increased cocoa yield and profitability in Ghana. The study emphasized that agronomic management is the dominant determinant of on-farm cocoa yields in Ghana, more so than environmental conditions (Asante et al., 2021).

Considering the low productivity levels of small-scale cocoa farmers in Ghana, which are often below 400 kg per hectare (Asamoah et al., 2013), it is recommended to assist these farmers in adopting yield-enhancing technologies. By implementing the method used in the study, cocoa farmers can increase their yields and stabilize their income over time, leading to substantial improvements in their quality of life (Nalley et al., 2014).

The integrated method employed in the study also has the potential to provide precision agriculture techniques for cocoa farmers in Ghana and beyond, ensuring sustainable yields on cocoa farms (Snoeck et al., 2009). By adopting these techniques and focusing on improving productivity through effective farm management practices, cocoa farmers in Ghana can enhance their profitability and contribute to the overall development of the cocoa industry in the country.

Farm Size: The relationship between farm size and cocoa profitability in Ghana is a topic of interest, and studies have provided varying insights. Oduro et al. (2016) found that larger cocoa farms demonstrated higher yields and profitability compared to smaller farms. This was attributed to the benefits of economies of scale and the ability to invest in mechanization and advanced technologies. These factors enable larger farms to optimize their production processes and achieve higher output levels. The positive relationship between farm size and cocoa output was supported by Balogu and Obi-Egbedi (2012), who observed that larger land sizes positively influenced cocoa production.

However, contrasting findings were reported by Kongor et al. (2018), who discovered a negative impact of farm size on cocoa productivity among smallholder farmers. This suggests that as farm size increases, there may be diminishing returns or challenges in effectively managing larger farms, resulting in decreased productivity.

Furthermore, the study conducted by Onumah et al. (2013) indicated that the productivity of cocoa is influenced by several factors related to farm size, such as land size, the level of agrochemical and intermediate inputs used, as well as labour input. These findings highlight the importance of appropriate resource allocation and efficient utilization of inputs to optimize cocoa productivity.

Syamsinar et al. (2015) emphasized the significance of farm size, production quantity, household income, cocoa farming experience, risk-taking ability, savings capacity, and responsiveness to advanced farming techniques. These factors can impact the reinvestment of farm receipts and ultimately influence cocoa profitability.

To reconcile the mixed findings, further research is needed to explore the specific dynamics and contextual factors that contribute to the relationship between farm size and cocoa productivity in Ghana. It is crucial to consider the unique circumstances of smallholder farmers, as they may face different challenges and opportunities compared to larger farms. Overall, understanding the implications of farm size on cocoa profitability can inform policies and strategies aimed at enhancing the sustainability and economic viability of cocoa farming in Ghana.

Input costs: Input costs play a crucial role in cocoa profitability, and effective management of these costs is essential for maintaining profitability in cocoa production. Darkwa et al. (2018) highlighted that input costs, including fertilizers, labour, and pesticides, accounted for a significant proportion of cocoa production costs in Ghana. Efficient management of input costs through proper budgeting and procurement practices is important for optimizing profitability.

Wongnaa et al. (2019) found that profitability in maize production in Ghana is influenced by the prices of relevant inputs, including pesticides, fertilizers, herbicides, labour, and seeds. An increase in input prices, combined with larger farm sizes, can have adverse effects on profitability. To enhance profitability and sustainability, strategies such as input subsidies, access to credit, cooperative initiatives, price regulation, and training on postharvest management have been suggested (Levai et al., 2015).

The competitiveness of cocoa production is influenced by changes in production, the price of cocoa beans, and subsidized fertilizer prices. Ibrahim et al. (2017) emphasized the importance of production changes as a significant indicator of competitiveness. Sensitivity analysis revealed that potential cost reductions ranging from 36% to 76% could be achieved through efficient farming practices.

Effendy et al. (2019) emphasized that technical and allocative efficiencies, as well as cocoa farm economies, are influenced by various factors such as the use of quality seeds, organic fertilizers, access to extension services and training, bank credit, market access, and the participation of women in cocoa farming. Increasing output can lead to higher income for farmers and poverty reduction in rural areas. The availability of extension services, training programs, and support for women farmer groups should be increased to enhance profitability and promote inclusive growth.

Overall, managing input costs effectively, promoting efficient farming practices, providing access to credit and extension services, and supporting initiatives for women farmers are crucial for improving cocoa profitability in Ghana. Continued research and targeted interventions in these areas can contribute to sustainable cocoa production and economic development in the cocoa sector.

Climate and Weather Conditions: Climate and weather conditions have a significant impact on cocoa production and its profitability. The changing patterns of rainfall, temperature, and humidity can affect cocoa yields and quality, posing risks to farmers. Gyasi et al. (2018) emphasized the importance of adopting climate-smart agricultural practices to enhance cocoa profitability in Ghana and mitigate the risks associated with climate change. Climate change, including floods, high temperatures, and heat, can negatively affect cocoa plantations and lead to declines in production (Oyedokum & Oyelana, 2016).

Studies have identified poor land use management and insufficient rainfall as major limiting factors for cocoa production and yield (Tenkap & Balogun, 2020). The livelihoods of cocoa-producing districts in Ghana are being affected by climate variability, as highlighted in the assessment by Amoatey and Sulaiman (2018). The observed changes in climate are already impacting cocoa production activities in various ways, as revealed by Oyekale (2012).

To address the challenges posed by climate change, it is recommended to provide training for farmers on cocoa production and other agricultural activities concerning climate variability and its impacts (Ehiakpor et al., 2016). Cocoa farmers should adopt new measures to cope with the negative effects of climate change (Nwachukwu et al., 2012). Strategies that encompass both short-term and long-term approaches are necessary to sustain cocoa production under climatic variability (Santosa et al., 2018). Denkyirah et al. (2017) found that cocoa farmers are aware of long-term changes in climatic variables, indicating their understanding of climate change and its impact on cocoa production. It is important to note that climate change can also influence the farm operations of cocoa farmers, leading to occupational stresses (Oyekale, 2015).

Considering the significant influence of climate and weather conditions on cocoa production, it is crucial to develop adaptive strategies, improve resilience, and provide support to cocoa farmers in Ghana to ensure the long-term sustainability and profitability of cocoa farming in the face of climate change.

Access to Finance and Credit: Limited access to finance and credit can have significant implications for cocoa farmers in Ghana, impacting their investments and overall profitability.

Ameyaw et al. (2017) identified inadequate access to credit as a major constraint for cocoa farmers in the country. To enhance profitability and promote sustainable cocoa production, it is crucial to improve access to affordable credit and financial services tailored to the specific needs of cocoa farmers.

Attipoe et al. (2020) highlighted the important role played by rural and community banks in increasing cocoa yield in Ghana, emphasizing the need for their continued support. Nkang et al. (2007) suggested that expanding access to cheap and flexible credit, as well as land, can significantly increase investments in cocoa production. These factors were identified as limiting factors in cocoa production based on the descriptive statistical analysis conducted in their study.

Djokoto et al. (2016) recommended increased and effective extension and credit services to enhance the adoption of organic cocoa production. Lack of adequate access to credit has been a significant barrier preventing smallholder cocoa farmers from expanding their farms and accessing necessary inputs such as pesticides, fertilizers, and seedlings. This situation has a negative impact on cocoa production and overall household welfare. By providing credit facilities to smallholder cocoa farmers, it is expected that they would gain access to the inputs needed to improve their cocoa production (Qaurtey & Asamoah, 2018).

Improving access to credit for cocoa farmers can enable them to make necessary investments, adopt sustainable practices, and enhance their overall profitability. It is essential for financial institutions, policymakers, and stakeholders to collaborate in developing and implementing effective credit programs tailored to the specific needs of cocoa farmers in Ghana, ensuring their financial inclusion and promoting the long-term sustainability of cocoa production.

Market Prices and Value Chain Efficiency: Fluctuations in cocoa prices and inefficiencies within the value chain can have significant implications for the profitability of cocoa farmers in Ghana. Price volatility and limited market access can directly impact farm income and overall profitability. Therefore, it is crucial to focus on improving value chain efficiency and reducing post-harvest losses to enhance the profitability of cocoa farming.

Mensah et al. (2019) emphasized the importance of enhancing value chain efficiency to maximize profitability in cocoa farming. This includes addressing challenges related to post-harvest losses and improving overall supply chain management. Asamoah and Annan (2012) suggested that the findings of their study can serve as a reference for developing services and standards within the cocoa value chain, not only in Ghana but also in similar countries.

Fahmid et al. (2018) highlighted the need to raise productivity, output prices, and exchange rates while simultaneously lowering input prices to increase the net transfer values for cocoa farmers. Bogetic et al. (2007) emphasized the importance of cocoa prices as a determinant of competitiveness in countries like Cote d'Ivoire. Enhancing cocoa output profitability also requires adopting cost-saving strategies rather than relying solely on price hikes, as suggested by Philip et al. (2013) in their study on dairies and cocoa-based products.

Additionally, Salifou et al. (2019) found that cocoa output is inversely related to the expected prices of competing agricultural commodities, such as green coffee. This implies that factors affecting the prices of competing commodities should be considered in cocoa farming strategies to maintain profitability.

In summary, addressing market price fluctuations and enhancing value chain efficiency are critical for improving the profitability of cocoa farming in Ghana. This requires collaboration among stakeholders, including farmers, industry players, policymakers, and researchers, to develop strategies that ensure fair prices, minimize losses, and optimize the value chain for the benefit of cocoa farmers.

Socioeconomic Factors: In Ghana, the profitability of cocoa production is influenced by a range of technical and socioeconomic factors. Socioeconomic characteristics, including education, training, access to extension services, and gender dynamics, have implications for cocoa profitability. Studies have shown that farmer education and training programs can improve productivity and profitability in cocoa farming (Adusei et al., 2017). Gender equity and inclusiveness in the cocoa sector are also important considerations for promoting sustainable cocoa production and enhancing profitability.

Research conducted by Djokoto et al. (2016) revealed that factors such as gender, household size, cocoa farming experience, access to extension services, and access to credit influence the adoption of organic cocoa production. This highlights the significance of socioeconomic factors in shaping farming practices and profitability.

Tetteh and Asase (2017) highlighted the importance of considering socioeconomic characteristics and farm management practices in achieving sustainable cocoa production. They found significant differences in these factors among smallholder farmers in cocoa-growing areas of Ghana, indicating the need for tailored strategies to improve profitability.

Investing in education and training targeted at farmers can enhance their managerial and technical capacities, leading to improved cocoa production and farmer welfare (Danso-Abbeam & Baiyegunhi, 2020). Farmer characteristics such as education, farming experience, and access to counselling services were identified as factors that can increase technical efficiency and cocoa production (Effendy et al., 2013).

Factors such as the gender and age of household heads, household size, years of schooling, annual cocoa output, and household non-agricultural income significantly influence food security among cocoa-producing households in Ghana (Antwi et al., 2018). Labour productivity among cocoa farmers is influenced by factors such as education level, experience, and choice of planting material (Obike et al., 2017). It is important to note that external factors such as malaria and climate change can also affect cocoa production and profitability. Malaria has been identified as a major sickness affecting cocoa farmers in Ghana, impacting their productivity (Oyedokum & Oyelana, 2016).

In conclusion, addressing both technical and socioeconomic factors is crucial for improving the profitability and sustainability of cocoa production in Ghana. This includes providing access to education, training, extension services, and credit facilities, promoting gender equity, and implementing measures to mitigate the impact of diseases and climate change. By considering and addressing these factors, cocoa farmers can enhance their profitability and improve their livelihoods.

Farm Practices and Technical Efficiency: The low productivity of cocoa in Ghana can be attributed to various factors, including farm management practices and the adoption of improved farming techniques. Studies conducted in cocoa-growing areas have examined the effectiveness of different management practices, such as fertilizer application and pest control (Bisseleua et al., 2013; Vaast and Somarriba, 2014; Appiah et al., 1997; Ghana Cocoa Board, 2002). Evidence suggests that the growth of the cocoa sub-sector in Ghana has been achieved through the adoption of these improved practices (Baffoe-Asare et al., 2013).

Efforts to enhance cocoa production can focus on increasing technical efficiency. Studies estimate the mean technical efficiency among cocoa producers to be 85%, indicating that a

15% increase in technical efficiency can be achieved through the adoption of best practices from successful cocoa farms (Onumah et al., 2013). Strengthening strategies for improving farmers' technical and managerial skills is crucial in this regard (Dans0-Abbeam & Baiyegunhi, 2020). Public investments in education have been found to have complementary effects on improved cocoa technical efficiency, and promoting the planting of younger cocoa trees can further enhance efficiency (Popoola et al., 2016).

The adoption of sustainable cocoa production systems is also important for ecosystem preservation and human health. Different cocoa production systems have been associated with externalities, such as the impact of pesticides on soils, water, and human health, emphasizing the need for policy considerations (Wainaina et al., 2021). However, challenges such as the availability of planting materials and pest and disease management still exist in some cocoa-producing areas (Awoyemi & Aderinoye-Abdulwahab, 2019; Denkyirah et al., 2016).

To improve cocoa production in various regions, technical training of farmers, extension services, and land rotation have been identified as important measures (Nicodeme & Bosambe, 2017; Aminu & Ayinde, 2021). Access to production inputs, such as fertilizers and pesticides, should be increased, and effective management practices should be implemented (Rouf et al., 2021). The sustainability of cocoa farming depends on factors such as farmer education, pest and disease control, cleanliness and quality of cocoa beans, institutions, extension services, technology, credit availability, and price stability (Muhardi et al., 2020). It is also essential to improve the technical efficiency and welfare of smallholder cocoa farmers as they complement each other for the sustainable growth of Ghana's cocoa sector (Danso-Abbeam & Baiyegunhi, 2020).

In conclusion, improving farm management practices, adopting sustainable techniques, enhancing technical efficiency, and addressing challenges related to inputs, pests and diseases is crucial for increasing cocoa productivity and ensuring the sustainability of the cocoa sector in Ghana.

2.8. Empirical Review of Analytical Frameworks

2.8.1. The Stochastic Frontier Approach

The stochastic Frontier Approach (SFA) is a widely used methodology in efficiency analysis and estimation of production frontiers. It allows for the measurement of efficiency and the identification of factors affecting efficiency levels. Here is an empirical review based on the provided information on various studies that employ the Stochastic Frontier Approach:

Paul & Shankar (2019) proposed a panel data-based stochastic frontier model that incorporated time-invariant unobserved heterogeneity and efficiency effects. Their model specified efficiency effects using a standard normal cumulative distribution function of exogenous variables, ensuring that efficiency scores fall within a unit interval. The researchers employed a within-transformed model and estimated it using non-linear least squares. Monte Carlo experiments were conducted to examine the finite sample properties of the proposed estimator, which generally performed well, even in small samples. An empirical illustration using panel data on Indian farmers demonstrated the simplicity and practical applicability of the model.

Jradi et al. (2019) focused on quantile estimation of the stochastic frontier model. They highlighted the connection between the stochastic frontier and specific quantiles of the output distribution. The researchers developed a computational approach to recover the quantile corresponding to the stochastic frontier. An empirical illustration showed comparable performance of their approach with more traditional estimation methods of the stochastic frontier model.

Kutlu et al. (2020) proposed a spatial autoregressive stochastic frontier model that accounted for endogeneity in both the frontier and environmental variables. Their model was estimated using a single-stage control function approach. Monte Carlo simulations demonstrated the satisfactory performance of the proposed model and estimation approach in finite samples. The researchers applied their methodology to Chinese chemical firm data and found evidence for spatial effects and endogeneity.

Karagiannis & Kellermann (2019) introduced several new specifications within the true random effects model and stochastic frontier models estimated with general least squares (GLS) and maximum likelihood estimation (MLE). The proposed specifications expanded the set of heterogeneity covariates to include environmental factors that affect the operation conditions of production units. These factors could be time-varying or time-invariant and might not be correlated with heterogeneity. The researchers emphasized the importance of considering environmental factors beyond Mundlak's adjustment terms in distinguishing between heterogeneity and efficiency.

Feng et al. (2019) proposed a kernel-based Bayesian framework for analyzing stochastic frontiers and efficiency measurement. Their framework approximated the unknown distribution of inefficiency using a transformed Rosenblatt-Parzen kernel density estimator. The researchers conducted a Monte Carlo study and applied the model to a panel of U.S. large banks. The results demonstrated that the kernel-based model provided more precise estimation and prediction results compared to the commonly used exponential stochastic frontier model. The empirical application favoured the kernel-based model over the exponential model.

Skevas et al. (2018) investigated productivity growth measurement and decomposition under a dynamic inefficiency specification using the dynamic stochastic frontier model. The model captured time-specific efficiency and total factor productivity growth shocks in the context of German dairy farms. It was able to capture the effects of high milk price volatility on efficiency and productivity. The dynamic stochastic frontier model outperformed models with restrictive time structures or no time structures at all.

Nguyen et al. (2021) examined the sensitivity of technical and scale efficiency estimates to various choices in stochastic frontier analysis. They explored the effects of input-output combinations, functional forms, distributional assumptions, and estimation methods on efficiency estimates using data from an Australian fishery. The study found that estimates of technical and scale efficiency were highly sensitive to distributional assumptions and the choice of time effects. Time-invariant efficiency models produced significantly higher efficiency scores compared to time-varying models. The choice of fixed input variables also had a significant impact on average efficiency estimates. These findings emphasize the importance of considering different model specifications and choices in stochastic frontier analysis to ensure robust and accurate efficiency estimates.

Stankova & Hampel (2020) focused on comparing technical efficiency results obtained through various stochastic frontier analysis models. They examined the effects of model type, possible frontier shift, distribution of inefficiency terms, different output variables, and estimator selection. The study utilized aggregated annual data from the EU construction sector for the years 2000-2015. The results indicated that the choice of estimator strongly affected the efficiency estimates for specific models. The study also showed that estimator selection significantly influenced the efficiency estimates for particular models. The findings underscore the need to carefully consider model specifications and estimator selection in stochastic frontier analysis to obtain reliable efficiency estimates.

Yao et al. (2018) investigated the semiparametric smooth coefficient stochastic frontier model for panel data. The researchers proposed multi-step estimators for smooth coefficient functions and the parameters of the distribution of the composite error term. The study utilized a panel data set of 451 large U.S. firms to explore the effects of computerization on productivity. The results demonstrated that the semiparametric model provided a more accurate estimation of the overall effect of computer capital on productivity compared to traditional parametric models. The efficiency levels, however, were not significantly different among the models. The findings suggested the potential of the proposed semiparametric model in providing more precise estimation and prediction results in stochastic frontier analysis.

These empirical studies contribute to the existing literature on stochastic frontier analysis by addressing various methodological and modelling aspects. They highlight the sensitivity of efficiency estimates to model specifications, distributional assumptions, and estimator selection. The studies emphasize the importance of considering different choices and specifications to obtain robust and accurate efficiency estimates. Furthermore, the studies demonstrate the applicability of stochastic frontier analysis in diverse fields such as agriculture, fisheries, construction, and finance, highlighting its usefulness in analyzing efficiency and productivity.

The other studies mentioned in the list provide additional contributions to the field of stochastic frontier analysis, addressing issues such as estimation under different assumptions, nonparametric approaches, the relationship between the stochastic frontier and quantiles, and the effects of model specifications and choices on efficiency estimates.

Overall, these empirical studies demonstrate the versatility and applicability of the Stochastic Frontier Approach in various contexts and highlight its usefulness in estimating technical efficiency, analyzing productivity growth, and exploring factors affecting efficiency levels.

2.8.2. Conditional Mixed Process

Varabyova & Schreyogg (2018) conducted a comparative analysis of conventional methods and a novel conditional approach in incorporating quality into efficiency analysis. They simulated data with various relationships between efficiency and quality to assess the performance of these methods. The results demonstrated that the conditional approach outperformed conventional methods in predicting true efficiency scores and capturing the original relationship between efficiency and quality. The conditional approach was deemed a powerful and flexible tool, particularly useful when the theoretical link between efficiency and quality is unclear.

Wee et al. (2018) expanded on the concept of conditionality, emphasizing its compounding nature in understanding precarious work. They used the model of chutes-and-ladders to analyze the experiences of migrant domestic workers in different degrees of precarity over time. Through qualitative interviews with migration intermediaries, they found that chutes and ladders were dynamically produced by these intermediaries, shaping the workers' situations of precarity. The study highlighted the dynamic and mutually reinforcing conditions that influence workers' access to security.

Dongen et al. (2020) addressed the challenge of conformance checking in mixed-paradigm process models, which combine the strengths of procedural and declarative representations. They developed an approach that utilized alignment-based replay to explore the intertwined state spaces of mixed-paradigm models. The technique effectively updated declarative constraints in each state to ensure compliance, resulting in efficient replay and optimal alignment. The proposed approach was implemented in ProM and demonstrated its performance using real-world event logs.

Lou et al. (2018) proposed a nonparametric approach, the mixed-effect Gaussian process (ME-GP) model, for analyzing multi-process data. The ME-GP model combined fixed-effect and random-effect Gaussian process regression models to capture both commonalities and heterogeneity among different processes. By simultaneously modelling the mean and covariance structures of the fixed- and random-effects, the ME-GP model provided improved performance compared to the GP model alone. The approach was applied to predict the melt-flow length in injection moulding processes, showcasing its effectiveness.

Herburger (2018) investigated bare conditionals and their conditional duality, focusing on their behaviour under dependence and negation. The study argued that bare conditionals exhibit different characteristics when appearing in downward entailing environments compared to elsewhere, highlighting the role of existential force rather than universal force. The analysis provided insights into the behaviour of bare conditionals under different conditions, including their connection to denial negation and the limitations of Conditional Excluded Middle.

Herburger (2018) examined the behaviour of bare conditionals under different linguistic contexts, specifically addressing their connection to conditional probability. The study proposed a notion of dependence that explained the appropriateness of bare conditionals under forward causal and backward evidential readings. It showed that under certain circumstances, the appropriateness condition of bare conditionals reduced to conditional probability, particularly in the case of the diagnostic reading. This analysis provided insights into the empirical observations made by Douven and Verbrugge (2010) regarding bare conditionals.

Zhou et al. (2021) proposed a deep generative approach for sampling from conditional distributions using normalizing flows. Their method allowed for the modelling of inverse problems by maximizing the posterior likelihood. By incorporating conditioning in normalizing flows, the authors trained an invertible network for conditional generation. The proposed method demonstrated effectiveness in various experiments, outperforming existing approaches for conditional density estimation. The study highlighted the ability of their approach to handle high-dimensional predictors and responses, as well as continuous and discrete types of variables.

Waansing & Unterhuber (2018) introduced propositional conditional logic based on four-valued logic and turned them into systems of weakly and unrestricted conditional logic. They presented a sound and complete tableau calculi for these logics and considered an expansion of the basic conditional connexive logics by a constructive implication. The study discussed recent work on the combination of indicative and counterfactual conditionals, demonstrating the applicability of their tableau calculi to constructive connexive conditional logic. Their work provided a comprehensive framework for conditional logic and inference systems.

Xiao et al. (2019) investigated the use of normalizing flows to model conditional distributions, specifically for solving inverse problems using invertible neural networks. Their method involved maximizing the posterior likelihood and incorporating conditioning in normalizing flows. They compared their approach to previous methods and showed its effectiveness in various experiments. The study emphasized the simplicity and ease of training their method, as it only required a single loss function. The proposed method provided a natural framework for conditional generation with normalizing flows.

Marnissi et al. (2018) focused on Bayesian inverse problems with Gaussian distributions, aiming to address the challenges posed by high-dimensional parameter spaces and complex dependencies. They proposed adding auxiliary variables to dissociate the different sources of dependencies, simplifying the sampling problem and reducing computational costs. Their approach was evaluated on image restoration problems, demonstrating improved sampling performance and reduced computational complexity. The study provided insights into enhancing the efficiency of stochastic sampling algorithms in high-dimensional spaces with heterogeneous correlations.

Bellini et al. (2018) examined conditional expectiles as a generalization of conditional expectations, defined by minimizing an asymmetric quadratic loss function. They characterized conditional expectiles by a conditional first-order condition and discussed their main properties. The study discussed the potential application of conditional expectiles as dynamic risk measures, focusing on their time consistency properties. The analysis contributed to the understanding and utilization of conditional expectiles in risk assessment and management.

Ajay et al. (2022) explored the application of conditional generative modelling to sequential decision-making. They framed decision-making as conditional diffusion modelling and compared their approach to offline reinforcement learning methods. The study showed that their formulation led to policies that outperformed existing approaches across standard benchmarks. By modelling policies as return-conditional diffusion models, they demonstrated the advantages of incorporating constraints and skills as conditioning variables. The results highlighted the power of conditional generative modelling in decision-making tasks.

These empirical studies explore the concept of conditionality in various domains, such as efficiency analysis, precarious work, process modelling, multi-process data analysis, and logic.

They highlight the importance of considering conditionality in modelling and analysis, demonstrating its effectiveness in capturing complex relationships, addressing challenges in conformance checking, improving prediction performance, and understanding the behaviour of conditional statements.

CHAPTER THREE

METHODOLOGY

3.1. Introduction

This chapter presents the approaches used towards achieving the study's objectives. The chapter sets out the study area from which the data was collected and a description of the approaches to data collection. A review of the theoretical basis for the methodologies selected is carried out and the various analysis undertaken for each objective is presented.

3.2. Study Area

This study was conducted within the framework of the Cocoa4Future (C4F) project, which is funded by the European DeSIRA Initiative and by the French Development Agency (CIRAD). For this study, primary data was collected from 15 communities in three districts of the Western and Ashanti regions of Ghana. The districts selected were the Elembelle and Wassa Amenfi Central in the Western region, and Afigya Kwabre North in the Ashanti region of Ghana. These districts were pre-selected by the project based on established farm observatories to track the decisions and activities of cocoa farmers. The observatories were setup to observe cocoa growing communities dealing with diversification from diseased coconut to cocoa (Elembelle), competition for land between cocoa and rubber (Wassa Amenfi Central) and adoption of new cocoa varieties to replace old varieties such as "Tetteh Quarshie" and Amazonia varieties (Afigya Kwabre). These observatories are geo referenced to Adubrim and Manso Amenfi in the Elembelle and Wassa Amenfi Central districts respectively, and Tetrem in the Afigya Kwabre North district. The location of these districts are shown in Figure 3.1.

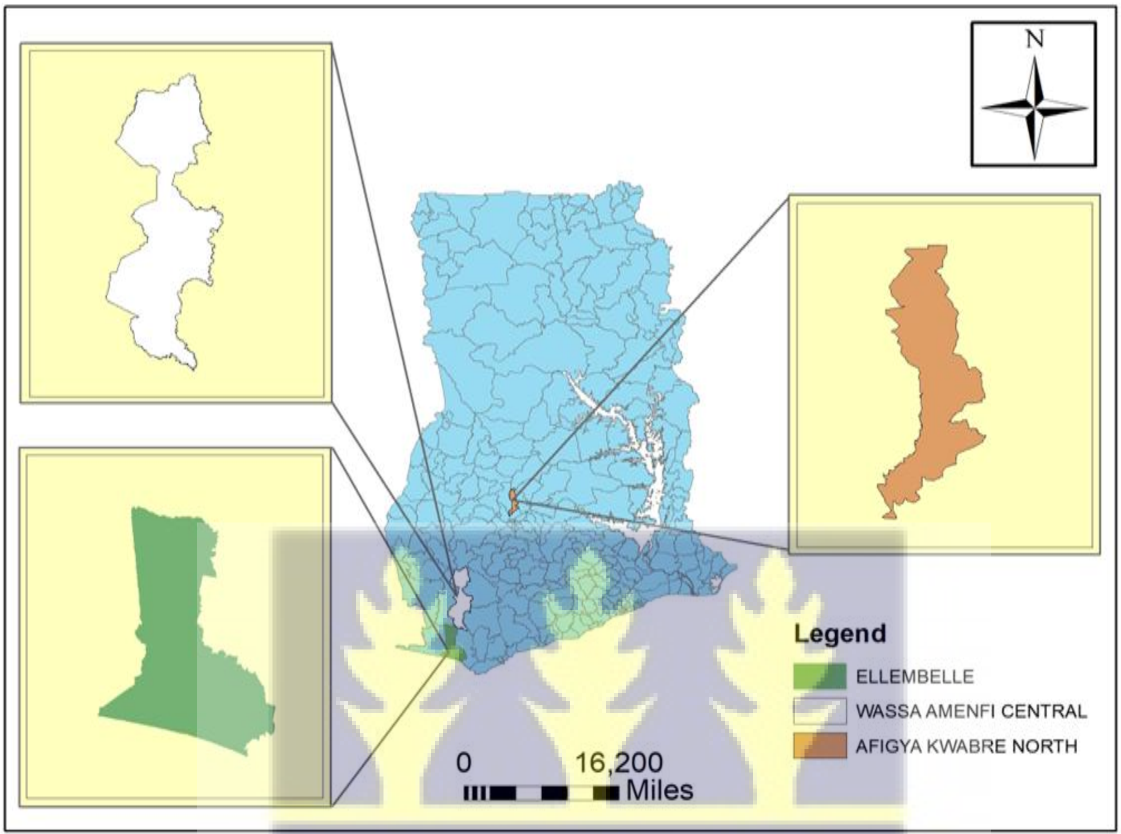
The Elembelle district is one of 14 districts in the Western Region of Ghana. Its coordinates are longitude 4°57′50″N and latitude 2°19′20″W. The 2021 Ghana Population and Housing

Census (PHC) puts the total population of the district at 120,893. The district is predominantly rural, with 86,975 (71.9%) of the population dwelling in rural areas and 33,918 (28.1%) in urban areas. In terms of gender, the population consists of 60,586 males and 60,301 females. The district covers an area of 973 square kilometres, and has an estimated 37,220 households, with an average household size of 3.1 (GSS, 2022).

The Wassa Amenfi Central district is another of the Western Region's 14 districts. It is located at coordinates longitude 5°37′59.52″N and latitude 2°15′4.32″W. The district has a population of 119,117, of which 84.4% live in rural areas and 15.6% live in urban areas. This population consists of 34,402 households with an average household size of 3.5. The district's population is made up of 63,212 males and 55,905 females. Its geographical size is 1,599 square kilometres (Ghana Statistical Service, 2022).

The Afigya Kwabre North is one of the Ashanti region's 49 districts. It is located at coordinates longitude 6°33′0″N and latitude 1°55′0″W. The district has an estimated population of 73,330 as per the 2021 PHC. Unlike the Elembelle and Wassa Amenfi Central districts, the Afigya Kwabre North district is predominantly urban, with a rural-dwelling population of 29,172 (39.8%) and an urban-dwelling population of 44,158 (60.2%). By gender, the district is made up of 36,608 males and 36,722 females. The district covers an area of 270 square kilometres. There are an estimated 18,529 households in the district, with an average household size of 3.9 (Ghana Statistical Service, 2022).

Figure 3.1 Map of Study Area for Primary Data Collection



Source: Author's Construct, 2022

3.3. Sample Size and Sampling Strategy

To derive the farmers for the study, a mult-stage sampling approach, involving two steps was used. The first step was based on a purposive selection of 15 communities from the three districts where the project had set up observatories, for which a list of cocoa farmers was available. These 15 selected communities all have a good population of active cocoa farmers. The next step involved a simple random sampling of cocoa farmers from the communities based on the farmer lists obtained from the district offices of the Ghana COCOBOD. In total, 3,009 farmers were identified from the farmer lists. The sample size was computed based on the Cochran formula (Cochran, 1954) stated as:

$$n_o = \frac{[t^2(p * q)]}{d^2} = 384$$

Where:

n_o= computed minimum sample size

d = the error margin, which was set at 5%.

t^2 = the t-distribution value for normal deviation set at a 95% confidence level, which was found to be 1.96.

p = the listed cocoa farmer population with all the characteristics required but unknown, hence the maximum 50% (here it is assumed that cocoa farm household characteristics are similar, that is, similar farmers living in similar cocoa farm environments).

q = 1- p = 1-0.5 = 0.5

Based on these parameters, the optimal sample size was found to be 384. Based on this and the C4F project's requirements, a total of 450 farmers were then sampled. The oversampling was done to allow for data completeness in the event of errors and omissions. Based on this analysis, 150 farmers from each district, representing 30 farmers from each community were selected randomly from farmer lists obtained from the district Cocoa Health and Extension Division (CHED). However, during data collection, a total of 402 farmers were eventually interviewed due to time constraints and limited budget for the field survey. Table 3.1 shows the distribution of farmers from the various communities.

Table 3.1 Population and Distribution of Selected Cocoa Farmers in the Study Communities and Districts

District	Community	Total number of farmers	Number Sampled	Respondents Reached
Ellembele	Adubrim	50	30	21
	Ebi[1]	25	30	26
	Ayawora Dump	97	30	22
	Ngabawie	63	30	19
	Nkropong/Tandan	503	30	27
	Total	738	150	115
Wassa-Amenfi	Aku Nkwanta	165	30	29
	Kramokrom	159	30	23
	K-Boateng	248	30	35
	Anwiafutu	85	30	25
	Subriho	93	30	31
	Total	750	150	143
Afigya Kwabre	Amoako	540	30	32
	Abroma	364	30	33
	Soko	269	30	25
	Adukro	257	30	29
	Tetrem	91	30	25
	Total	1521	150	144

Source: Field Survey 2022

Structured questionnaires were designed and then programmed on the Insyt® computer-assisted personal interview (CAPI) software and administered on the field in July 2022, with the assistance of trained enumerators and the C4F Project team based at the University of Ghana, School of Agriculture. This data collection formed the baseline study for the C4F project component being implemented by the School of Agriculture.

[1] For Ebi, all the farmers on the farmer list were selected and 5 additional cocoa farmers in the community and not among the list of cocoa farmers known to COCOBOD in the community) were also selected based on recommendation from the District Cocoa Health and Extension Directorate Officer

Data from the Tree Crop Development Authority was also used to estimate economic profit for tree crop alternatives at their various tree crop ages.

3.4. Theoretical Framework

3.4.1. Theories of Livelihood

Sustainable Livelihoods Framework (SLF)

The Sustainable Livelihoods Framework (SLF) was developed by the United Kingdom's Department for International Development (DFID) in the late 1990s as a comprehensive approach to understanding livelihoods and diversification (DFID, 1999). The framework emphasizes the importance of five key assets that individuals and households utilize in their pursuit of different livelihood strategies.

Human Capital, which includes knowledge, skills, and capacities, plays a crucial role in accessing and adapting to various livelihood opportunities. Education, health, and labour market capabilities are important components of human capital, enabling individuals to engage in diverse livelihood strategies.

Social Capital, comprising social relationships, networks, and institutions, is essential for accessing resources, information, and support networks necessary for diversification and resilience. Trust, social norms, social support, and community organizations are examples of social capital that contribute to livelihood strategies.

Natural Capital encompasses natural resources, ecosystems, and environmental services that support livelihoods. This includes land, water, forests, biodiversity, and other natural assets. Sustainable management and utilization of natural resources are vital for long-term livelihood security and environmental sustainability.

Physical Capital, which includes infrastructure, equipment, tools, and technology, is necessary for improving productivity and accessing market. Buildings, machinery, transport, and communication infrastructure are examples of physical capital that enable individuals and households to engage in livelihood activities effectively.

Financial Capital represents the financial resources, savings, credit, and access to financial services available to individuals and households. Income, savings, investments, access to credit, insurance, and remittances are all part of financial capital, enabling individuals to invest in their livelihood activities, manage risks, and cope with shocks and uncertainties.

The SLF recognizes that livelihood diversification serves multiple purposes. It acts as a coping strategy for managing risks and shocks, reducing vulnerability and enhancing resilience. Diversification also contributes to poverty reduction and sustainable development by providing opportunities for income growth, skill development, and improved well-being.

The framework emphasizes the interdependencies and interactions among the different assets, highlighting the need for a holistic approach to livelihoods (DFID, 1999). Interventions and policies should address not only individual assets but also the relationships and dynamics between them. By strengthening and promoting the sustainable use of the various assets, the SLF aims to enhance livelihoods, reduce poverty, and contribute to sustainable development at individual, household, and community levels.

The New Household Economics Theory

The New Household Economics theory provides useful learnings into which factors influence households' decisions regarding income diversification. This theory emphasizes the importance of considering intra-household dynamics, such as gender roles, bargaining power, and resource allocation, in shaping income diversification choices (Quisumbing, 2003). This is relatable to this study, as it similarly explores the role of farmers' socioeconomic characteristics in the choice of on-farm income diversification strategies.

Gender roles play a crucial role in determining diversification strategies within households. Women often face specific constraints and have limited access to resources, including land, credit, and agricultural training (Doss, 2006). These gender inequalities can influence women's participation in different livelihood activities and their ability to access income-generating opportunities. Studies have shown that empowering women and promoting gender equality can enhance household diversification and overall welfare (Malapit et al., 2014; Asadullah & Kambhampati, 2021).

Bargaining power within households also affects diversification decisions. In contexts where power dynamics favour certain household members, their preferences and interests may dominate decision-making processes. This can have implications for the allocation of resources and the choice of livelihood activities (Quisumbing, 2003). For example, in male-dominated households, decisions related to agricultural production and income-generating activities are often controlled by men, while women's roles may be restricted to unpaid household labour. Such dynamics can shape the extent and nature of diversification pursued by households.

Resource allocation within households is another critical aspect considered by the New Household Economics theory. Household members allocate their labour, time, and financial resources in a way that maximizes overall income and well-being. Factors such as labour market opportunities and market access influence the household's ability to diversify its income sources. For instance, proximity to markets, availability of transportation infrastructure, and access to credit can aid the expansion of non-farm activities and enhance income diversification (Barrett et al., 2001; Reardon et al., 2001).

Moreover, household composition plays a role in shaping diversification choices. The number of household members, age, and skills can determine the potential for engaging in various livelihood activities. Larger households may have more labour available, allowing for greater diversification (Quisumbing, 2003). Additionally, the level of education within the household has been found to positively influence diversification strategies, as educated individuals are more likely to have the skills and knowledge necessary to engage in a range of income-generating activities (Hirvonen et al., 2018).

In summary, the New Household Economics theory provides valuable insights into the factors influencing households' decisions regarding income diversification. By considering intra-household dynamics, such as gender roles, bargaining power, and resource allocation, this theory highlights the importance of maximizing overall income and efficiently allocating resources. Factors such as labour market opportunities, market access, household composition, and gender dynamics all play a significant role in shaping diversification choices. Understanding these factors is essential for designing effective policies and interventions that promote sustainable livelihoods and poverty reduction.

Portfolio Theory

The portfolio theory, adapted from financial portfolio theory, provides a useful framework for understanding livelihood diversification as a risk management strategy (Ellis, 2000; Ellis & Allison, 2004). This approach advocates that households participate in various income-generating activities to create a diversified portfolio of livelihoods, similar to investors diversifying their financial portfolios to minimize risks and maximize returns.

The livelihood portfolio approach recognizes that households face multiple risks and uncertainties, including economic fluctuations, climate change, natural disasters, and social shocks. By spreading their livelihood activities across different sectors or income sources, households can reduce their vulnerability to these shocks and minimize income variability (Ellis, 2000; Ellis & Allison, 2004).

Diversifying livelihood activities helps households smooth their consumption patterns over time. When one income source is affected by a shock, other sources may provide a buffer, allowing households to maintain a given level of consumption (Barrett et al., 2001). For example, if a farming household also engages in non-farm activities, such as handicraft production or wage labour, income from these diversified sources can compensate for crop failures or market fluctuations.

Moreover, income diversification reduces households' dependence on a single income source. Relying on a single activity or sector increases vulnerability to specific risks associated with that activity. By diversifying their income streams, households become less reliant on a single source of income, reducing their exposure to risks associated with any particular activity (Ellis, 2000). This increased resilience helps households cope with shocks and maintain their overall well-being.

The portfolio theory highlights the importance of balancing different income sources to achieve a diversified livelihood portfolio. The optimal composition of livelihood activities may vary depending on factors such as household characteristics, resource endowments, market opportunities, and environmental conditions (Barrett et al., 2001; De Janvry & Sadoulet, 2006). Households must carefully allocate their resources, skills, and labour across different activities to maximize returns and minimize risks.

Empirical studies have provided evidence supporting the portfolio theory in the context of livelihood diversification. For example, Wouterse and Taylor (2008) found that diversification of income sources contributed to poverty reduction in rural Ethiopia. In another study in rural Nepal, Carter et al. (2009) observed that diversification of livelihood activities reduced income variability and increased household welfare.

In summary, three theories have been explored, that is, The Sustainable Livelihoods Framework, The New Household Economic Theory and The Portfolio Theory. These theories offer valuable insights into livelihood and income diversification as a risk management strategy, the resources required to undertake this diversification and the factors that affect this decision. By diversifying their income sources, households can reduce vulnerability to shocks, smooth consumption patterns, decrease dependence on a single income source, and increase resilience to uncertainties. Understanding these principles can inform policies and interventions that support sustainable livelihoods and enhance the well-being of households in diverse contexts. Hence, the analysis conducted in this study are shaped by the principles of these three theories.

Definition of On-Farm Income Diversification

For this study, on-farm income diversification refers to the practice of expanding or altering farm activities to include multiple income-generating sources, such as growing a mix of crops and raising livestock (Asravor, 2019). Various studies also highlight different dimensions of on-farm diversification. It is considered a climate adaptation strategy where farmers integrate diverse activities like cropping, agroforestry, or pastures, aiming to increase food security and stabilize incomes amidst ecological and economic challenges (van Zonneveld et al., 2020). The concept also incorporates market-based diversification, where farm operations include local selling, specialty crops, or organic farming practices. These strategies are linked to both environmental benefits and financial sustainability (Lancaster & Torres, 2019). Pertaining to this study, on-farm income diversification takes the economic perspective, where diversification is viewed as a means to balance financial gains by spreading risks across different farming activities or ventures, such as crops or integrating livestock operations (Chen et al., 2018). For this study a farmer is deemed to have on-farm diversification if he/she is engaged in a livestock or cropping activity for which land utilization is at least 0.5ha and at least some produce and/or livestock is sold.

3.4.2. Theories of Profitability

Walker's Theory of Profit

Walker's Theory of Profit posits that profit is the result of exceptional abilities possessed by entrepreneurs that surpass those of their competitors (Walker, 1880). According to the theory, profit can be seen as the rent earned by entrepreneurs due to their unique skills and talents. Walker's Theory of Profit suggests that the difference in yields between the least and most efficient entrepreneurs represents the concept of rent. In other words, the more capable entrepreneurs can earn higher profits compared to their less capable counterparts.

In formulating this theory, Walker made certain assumptions, including a state of perfect competition where all firms are presumed to possess equal managerial ability (Walker, 1880). Under this assumption, each firm would receive only wages, which Walker viewed as ordinary wages and not part of pure profit. In perfectly competitive conditions, there would be no pure profit, and all firms would earn only wages, which is referred to as normal profit.

However, Walker's Theory of Profit as Rent of Ability has faced several criticisms. One major criticism is that this theory is considered unrealistic. Some argue that the notion of profit as a surplus similar to rent is unrealistic and not a true approach to understanding profit (Blaug, 1997). They suggest that profit is a more complex phenomenon influenced by various factors beyond the abilities of entrepreneurs.

Another criticism is that the theory fails to account for situations where entrepreneurs may experience negative profits or losses. While land can earn positive or zero rent, entrepreneurs can face circumstances that result in losses rather than profits (Marshall, 1890). This highlights the inherent risk and uncertainty in entrepreneurial activities that can challenge the idea of profit solely as rent of ability.

Additionally, it is argued that profit exists primarily in a dynamic state, while rent can emerge in both static and dynamic conditions (Schumpeter, 1911). Profit is not solely determined by the superior ability of the entrepreneur but can also arise due to factors such as monopoly power, innovation, risk-taking, and market dynamics. This perspective highlights the limitations of attributing profit solely to entrepreneurial ability and emphasizes the role of external factors in profit generation.

Another criticism of Walker's theory is its failure to adequately acknowledge the important function of entrepreneurs as risk-bearers. While entrepreneurs may earn profits, these profits must be seen in the context of the losses sustained by other individuals who have been driven to bankruptcy. When these losses are considered, the surplus element in profit diminishes, and the analogy to rent becomes less applicable. Moreover, the theory falls short in explaining the profitability of ordinary shareholders in joint-stock companies, as their role and contribution to profit generation differ from that of individual entrepreneurs.

Moreover, Walker's theory is unable to explain the main causes of the size of profits. While the theory recognizes that differential gains arise due to the scarcity of superior units, such as land or entrepreneurs, it fails to explain the underlying reasons for the scarcity of these superior units. In the case of rent for land, the limitations are attributed to natural factors, but this theory does not shed light on the fundamental questions surrounding the scarcity of superior entrepreneurial abilities.

Finally, it is argued that profits, as a reward for risk-bearing, must be accounted for as a component of long-term production costs. While profits may not enter into short-term pricing decisions, in the long run, where the supply of entrepreneurs is not fixed by nature, normal profits must form part of the overall cost of production (Knight, 1921). The reward for risk-bearing, including the uncertainty associated with profit, must be considered as part of the entrepreneurial cost of doing business.

In conclusion, Walker's Theory of Profit as Rent of Ability suggests that profit is the rent earned by entrepreneurs due to their exceptional abilities. However, this theory has faced several criticisms, including its unrealistic nature, the failure to explain the causes of profit size and its limited consideration of risk-bearing. While this theory offers insights into the role of entrepreneurial ability in profit generation, it is necessary to consider alternative perspectives and factors that contribute to the complexity of profit determination.

Dynamic Theory of Profit

Clark's Dynamic Theory of profit highlights that profits arise in a dynamic economy rather than a static one. In a static economy, characterized by absolute freedom of competition, stationary population and capital, unchanged production processes, homogeneous goods, and no uncertainty or risk, all firms earn only normal profit (Clark, 1899). In contrast, a dynamic economy experiences changes such as population growth, capital accumulation, improvements in production techniques, and changes in business organization forms.

According to Clark, in a dynamic economy, the major role of entrepreneurs or managers is to take advantage of the changing conditions by expanding sales and reducing production costs. Clark describes profit as an elusive sum that entrepreneurs grasp but cannot hold. As profits are obtained, demand for factors of production increases, leading to a rise in factor prices and subsequent increases in production costs. Consequently, the selling prices of commodities fall, and profits disappear. However, the disappearance of profit does not imply that profit arises only once in a dynamic economy, but rather that managers continually seize opportunities and make profits as they take advantage of the changing economic conditions (Clark, 1899).

Despite its contributions, Clark's Dynamic Theory of profit has faced several criticisms. One criticism is that the theory fails to differentiate between changes that are foreseen and those that are unforeseen. In reality, not all changes can be foreseen in advance, and their effects differ. Therefore, it is necessary to distinguish the effects of change from the general concept of change itself (Knight, 1921).

Another criticism is that Clark's theory creates an artificial dichotomy between "Profit" and "Wages of management." This dichotomy overlooks the complexity of profit determination and the multifaceted nature of managerial compensation (Taussig, 1915). It is argued that not all dynamic changes lead to profit; only unpredictable changes may give rise to profits, while predictable changes may lead to precise adjustments without the emergence of a surplus (Blaug, 1997).

Furthermore, Clark's theory presents a vague concept of frictional profit in a stationary state. While the theory suggests that only frictional profit exists in a stationary state, the notion of frictional profit lacks clarity, and it is the normal profit that is earned in such a state (Blaug, 1997).

Additionally, Clark's theory does not adequately emphasize the element of risk involved in business due to dynamic changes. Critics argue that to understand the true nature of profit in a modern economy, it is essential to consider the combination of risk elements and dynamic changes (Knight, 1921).

In summary, Clark's Dynamic Theory of profit focuses on the role of dynamic changes in profit generation. However, it has faced criticisms related to the distinction between foreseen and unforeseen changes, the artificial dichotomy between profit and managerial wages, the selective nature of profitable changes, the vague concept of frictional profit, and the need to consider risk elements alongside dynamic changes. These criticisms highlight the complexities and nuances involved in understanding the nature and determinants of profit in a dynamic economic environment.

Hawley's Risk Theory of Profit

Hawley's Risk Theory of Profit, proposed by Hawley in 1893, emphasizes the role of risk in profit generation. According to Hawley, risk in business can arise from various factors such as product obsolescence, sudden price falls, material unavailability, competition introducing better substitutes, and risks associated with events like fire or war. Hawley considers risk-taking as an inherent element of production, and those who assume greater risks are more likely to earn larger profits. He argues that profit is simply the price paid by society for assuming business risks, beyond the predetermined level (Hawley, 1893).

In Hawley's view, profit consists of two parts. The first part represents compensation for actual or average loss incurred due to various risks, while the second part represents a penalty for bearing the consequences of being exposed to risk in entrepreneurial activities. Hawley believes that profits arise from factor ownership as long as ownership involves risk.

Entrepreneurs have to assume risks to earn increasing profits, and in the absence of risks, they would cease to be entrepreneurs and receive any profit. According to Hawley, profits emerge from uninsured risks, and the precise amount of reward cannot be determined until uncertainty is resolved through the sale of entrepreneurial products. Therefore, Hawley's theory is often referred to as the Residual Theory of profit (Hawley, 1893).

However, the Risk Theory of Profit has faced several criticisms. One criticism is that there may not always be a functional relationship between risk and profit. Those who dare to take high risks in certain businesses may not necessarily earn high profits, as profit is influenced by various factors beyond the level of risk undertaken (Blaug, 1997).

Furthermore, it is argued that profit is not solely based on an entrepreneur's ability to undertake business risks, but rather on their capability to avoid or mitigate risks. Profitability depends on the entrepreneur's decision-making, resource allocation, and strategic actions rather than simply their willingness to assume risks (Kirzner, 1973).

Another criticism is that the Risk Theory of Profit is incomplete. While it recognizes that all business enterprises involve risk and uncertainty, it does not explain why entrepreneurs aim to make large profits despite the uncertain nature of profitability. The theory overlooks the broader factors and strategies that entrepreneurs employ to generate profits beyond risk-taking (Blaug, 1997).

Moreover, the amount of profit earned is not necessarily proportional to the size of the risk involved. If profit were directly related to the size of the risk, entrepreneurs would always opt for larger risks to earn higher profits, which is not the case in reality (Kirzner, 1973).

Lastly, the *Risk Theory of Profit* primarily focuses on risk and neglects other factors that contribute to profit generation. Profitability is influenced by multiple factors, including market demand, competitive advantage, efficiency, innovation, and customer satisfaction, which extend beyond the consideration of risk alone (Blaug, 1997).

In conclusion, Hawley's Risk Theory of Profit highlights the role of risk in profit generation. However, the theory has faced criticisms regarding the functional relationship between risk and profit, the significance of entrepreneurial ability beyond risk-taking, its incomplete explanation of profit determination, the lack of direct proportionality between risk and profit, and the neglect of other profit-contributing factors. Considering these criticisms is important for a comprehensive understanding of profit dynamics in business.

Knight's Theory of Profit

Knight's Theory of Profit, proposed by Frank H. Knight, views profit as a residual return resulting from uncertainty rather than risk-bearing. Knight distinguishes between calculable risks, which can be estimated based on available data and are insurable, and incalculable risks, which cannot be precisely calculated. Incalculable risks arise from elements such as uncertain costs or the strategies of competitors. It is in the realm of uncertainty that decision-making becomes a crucial function for entrepreneurs. When their decisions prove to be correct, entrepreneurs earn profits (Knight, 1921).

According to Knight, profits arise from decisions made and implemented under conditions of uncertainty. Profitability can be the result of decisions related to market conditions, such as those increasing the degree of monopoly power, decisions regarding stock holdings that lead to windfall gains, or decisions to introduce new techniques and innovations (Knight, 1921).

However, Knight's Theory of Profit has faced several criticisms. One criticism is that it equates the functions of an entrepreneur with those of workers. The work of an entrepreneur is filled with risk and uncertainty, and profit is considered a reward for bearing this risk. In contrast, workers receive wages solely for their labour, without incorporating the elements of risk and uncertainty into their compensation. The risk for workers primarily involves the possibility of losing their jobs, which is seen as an extreme outcome (Baumol, 1957).

Another criticism is that profit is flexible and can vary depending on business conditions and situations. Profit levels may rise or fall, while wages tend to remain stable and do not fluctuate as significantly in the short term (Hollander, 1979).

Furthermore, Knight's theory is silent about the payment to shareholders. Shareholders in an organization or company do not directly perform any functions, yet they receive a share of profits in the form of dividends for undertaking the risk of investing their money. This theory fails to explain why shareholders receive such payments (Hollander, 1979).

Lastly, the theory does not account for the possibility of entrepreneurs receiving windfall or chance profits, whereas workers do not have the opportunity to receive wages based on such unexpected gains (Schumpeter, 1954).

In conclusion, Knight's Theory of Profit highlights the role of uncertainty in profit generation and emphasizes decision-making under uncertain conditions. However, criticisms of the theory include the distinction between entrepreneurs and workers, the flexibility of profit compared to wages, the payment to shareholders, and the occurrence of windfall or chance profits. Consideration of these criticisms contributes to a comprehensive understanding of the complexities involved in profit determination.

Schumpeter's Innovation Theory of Profit

Schumpeter's Innovation Theory of Profit, developed by Joseph A. Schumpeter, focuses on the role of innovation in profit generation and economic development. According to Schumpeter, factors such as interest and profits, as well as the recurrence of trade cycles, merely supplement the distinct process of economic development. To explain the phenomenon of economic development and profit, Schumpeter starts from a state of stationary equilibrium, characterized by equilibrium in all spheres. In this state, total business receipts exactly match costs, resulting in no profit. Schumpeter argues that profit can only be earned by introducing innovations in manufacturing techniques and methods of supplying goods (Schumpeter, 1934).

Innovation, as defined by Schumpeter, includes various activities such as introducing new commodities or quality goods, new methods of production, new markets, finding new sources of raw materials, and organizing industries in innovative ways with new techniques. These innovations disrupt the equilibrium and lead to changes in the economic landscape. As the adoption of innovations increases, the supply of goods and services expands, resulting in a fall in their prices. However, the costs of production also increase due to rising factor prices while the supply of factors remains constant. This leads to a situation where the cost per unit of output rises, and revenue per unit decreases. Eventually, a stage is reached where costs and receipts become equal, eliminating profits. The economy reaches a state of equilibrium, but the possibility of profits still exists in the form of quasi-rent, which arises due to the special characteristics of productive services. It should be noted that profits arising from factors such as patents or trusts are more akin to monopoly revenue rather than entrepreneurial profits (Schumpeter, 1934).

However, Schumpeter's Innovation Theory of Profit has faced several criticisms. One criticism is that Schumpeter does not consider profit as the reward for risk-taking. He argues that risk-taking is the function of the capitalist rather than the entrepreneur, suggesting that shareholders undertake risks and earn profits (Baumol, 1968).

Furthermore, Schumpeter's theory does not explicitly address the role of uncertainty in profit determination. Profit is seen as the wages of management rather than a reward for uncertainty (Baumol, 1968).

Lastly, critics argue that the theory is incomplete. Profit, in Schumpeter's view, arises from the entrepreneur's organizational ability and nothing else. This limited focus on organizational ability as the sole explanation for the emergence of profits is considered an incomplete explanation of profit generation (Baumol, 1968).

In conclusion, Schumpeter's Innovation Theory of Profit highlights the importance of innovation in profit generation and economic development. However, criticisms of the theory include the neglect of risk-taking as a determinant of profit, the omission of uncertainty as a factor, and the theory's incomplete explanation of the emergence of profits. Considering these criticisms helps to develop a more comprehensive understanding of the complexities involved in the determination of profits.

3.4.3. Economies of Scope

Economies of scope refer to the economic benefits that arise from producing a variety of goods and services within the same organization (Boot, 2016). Economies of scope is an economic theory stating that average total cost of production decrease as a result of increasing the number of different goods produced (Panzar & Willig, 1977; Silberston, 1972). It involves the ability to leverage existing resources and capabilities across different product lines or business units. By diversifying their operations, companies can take advantage of various synergies and cost efficiencies (Kaul, 2003). The theory of Economies of Scope originates from the idea that combining the production of multiple products can lead to cost savings and increased efficiency (Curtis & Sarmiento, 2002). This concept has been widely discussed and studied by researchers in the fields of economics and business.

One of the main advantages of economies of scope is the ability to reduce production costs. When a company produces a wider range of products, it can benefit from shared resources and economies of scale. This means that fixed costs, such as overhead expenses, can be spread across multiple product lines, resulting in lower average production costs for each product (Alem et al., 2018). This reduces duplication of efforts and allows for better utilization of available resources (Love et al., 2001). Additionally, economies of scope can lead to increased efficiency in resource allocation. By having multiple business activities that are related to one another, companies can allocate their resources more efficiently (Sayem et al., 2019). For example, a company that operates in both the manufacturing and distribution industries can streamline their supply chain by utilizing the same distribution system for all of its products. This not only reduces costs but also improves the overall efficiency of their operations.

Furthermore, economies of scope can also lead to the development and transfer of specialized technical and managerial skills within the organization (Palvia, 1997). For instance, if a company has a strong brand name and production know-how in one business unit, it can leverage that expertise to enhance the performance of other business units(Molnar, 2018). In a multivariate analysis of variance, the concept of economies of scope can be explored to understand how different business activities within an enterprise are related to each other and how they contribute to overall performance and efficiency. This analysis can help quantify the extent to which economies of scope exist and identify the specific factors that contribute to them.

Economies of scope in agriculture can be achieved when multiple crops or livestock are grown/raised on the same farm, allowing for shared resources such as land, infrastructure, and machinery (Alem et al., 2018). Thus, the concept of economies of scope can also be applied to the agricultural industry. This approach allows for the efficient sharing of resources such as land, infrastructure, and machinery. By diversifying their agricultural activities, farmers can benefit from increased efficiency and cost savings. For example, a farmer who grows both corn and soybeans on their land can make use of the same equipment for planting, harvesting, and irrigation. This eliminates the need for separate machinery and reduces overall operational costs. In addition, by growing multiple crops or raising multiple livestock, farmers can also mitigate risks associated with relying on a single crop or livestock type (Curtis & Sarmiento, 2002). In tree crops such as cocoa and oil palm, economies of scope can be achieved by utilizing the same farm infrastructure and labour for both crops and other land-based enterprises (Curtis & Sarmiento, 2002). This can lead to cost savings and improved efficiency in the production of both crops, as resources are shared and utilized more effectively. The application of economies of scope in agriculture can lead to increased productivity, profitability, and resilience for farmers. Economies of scope are also expressed in diversification in agriculture, where farmers have economic incentives to produce multiple products or different grades of the same product (Curtis & Sarmiento, 2002). Multivariate analysis of variance can be used to examine the presence and magnitude of economies of scope in agriculture by analyzing the joint production of multiple agricultural outputs and their impact on cost efficiency (Han & Lu, 2021). This analysis can help determine the extent to which economies of scope exist in agriculture and identify the specific factors that contribute to them. As a risk management strategy, economies of scope in agriculture can help farmers diversify their production and reduce vulnerability to market fluctuations. In addition to cost savings and efficiency gains, economies of scope in agriculture can also have positive environmental effects. By diversifying their agricultural activities, farmers can enhance biodiversity and promote ecosystem services (Alem et al., 2018). For example, planting a variety of crops can attract a diverse range of beneficial insects and pollinators, which can help control pests and improve crop yields. Additionally, incorporating wildlife habitats, such as hedgerows or ponds, into the agricultural landscape can provide shelter and food sources for wildlife, contributing to overall ecosystem health.

To further explore the concept of economies of scope in agriculture, it is important to consider the role of shared inputs and fixed costs. Shared inputs, such as farm machinery, irrigation systems, and storage facilities, can contribute to economies of scope in agriculture. By utilizing these shared inputs for multiple agricultural outputs, farmers can spread the costs of these inputs across a larger production base, reducing overall production costs and increasing profitability (Han & Lu, 2021).

3.4.4. Theory of the Firm

The theory of the firm is a cornerstone of microeconomics, delving into the very essence of businesses and their behavior within the marketplace. It seeks to answer fundamental questions: Why do firms exist? How do they make decisions? What determines their structure and interaction with the market?

The traditional theory, rooted in neoclassical economics, posits that firms strive to maximize profits. Pioneered by Alfred Marshall, this approach assumes firms operate in perfectly competitive markets with perfect information (Marshall, 1890). Firms act as rational actors, meticulously calculating costs and revenues to reach the optimal output level that yields the highest profit. This framework provided a foundational understanding of firm behavior, influencing decisions on resource allocation, production techniques, and pricing strategies.

However, the limitations of the profit maximization model soon became apparent. Ronald Coase, in his groundbreaking work "The Nature of the Firm," challenged the assumption of perfect information. He argued that market transactions incur costs, such as searching for information, negotiating contracts, and monitoring compliance. These transaction costs provide a compelling reason for firms to exist (Coase, 1937). Firms can achieve economies of scale by internalizing these costs, coordinating production activities within a hierarchical structure, rather than relying on the potentially inefficient market mechanism. Coase's transaction cost economics offered a more nuanced explanation for firm formation and boundaries.

Building on Coase's work, Oliver Williamson further explored the concept of transaction costs. He identified factors like asset specificity, uncertainty, and bounded rationality that influence the decision to make or buy (Williamson, 2007). Asset specificity refers to the degree to which an asset is valuable only to a particular firm. When such assets are involved, transaction costs associated with external contracting can be high, incentivizing firms to bring production in-house. Uncertainty in the environment, such as difficulty predicting future demand or technological advancements, can also lead firms to internalize transactions to maintain control and flexibility. Bounded rationality, the limitation of human cognitive abilities, necessitates the development of routines and hierarchies within firms to overcome these limitations.

Beyond transaction costs, behavioral theory has enriched the understanding of firm behavior. Herbert Simon, a prominent figure in this field, argued that firms pursue satisficing rather than maximizing behavior. Faced with complex decision-making processes and limited information, firms aim to achieve satisfactory levels of performance rather than the absolute optimum (Simon, 1997). This approach acknowledges the cognitive limitations of managers and the influence of organizational goals and routines on decision-making.

Managerial discretion is another key concept that departs from the profit maximization model. Managers, with their own goals and risk preferences, can influence firm behavior. They may prioritize growth, market share, employee satisfaction, or innovation alongside profit considerations. Agency theory explores the potential conflict of interest between managers and shareholders, where managers may not always act in the best interests of the owners (Jensen & Meckling, 1976).

The theory of the firm has also embraced the influence of the institutional environment. Firms operate within a web of institutions, including legal systems, cultural norms, and regulatory frameworks. These institutions shape the incentives and constraints faced by firms, influencing their strategies, structures, and long-term goals. New institutional economics emphasizes the role of institutions in shaping firm behavior and performance (North, 1990).

In conclusion, the theory of the firm has undergone a fascinating journey. From the neoclassical focus on profit maximization to contemporary perspectives that acknowledge transaction costs, bounded rationality, managerial discretion, and the institutional environment, the theory has become more nuanced and realistic. This enriched understanding allows for a more accurate prediction of firm behavior, leading to better economic models and informed policy decisions.

3.4.5. The Resource-Based View Theory of the Firm

The quest for understanding what drives a firm's success has led to the development of various theories. Among them, the Resource-Based View (RBV) has emerged as a prominent framework, shifting the focus from external market forces to the internal capabilities of the firm.

The RBV, spearheaded by scholars like Jay Barney, posits that a firm's competitive advantage hinges on its unique and valuable resources and capabilities (Barney, 1991). In the context of cocoa farmers, resources encompass tangible assets like land and financial resources, as well as intangible assets such as farmer managerial ability, brand reputation, and social networks. Capabilities, on the other hand, represent the processes through which firms combine and leverage resources to create value (Grant, 1998). The core proposition of RBV lies in the VRIN (Valuable, Rare, Inimitable, and Non-Substitutable) framework (Barney, 1991). For a resource or capability to contribute to SCA, it must be:

- Valuable: It must contribute to the creation of customer value or reduce costs for the firm, ultimately enhancing its competitive position.
- Rare: Not possessed by a large number of competitors, creating a differentiation advantage.

- Inimitable: Difficult for competitors to imitate due to factors like complexity, path dependence, or causal ambiguity.
- Non-substitutable: No readily available substitute resources or capabilities exist, preventing competitors from replicating the advantage.

The VRIN framework provides a valuable tool for firms to evaluate their internal resources and identify potential sources of SCA. By focusing on developing and leveraging resources with VRIN characteristics, firms, in this case cocoa farmers, can create a competitive edge that is difficult for rivals to erode.

The RBV has shed light on several critical aspects of strategic management. It emphasizes the importance of dynamic capabilities, the ability to adapt and reconfigure resources in response to a changing environment (Teece et al., 1997). Furthermore, it highlights the role of internal organizational processes and routines in orchestrating and utilizing resources effectively (Nelson, 1993). RBV also encourages a focus on knowledge-based resources, such as innovation capabilities and technological expertise, which are increasingly crucial in today's competitive landscape (Grant, 1996).

However, the RBV has also faced some criticisms. Critics argue that the model fails to adequately address the dynamic nature of competitive environments (Peteraf, 1993). Resources can become less valuable or easier to imitate over time, requiring firms to continuously seek renewal and innovation. Additionally, the RBV can be seen as inward-looking, neglecting the impact of external factors like industry structure, customer power, and technological disruptions (Hitt et al., 1997).

Despite these limitations, the RBV has undoubtedly enriched our understanding of strategic management. Its emphasis on internal resources provides a valuable foundation for developing and sustaining competitive advantage. Recent advancements in the RBV framework have addressed some of the initial limitations. The dynamic capabilities perspective acknowledges the need for continuous adaptation, while the co-evolutionary perspective recognizes the interplay between firms and their environment (Teece et al., 1997).

In conclusion, the RBV has become a cornerstone within strategic management theory. By focusing on internal resources and capabilities, the framework provides valuable insights for firms seeking to achieve and maintain a competitive edge. While acknowledging the limitations of a strictly internal focus, the RBV, when integrated with other strategic frameworks, offers a powerful lens for understanding firm performance and formulating effective strategies in a dynamic business landscape.

3.5. Methods of Analysis of the Specific Objectives

3.5.1. Estimation of Economic Profitability

The first specific objectives of this study is to estimate the financial and economic profitability of cocoa farm plots, and estimate the profit efficiency of cocoa farmers in the Ashanti and Western Cocoa Regions of Ghana, respectively. This study measures economic profitability rather than financial profitability. This implies that the study estimates the financial profitability of cocoa farm plots by subtracting explicit costs from cocoa revenue, and then economic profit, by further subtracting the implicit cost incurred in pursuing cocoa farming (Dobrovič et al., 2022).

Mathematically this is represented as follows:

$$E\pi = \pi_C - \pi_A \ldots \qquad (1)$$

Where:

$E\pi$ is Economic Profit

π_C and π_A are profit from cocoa and profit from the next best alternative respectively.

For this study, the next best alternative for cocoa farmers is argued to be a competing tree crop. Given the study's thesis, we postulate that a farmer could use the same set of land, labour and capital resources to produce either oil palm or rubber, taking into context the situations in the Elembelle, Manso Amenfi and Afigya Kwabre North districts, where data for this study was taken. Thus, the next best alternative for cocoa farmers in Elembelle and Manso Amenfi and Oil Palm for cocoa farmers in the Afigya Kwabre North district.

To further discuss the estimation of economic profitability, we unpack the components of profitability. From economic theory, profit is simply, total revenue less total cost (Battistini, 2015).

$$\pi_C = TR_c - TC_c \quad (2)$$

Where TR_c is Total revenue from Cocoa and TC_c is the Total cost of cocoa activities.

For cocoa farmers in Ghana, the price of cocoa beans at farmgate is fixed by COCOBOD. Therefore, the main way of increasing revenue is to maximize output per hectare.

$$TR_C = P_c . Q_c \quad (3)$$

Here P_c and Q_c are the price and quantity produced of cocoa respectively.

On the other hand, to maximize profit, farmers also need to be efficient with their expenditures. This allocative efficiency, together with the need to maximize output per given hectare of land, are the fundamental factors that influence profitability. Expenditure consists of costs related to payments for farm labour, fertilizer, and agrochemicals among others. There is also another component of cost, which is production overhead costs. This includes costs of land rent, hiring of equipment, transportation costs and other similar expenditures. This relationship is modelled as:

$$TC_C = \Sigma(P_{1..n} \, . \, Q_{1...n}) + TC_{ovhds} \qquad (4)$$

Where $\Sigma(P_{1..n} \, . \, Q_{1...n})$ represents the products of the price and costs of inputs 1 to n, and TC_{ovhds} is production overhead costs.

Substituting Equations 3 and 4 into Equation 1, the economic profit of cocoa farmers is expressed as:

$$E\pi = P_c . Q_c - \Sigma(P_{1..n} \, . \, Q_{1...n}) + TC_{ovhds} - \pi_A \qquad (5)$$

From equation 5, the main components of Economic Profit of cocoa farmers are the price of cocoa, quantity of cocoa produced, price of inputs, quantity of inputs, production overhead costs and profit of forgone alternative.

Estimation of Profit of Forgone Alternative

The estimation of the profit of the forgone alternative or the implicit cost, is similar to the estimation of profit from cocoa as estimated in Equation 1. In this study, data on standard production costs for Rubber and Oil Palm was obtained from the Tree Crop Development Authority. This provides information on the cost of production and yields per hectare for each year of the tree crops' productive lifetime.

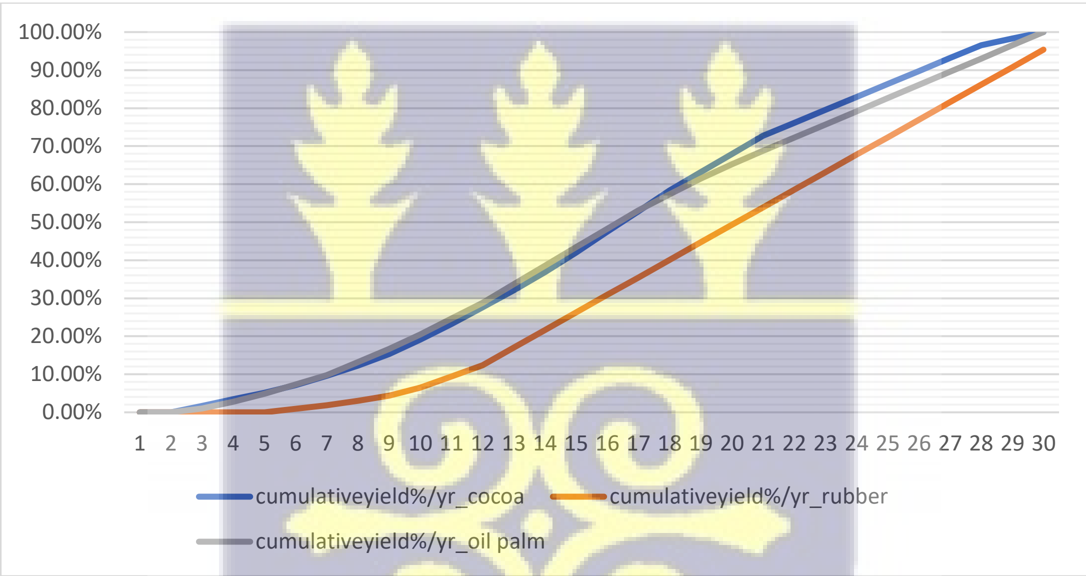
Key Assumptions and Considerations

For the computation of economic profit in this study, five key assumptions are made.

- Difference in Yield Curves of Tree Crops

The three tree crops used for the economic profit estimation in this study, that is cocoa, rubber and oil palm, have different yield curves but have similar productive life spans. From literature, the economic life of cocoa, rubber and oil palm trees is between 25 and 30 years (Obeng & Adu, 2016; Wongnaa et al., 2022).

Figure 3.2 Cumulative percentage of Lifetime Yield Achieved per annum for Cocoa, Oil Palm and Rubber



Source: Adapted from GIRSAL, 2021 (accessed 2023)

Figure 3.2 shows the cumulative annual percentage of total lifetime yield per year of cocoa, rubber and oil palm trees. Given the difference in yield curves, in comparing the profit from these tree crops for plots of the same age, it is important to ensure that a relative comparison is done. Thus, the production from each year is weighted by its proportion to the total production expected per hectare over the productive life of the plot. Thus, this weighted yield for a tree crop in year *t*, wY_t, is given as:

$$wY_t = aY_t \cdot \frac{eY_t}{tY} \qquad (6)$$

Where aY_t is the actual or recorded farmer output per hectare in year t, eY_t is the expected yield in year t and tY is the total expected production in the tree crop's productive lifetime per hectare.

- Comparative Production of Farmers

Although there are average expected yields for each of the tree crops, the yields of smallholder farmers for each of these tree crops, especially oil palm and cocoa are known to be significantly lower than expected yields (Brako et al., 2021; Jagoret et al., 2017; Somarriba et al., 2021). In comparing what a farmer's output would have been if the farmer were to be engaged in the next best forgone alternative, it is assumed that the farmer's percentage attainment of the achievable output in cocoa and for the alternative will be similar. Therefore, for this estimation, farmers' yield per hectare for cocoa as a proportion of the average attainable for the age of the cocoa plot, was applied to the attainable average production for the same age of plot for the alternative tree crop.

- Plantation Establishment Costs

Given that production from tree crops takes some years from the planting of seedlings, there are establishment costs, which comprise all the expenditures a farmer incurs in maintaining the farm plot until revenues are recorded (GIRSAL, 2025). Although the period for this establishment costs varies per tree crop, the actual cost for cocoa, oil palm and rubber are assumed to be similar.

- Cost Function of Farmers in Cocoa and Other Tree Crop Production

In achieving the optimum output per hectare for each of the three tree crops being studied, there are associated costs which have been elaborated. However, based on managerial decisions, farmers' allocation of costs of production is a proportion of the recommended costs to be incurred in producing the optimum levels of yield. Therefore, in estimating the cost of production of the forgone alternative, the cost incurred by the farmer is assumed to be the same factor as the recommended cost for that tree crop. This is estimated as the farmer's factored cost of production of cocoa against the recommended cost of production of cocoa for the age of the farm plot. This implies that:

If aTC_{Ct} and rTC_{ct} are the actual and recommended total cost functions for a cocoa farmer whose plot is at year *t,* then these costs will vary by a cost function variation factor, φ.

That is,

$$aTC_{Ct} = \varphi \, . rTC_{ct} \qquad (7)$$

Where 0 <φ, and φ changes as farmers cost functions changes in year t

From this, this study assumes that the estimated cost of production for the same farmer if he or she were to produce an alternative crop would vary by a cost function variation factor, φ. The cost of production for the farmer for the alternative tree crop would therefore be:

$$aTC_{at} = \varphi \, . rTC_{at} \qquad (8)$$

Where aTC_{at} is the farmer's estimated actual cost of production for the alternative tree crop at the same age t, rTC_{at} is the recommended cost function for the tree crop alternative at age t and φ is the cost function variation factor calculated from Equation 7.

- Revenue Structure from a Typical Cocoa Farm of a Smallholder

One of the unique characteristics of cocoa in comparison with the other tree crops under study, that is oil palm and rubber, is the nature of returns from cocoa farm plots. The architecture of cocoa farms allows farmers better opportunities to include other on-farm income-generating activities. These may include intercropping with food crops, including perennial food tree crops such as citrus and avocado, plantain, vegetables and livestock keeping. Amfo & Ali (2020b) estimated that cocoa farmers can make as much as 17.8% of cocoa revenue from on-farm diversification activities. For this study, a conservative estimate of 10% of cocoa income was applied to cocoa revenues recorded from field data collected on farmers' cocoa incomes. However, the nature of oil palm and rubber especially do not allow intercropping to generate other on-farm revenues as with cocoa plots.

For this first objective, the hypothesis to be tested is a stated below:

> H_o (Null hypothesis): Cocoa farm plots in the Ashanti and Western Cocoa Regions of Ghana are not financially and economically profitable.
>
> H_1 (Alternate hypothesis): Cocoa farm plots in the Ashanti and Western Cocoa Regions of Ghana are financially and economically profitable.

Decision Rule:

If pooled financial and economic profit, estimated as GHS/ha, is greater than 0, reject the null hypothesis (i.e., Cocoa farmers in the Ashanti and Western Cocoa Regions of Ghana are financially and economically profitable);

If pooled financial and economic profit, estimated as GHS/ha, is less than or equal to 0, fail to reject the null hypothesis (i.e., Cocoa farmers in the Ashanti and Western Cocoa Regions of Ghana are not financially and economically profitable).

3.5.2. Estimation of Financial Profit Efficiency

The frontier methodology is one of the most popular methods in recent times for estimating efficiency in several fields including strategic management (Chen et al., 2015) and agriculture (Onumah, Al-Hassan, et al., 2013b). With the Stochastic Frontier Method (SFM), a firm is labelled as efficient if it operates in the industry's efficient frontier. In applying the SFM to this study, a farmer is efficient if he/she operates in the most efficient economic profit frontier among the group of farmers sampled.

The SFM utilizing random coefficients is used for efficiency estimation in this study. The SFM employs parametric techniques, which differ in comparison to alternatives like Data Envelopment Techniques (DEA) and Ordinary Least Square Regression (Nguyen & Pham, 2020; Strange et al., 2021). DEA, which is underlined by linear programming and is a nonparametric method, estimates technical efficiency (Powar et al., 2020; Salahi et al., 2021). Additionally, the traditional DEA approach does not decompose the error term, treating the difference between measured efficiency and the maximum efficiency frontier as inefficiency.

The SFM, in contrast, produces a compound error term, consisting of the firm's inefficiencies (the difference between estimated efficiency and the most efficient frontier) and a random error term (Spiegelhalter et al., 2002). Deviating from traditional SFM assumptions, this study adopts the model proposed by Battese and Coeli (1995), suggesting that the determinants of inefficiency can be expressed linearly based on explanatory variables reflecting a firm's inherent characteristics. The alternative profit model is expressed as:

$$E\pi_i = \alpha + \beta_i X_i + v_i - u_i \qquad (9)$$

Here, $E\pi_i$ is the financial profit of farmer i, α is an intercept, X_i is the vector of explanatory variables, β_i is the vector of parameters to be estimated, u_i represents inefficiencies reducing profit, and v_i represents random error.

The SFM approach also estimated the financial profit efficiency scores for each of the units. Applying the Resource-Based View (RBV) Theory of the Firm to this estimation introduces assumptions such as resource heterogeneity between units, which is especially true for cocoa farmers with varying qualities, types, and access to inputs. The RBV assumption aligns with the realistic view that firms may operate on different profit efficiency frontiers due to differing resources, deviating from the traditional SFM's assumption of resource homogeneity.

The translog functional form is selected for this study as it aligns with the assumption of this study. Bayesian techniques, incorporating the translog functional form used in the SFM, follow a multivariate normal distribution, with parameter estimates depending on means and a positive definite covariance matrix (Spiegelhalter et al., 2002).

The financial profit function for the efficiency frontier estimations uses the log mean of the calculated economic profit per hectare, normalized by dividing it by revenue per hectare, as the output variable and a positive definite means of explicit and implicit cost per hectare, also expressed in price terms as proportions of revenue, as input variables. The variables therefore consist of the normalized log mean of economic profit per hectare as the output variable (Y_i) and the positive definite covariate matrix of the log means of revenue (X_1), expenditures on fertilizer (X_2), pesticides (X_3), fungicides (X_4), herbicides (X_5), labour (X_6) and overheads (X_7) as input variables. Here, for this study, the implicit cost is left out as it is not a non-cash cost item.

The Stata function *sfcross*, also estimates the determinants of the inefficiency term estimated. A list of explanatory variables, consisting of socioeconomic, plot/farm characteristics, institutional and location variables used for this estimation is provided in table 3.3.

Table 3.2: List of Variables for SFM Matrix

Variables	Measurement
Gross profit per ha (Y_i)	GHS/ha
Revenue per ha (X_1)	GHS/ha
Expenditure on fertilizer per ha (X_2)	GHS/ha
Expenditure on pesticide per ha (X_3)	GHS/ha
Expenditure on fungicide per ha fungicides (X_4)	GHS/ha
Expenditure on herbicides per ha (X_5)	GHS/ha
Expenditure on labour per ha (X_6)	GHS/ha
Expenditure on other costs & overheads per ha (X_7)	GHS/ha

Table 3.3 List of Explanatory Variables for Profit Inefficiency Estimation

Variable Class	Variables	Measurement	a-priori Expectation (+/-)
Socioeconomic	Household Size	Number	-
	Migrant/Native	Dummy: Native=1, Migrant =0	-
	Age	Years	-
	Age^2	Years	+
	Gender	Dummy: Male=1, Female=0	-
	Education	Categorical: No education=0 At least primary-1 At least JHS=2 At least SHS=3 Tertiary and above=4	-
	Diversification type	Categorical: Cocoa only=0 Tree crop=1 Food crop=2 Tree crop+food crop=3 Livestock=4 Tree crop+livestock=5 Food crop+livestock=6 Tree crop+Food crop+Livestock=7	
Farm Characteristics	Farm distance from dwelling	Kilometres	+

Variable Class	Variables	Measurement	a-priori Expectation (+/-)
	Farm Area (hectares)	Hectares	-
	Age of Plot	Categorical: 3-7yrs = 0 8 - 15 years=1 16 - 30 years=2 31 years and above=3	-
Institutional	Training in past 5 years	Dummy: has had training in past 5 years=1, otherwise-0	-
	Certification program participation	Dummy: Currently enrolled in certification program=1, otherwise=0	-
	FBO membership	Dummy: Member of an FBO=1, otherwise=0	-
	Credit access in past year	Dummy: Accessed credit in past year= 1, otherwise=0	-
Location	District	Categorical: Elembelle =0 Wassa Amenfi Central=1 Afigya Kwabre North=2	

Source: Author's Construct

The Stochastic Frontier Model is specified as:

$$\ln(Y) = \beta_0 + \beta_1 \ln(X_1) + \beta_2 \ln(X_2) + \beta_3 \ln(X_3) + \beta_4 \ln(X_4) + \beta_5 \ln(X_5) + \beta_6 \ln(X_6) + \beta_7 \ln(X_7) + \frac{1}{2}\sum_{i=1}^{7}\sum_{j=1}^{7} \gamma_{ij} \ln(X_i) \ln(X_j) + v - u \quad (10)$$

Where: ln ( ) is the natural log.

$\beta_0, \beta_1 \ldots \beta_7$ are parameters to be estimated.

γ_{ij} are parameters capturing the interaction effects between input variables.

v is the random error term representing the stochastic component.

u is the inefficiency term representing the deviation of observed output from the frontier

The hypothesis to be tested is stated below:

H_o (Null hypothesis): Cocoa farmers in the Ashanti and Western Cocoa Regions of Ghana are not profit-inefficient in their cocoa production operations.

H_1 (Alternate hypothesis): Cocoa farmers in the Ashanti and Western Cocoa Regions of Ghana are profit-inefficient in their cocoa production operations.

The Stochastic Frontier Model estimated by Stata using the *sfcross* provides a probability value (p-value, represented as Prob > chi^2) associated with the likelihood ratio (LR) test of a restricted and unrestricted model for the same estimation.

It represents the probability of observing a LR statistic as extreme or more extreme than the calculated one, assuming the null hypothesis (no inefficiency) is true.

Decision Rule:

If Prob > chi^2 value is less than the significance level (0.05), reject the null hypothesis (i.e., there is evidence of inefficiency);

If Prob > chi^2 value is less than or equal to the significance level, fail to reject the null hypothesis (i.e., there is no strong evidence of inefficiency).

3.5.3. Estimation of the Relationship Between Profitability and On-Farm Income Diversification

The third objective determines the relationship between on-farm income diversification and profitability of farmers in the Ashanti and Western Cocoa Regions of Ghana. This study makes the argument that the economic profitability of cocoa farm plots in the study area is influenced by their diversification status. There are also several socioeconomic variables that have been shown by other studies to influence the profitability of cocoa farmers. These include age, farm size, production quantity, household income, cocoa farming experience, and access to credit (Meliko, 2021; Onoja et al., 2012; Onumah et al., 2013a). To test the effect on-farm income diversification status and these socioeconomic variables have on profit, a Log-linear Ordinary

Least Squares (OLS) regression is used. Here the dependent variable used is the log of economic profit, ($\ln(E\pi)$), which suggests that the model used predicted the percentage change in economic profit given a unit change in the explanatory variables. The main explanatory variable here was diversification (∂_i), proxied as 1 if diversified (cocoa production with either food crop, livestock, or other tree crop) or 0 if not diversified (cocoa production only). Other socioeconomic variables (X_i) were also added to the model. The full list of variables and associated apriori expectations for the model is shown in Table 3.4 below.

Table 3.4: Variables and Apriori Expectations for Conditional Mixed Process Model

Variable Class	Variables	Measurement	a-priori Expectation (+/-)
Socioeconomic	Household Size	Number	-
	Migrant/Native	Dummy: Native=1, Migrant =0	-
	Age	Years	-
	Age^2	Years	+
	Gender	Dummy: Male=1, Female=0	-
	Education	Dummy: No education=0 At least primary-1 At least JHS=2 At least SHS=3 Tertiary and above=4	-
	Diversification type	Categorical: Cocoa only=0 Tree crop=1 Food crop=2 Tree crop+food crop=3 Livestock=4 Tree crop+livestock=5 Food crop+livestock=6 Tree crop+Food crop+Livestock=7	
Farm Characteristics	Farm distance from dwelling	Kilometres	+
	Farm Area (hectares)	Hectares	-
	Age of Plot	Categorical: 3-7yrs = 0	-

Variable Class	Variables	Measurement	a-priori Expectation (+/-)
		8 - 15 years=1 16 - 30 years=2 31 years and above=3	
Institutional	Training in past 5 years	Dummy: has had training in past 5 years=1, otherwise-0	-
	Certification program participation	Dummy: Currently enrolled in certification program=1, otherwise=0	-
	FBO membership	Dummy: Member of an FBO=1, otherwise=0	-
	Credit access in past year	Dummy: Accessed credit in past year= 1, otherwise=0	-
Location	District	Categorical: Elembelle =0 Wassa Amenfi Central=1 Afigya Kwabre North=2	

The log-linear OLS model was specified as follows:

$$ln(E\pi_i) = \propto + \delta_1 \partial_i + \delta_2 X_i + \varepsilon_1 \qquad (11)$$

The error term ε_1 follows a random distribution. The constant term $\propto$ represents the intercept, while δ_1 and δ_2 are model parameters slated for estimation. Specifically, δ_1 denotes the effect of diversification status on profit.

From literature reviewed, income diversification is also affected by education level, farm size, membership in farmer-based organizations, credit accessibility, savings groups, and others (Dagunga et al., 2018; Asravor, 2018). This study also seeks to investigate if the level of cocoa farm profitability is one of the factors that affect the diversification of cocoa farmers. For this study, diversification is defined in terms of other agricultural activities undertaken together with cocoa. This may be on the same cocoa plot, as is the case with some food crops and livestock, or on other plots of land, as is the case with farmers who diversify into other tree crops such as rubber, oil palm and coconut. For this, a probit model with On-Farm Income

Diversification (∂_i), proxied as 1 if diversified or 0 if not diversified, was the dependent variable, and economic profit, defined as economic profit per hectare, and other farmer and plot demographics as explanatory variables.

$$\partial_i = \eta + \beta_1 E\pi + \beta_2 X_i + \varepsilon_2; \qquad (12)$$

$$\varepsilon_2 | \, N(0,1)$$

The Conditional Mixed Process (CMP) model was used to evaluate the relationship between the two dependent variables, profitability (proxied as log of gross profit) for the OLS model and on-farm income diversification (proxied as dummy, where 1 = diversified and 0 = non-diversified) for the probit model. With this approach, it is possible to implement equations (11) and (12) simultaneously in a system. This method works well for handling possible endogeneity and selectivity problems. Roodman et al., (2022) introduced the CMP framework, which makes it easier to model multiple equations at once, including error term cross-equation correlation, integrate these models in multi-equation systems, and take individual model variation into account across observations. The two equations were fitted into a single CMP model as:

$$y_1^* = \theta_1 + \varepsilon_1 \qquad (13)$$

$$y_2^* = \theta_2 + \varepsilon_2 \qquad (14)$$

Where $\theta_1 = \propto + \delta_1 \partial_i + \delta_2 X_i$ (equation 11)

and $\theta_2 = \eta + \beta_1 E\pi + \beta_2 X_i$ (equation 12)

$$y = g(y^*) = (1\{y_1^* > 0\}, y_2^*) \qquad (15)$$

$$\text{Where } \epsilon = (\varepsilon_1, \varepsilon_2)' \sim N(0, \Sigma),$$

$$\text{and } \Sigma = \begin{bmatrix} 1 & \rho_{12} \\ \rho_{21} & 1 \end{bmatrix}$$

The association between the error terms in the economic profit and diversification equations is indicated in this case as $\rho_{12} = \rho_{21}$. The latent variables y_1^* and y_2^* respectively, indicate the profitability and diversification status latent factors.

The hypothesis to be tested is stated below:

> H_o (Null hypothesis): There is a no positive covariation between profitability and on-farm income diversification and between on-farm income diversification and profitability among cocoa farmers in the Ashanti and Western regions of Ghana.
>
> H_1 (Alternate hypothesis): There is a positive covariation between profitability and on-farm income diversification and between on-farm income diversification and profitability among cocoa farmers in the Ashanti and Western regions of Ghana.

Decision Rule:

If Prob>Chi^2 for On-Farm Income Diversification is less than the critical value in the Profitability equation AND Prob>Chi^2 for Profitability is less than the critical value in the On-Farm Income Diversification equation is less than the critical value, then we reject the Null hypothesis. We accept the alternate hypothesis if otherwise.

Treatment for Endogeneity in the CMP Model

Whereas traditionally, endogeneity is treated with the use of instrumental variables, several studies utilize the CMP in estimating systems of equations without the use of instrumental variables. Alhassan et al. (2020) adopt the use of the CMP to investigate the relationship between credit and productivity as well as the relationship between market involvement and productivity under a simultaneous modelling framework that includes credit, productivity, and market participation. The study applies the conditional mixed process estimation technique to correct for selectivity bias and unobserved endogeneity. From the study, it was found that credit positively impacts productivity, which in turn positively impacts market participation.

Another study by Nguyen et al. (2018) explores a reverse causality similar to this study's third objective, which is to determine the relationship between diversification and economic profitability of farmers in the Ashanti and Western Regions of Ghana using the CMP, without the use of instrumental variables. The study explored the relationship between ownership concentration, innovation, and firm performance in small and medium-sized firms (SMEs) in Vietnam from 2011 to 2015. Using a CMP model, the results demonstrate that ownership concentration positively impacts sales growth but has no effect on innovation; innovation has a positive impact on firm performance; and there is a positive reverse causality between innovation and sales growth.

Furthermore, studies also demonstrate that further robustness can be achieved with the CMP in treating endogeneity and selection bias, using advanced user written commands which build on the existing default CMP commands in the Stata application (Bartus & Roodman, 2014).

The CMP model by Roodman (2011) can cater for possible endogeneity which may exist between the 2 dependent variables if the 2 equations were to be modelled separately in the following ways:

Use of Latent Variables:

In the CMP model, unobservable factors, or latent variables y_1^* and y_2^*, are introduced to capture hidden sources of heterogeneity or endogeneity within the system. These latent variables represent the concealed elements of the diversification and profitability equations, and by incorporating them, the model seeks to address potential endogeneity.

Equation System:

The CMP model engages in the simultaneous estimation of multiple equations within a system. By jointly estimating the diversification and economic profit equations, the model takes into account the mutual dependence between the two variables, thereby tackling potential endogeneity concerns that might arise when estimating them separately.

Correlation Between Equations:

The CMP model permits the incorporation of cross-equation correlation of error terms. This implies that the errors in one equation can exhibit a correlation with the errors in another equation. This feature is designed to capture possible connections or interdependencies between the errors of the diversification and profitability equations, which could stem from endogeneity.

Individual Model Variability by Observations

Within the CMP framework, allowance is made for individual model variability based on observations. This signifies the model's acknowledgement that different observations may possess distinctive characteristics or behaviors. By accommodating variation at the individual level, the CMP model can account for idiosyncratic factors that may contribute to endogeneity.

Two-Step Estimation

The process of estimating CMP models typically involves a two-step approach. In the initial step, latent factors are estimated, and in the subsequent step, the parameters of the equations are estimated. This dual-step methodology enhances the efficiency of model estimation and assists in managing potential endogeneity issues effectively (Roodman, 2011; Roodman et al., 2022).

In this chapter, the geographical areas where data was taken for this study have been introduced, that is the Elembelle and Wassa Amenfi Central districts in the Western Region and the Afigya Kwabre North district in the Ashanti region. The chapter also elaborated on the method of determination of the sample size and the use of the mixed sampling approach to select the sample for the study. The chapter also introduces 5 theories which form the framework on which this study is built. The chapter finally elaborates on how the financial and economic profitability of cocoa farm plots is estimated. The chapter also outlines the use of the stochastic frontier model to estimate the profit efficiency of cocoa farm plots and also the use of the Conditional Mixed Process to investigate the relationship between on-farm income diversification and profitability. The next chapter discusses the results of the study, where the methodology outlined in this chapter is operationalized to test the hypothesis stated.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Introduction

This chapter presents the results and discussions of the study's specific objectives. The chapter presents the descriptive statistics from the data generated related to cocoa farms. Subsequently, the results of estimations from the study's three main objectives are presented and discussed.

4.2. Descriptive Statistics

4.2.1. Socioeconomic Characteristics

Table 4.1 presents a summary of the socioeconomic characteristics of the cocoa farmers interviewed for this study in July 2022. The average age of the cocoa farmers is 51 years, with a standard deviation of 13.96 years. This means that most of the farmers are middle-aged or older. The minimum age is 23 years and the maximum age is 93 years. About 15.67% of the farmers are between 18 and 35 years old, 58.96% are between 36 and 60 years old, and 25.37% are above 60 years old. This suggests that the younger generation is less involved in cocoa farming, which may have implications for the future sustainability and growth of the sector.

Table 4.1: Summary of Descriptive Statistics of Socioeconomic Variables

Variable	Observations	Mean	Std. dev.	Min	Max
Age	402	50.559	13.964	23	93
Age	*Frequency*	*Percentage*	*Cumulative*		
18 -35	*63*	*15.67%*	*15.67%*		
36 - 60	*237*	*58.96%*	*74.63%*		
above 60	*102*	*25.37%*	*100.00%*		
Gender	402	0.714			
Marital Status	402				
Marital Status	*Frequency*	*Percentage*	*Cumulative*		
Single	*10*	*2.49%*	*2.49%*		
Married (Civil)	*28*	*6.97%*	*9.45%*		
Married (Traditional)	*292*	*72.64%*	*82.09%*		
Widowed	*45*	*11.19%*	*93.28%*		
Divorced or separated	*20*	*4.98%*	*98.26%*		
Cohabitation	*7*	*1.74%*	*100.00%*		
Household size	402	5.306	2.383	1	16
Household size	*Frequency*	*Percentage*	*Cumulative*		
0 to 4	*150*	*37.31*	*37.31*		
5 to 9	*233*	*57.96*	*95.27*		
10 to 14	*18*	*4.48*	*99.75*		
15 and above	*1*	*0.25*	*100*		
Years of experience	402	17.52	11.423	1	66
Years of Experience	*Frequency*	*Percentage*	*Cumulative*		
0-4yrs	*26*	*6.47*	*6.47*		
5-14yrs	*157*	*39.05*	*45.52*		
15-24	*122*	*30.35*	*75.87*		
25 and above	*97*	*24.13*	*100*		
Training in past 5 years	402	0.689	0.463		
Certification program participation	402	0.037			
FBO membership	402	0.746			
Credit access in past year	402	0.376			
Formal bank account ownership	402	0.567			
Native/migrant	402	0.557			

Source: Author's Field Data Collection, 2022

In terms of the gender of respondents, 71.39% of the farmers are male and 28.61% are female. This indicates that cocoa farming is dominated by men, and there may be gender inequalities and barriers for women to participate in the sector. For women, these include challenges with access to credit, access to and use of inputs and other cultural factors (Hiscox et al., 2014).

For the study, marital status was categorized into six options: single, married (civil), married (traditional), widowed, divorced or separated, and cohabitation. The results show that 2.49% of the farmers are single, 6.97% are married (civil), 72.64% are married (traditional), 11.19% are widowed, 4.98% are divorced or separated, and 1.74% are cohabiting. This shows that most of the farmers (79.61%) are married, and there is a low rate of cohabitation. Marital status may affect the household decision-making and labour allocation of the farmers.

The household size variable measures the number of people living in the same household as the farmer. The average household size of the sample was found to be 5.31, with a standard deviation of 2.38. Comparatively, a national average of 4.2 was reported from the Ghana Living Standards Survey 7 (GLSS 7) conducted by the Ghana Statistical Service (GSS) in 2021. Furthermore, the 2021 Ghana Population and Housing Census (GSS, 2022) study estimated regional average household sizes of 3.3 and 3.4 for the Western and Ashanti regions respectively. This implies that the farmers in this study have relatively large families in comparison with the national and respective regional averages. The minimum household size is 1, where the farmer lives alone, and the maximum household size is 16. The frequency table shows that 37.31% of the farmers have a household size of 0 to 4, 57.96% have a household size of 5 to 9, 4.48% have a household size of 10 to 14, and 0.25% have a household size of 15 and above. This suggests that most of the farmers have a moderate to large household size, which may influence labour availability, household income and expenditures patterns.

The "years of experience" variable measures the number of years that the farmer has been engaged in cocoa farming. The average years of experience is 17.52 years, with a standard deviation of 11.42. The minimum value of years of experience is 1 and the maximum years of experience is 66. About 6.47% of farmers in the sample have 1 to 4 years of experience, 39.05% have 5 to 14 years of experience, 30.35% have 15 to 24 years of experience, and 24.13% have

25 and above years of experience. This indicates that most of the farmers (54.48%) have been in the sector greater than 15years and have significant practical knowledge in cocoa farming.

In terms of training in cocoa production, 68.91% of the farmers have received some form of training in the past 5 years and 31.09% have not. This shows that most of the farmers have access to training opportunities, which may improve their knowledge, skills, and practices in cocoa farming.

Only 3.73% of the farmers are part of a certification program and 96.27% are not. This indicates that participation in certification programs is very low among the farmers despite the growing percentage of cocoa produced under certification programs (Iddrisu et al., 2020). This may limit their access to premium markets and incentives for sustainable and quality cocoa production.

About 74.63% of the farmers are members of a farmer-based organization (FBO) and 25.37% are not. This suggests that most of the farmers are organized and affiliated to groups, which should have the potential to enhance their collective bargaining power, access to inputs and services, and social capital.

Access to credit is a key variable in the productivity of many agricultural value chains in Ghana (Alhassan et al., 2020b; Ankrah-Twumasi et al., 2019). About 37.56% of the farmers have accessed credit in the past year and 62.44% have not. This implies that access to credit is limited among the farmers, which may constrain their investment and working capital needs for cocoa farming.

As shown in Table 4.2, The result of the survey indicates that the most common educational level among the farmers in the Ashanti Region is at least Junior High School (JHS), with 72 out of 143 (50.35%) having completed at least JHS.

Table 4.2 Levels of Education

Educational Level	**Ashanti Region**	**Western Region**	**Total**
No education	22 (15.38%)	71 (27.24%)	93 (23.00%)
Completed at least primary school	28 (19.58%)	60 (23.35%)	88 (22.00%)
Completed at least Junior High School	72 (50.35%)	90 (34.63%)	162 (40.25%)
Completed at least Senior High School	15 (10.49%)	29 (11.28%)	44 (11.00%)
Completed at least Tertiary or above	6 (4.20%)	9 (3.50%)	15 (3.75%)
Total	143 (35.75%)	259 (64.25%)	402 (100%)

Source: Field Data Collection, 2022

In general, the overall distribution of the educational level of the farmers is similar to the distribution in the Western Region, as the Western Region has more farmers than the Ashanti Region. The most common educational level among the farmers across both regions is at least JHS, with 162 out of 400 (40.25%) having completed at least junior high school. The second most common educational level among farmers interviewed in the Ashanti Region is at least primary, with 28 out of 143 (19.58%) having completed at least primary school. The least common educational level in the Ashanti Region is Tertiary, with only 6 out of 143 (4.20%) having attained a tertiary degree. The table also reveals that commonly, farmers in the Western Region have had no formal education, with 71 out of 257 (27.24%) having no formal education. A multivariate test of means conducted confirms that the observed difference in educational level between the two districts is statistically significant (See Appendix 2).

About 56.72% of the farmers own a formal bank account and 43.28% do not.

Also, 55.72% of the farmers are native to the community where they farm and 44.28% are migrant. This shows that there is a significant proportion of migrant farmers in the sector, who may face different challenges and opportunities than the native farmers.

4.2.2. Plot Level Characteristics

Table 4.3 shows the summary statistics of plot level variables for cocoa farmers in the Western and Ashanti regions of Ghana related to their cocoa production and profitability. The variables include the distance between where the farmer lives and the location of the farm, age of farm plot, cocoa variety planted, farm area, yield, revenue, expenditure on various inputs and costs, and estimated gross profit.

Table 4.3 Summary of Plot Level Characteristics

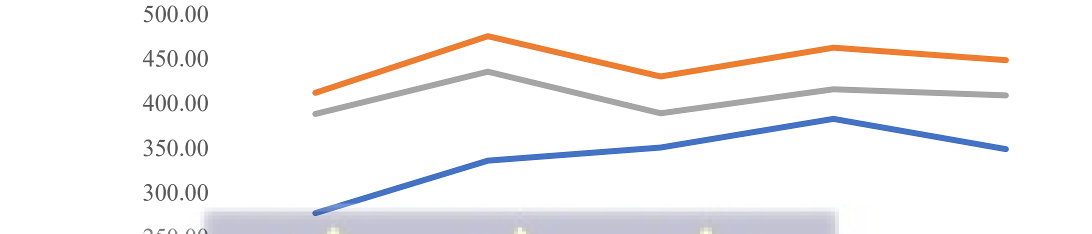
Variable	Observations	Mean	Std. dev.	Min	Max
Farm distance from dwelling (km)	513	3.29	4.19	0.00	59.76
Age of Plot (years)	513	17.55	8.92	2	40
Number of plots owned	513	1.32	0.63	1	5
Cocoa variety cultivated					
Variety	**Count**	**Percentage**			
Tetteh Quarshie only	*63*	*12%*			
Hybrid only	*244*	*48%*			
Amazonia only	*74*	*14%*			
Other (including mixed)	*132*	*26%*			
	513	*100%*			
Farm Area (hectares)	513	2.23	2.20	0.40	20.24
Yield (kgha-1)	513	411.57	301.03	0.51	1,580.80
Revenue per ha (GHS/ha)	513	4,693.23	3,464.58	5.74	17,932.20
Expenditure on fertilizer per ha (GHS/ha)	513	226.58	620.59	0.00	6,298.50
Expenditure on pesticide per ha (GHS/ha)	513	253.44	494.48	0.00	5,928.00
Expenditure on fungicide per ha (GHS/ha)	513	84.46	186.42	0.00	2,470.00
Expenditure on herbicides per ha (GHS/ha)	513	110.39	441.24	0.00	8,645.00
Expenditure on labour per ha (GHS/ha)	513	364.95	728.75	0.00	8,496.80
Expenditure on other costs & overheads per ha (GHS/ha)	513	389.80	644.19	0.00	4,940.00
Gross profit per ha (GHS/ha)	513	3,263.60	3,416.13	-8,875.95	16,709.55

Source: Author's Field Data Collection, 2022

As cocoa marketing is a monopsony market with farmgate prices set by COCOBOD, the selling price of cocoa is constant for all farmers. At the time of data collection for this study, that is July 2022, the farmgate price per 64kg bag of cocoa was GHS660.00.

The average farm distance from dwelling measures the distance between the farmer's dwelling and the farm in kilometres.

Figure 4.1 Farm Plot Age versus Yield (kilogram/ha) per Region[2]



	3 - 7 years	8 - 15 years	16 - 30 years	31 years	Pooled
Ashanti Region	277.25	335.92	350.65	382.80	348.90
Western Region	411.95	475.33	430.39	462.35	448.47
Pooled	388.28	435.61	389.03	415.94	408.99

Source: Field Data 2022

Table 4.4 Multivariate Test of Means for Yield Among 4 Plot Age Categories in Ashanti and Western Regions

Statistic	**F**	**df 1**	**df 2**	**F**	**Prob>F**
Wilks' Lambda	0.9958	3	509	0.72	0.5411
Pillai's trace	0.0042	3	509	0.72	0.5411
Lawley-Hotelling trace	0.0042	3	509	0.72	0.5411
Roy's largest root	0.0042	3	509	0.72	0.5411

Source: Authors Construct

[2] Farm plot age category 31years refers to farm plots that are aged 31years and above.

Table 4.4 shows the results of the multivariate test of means which aims to test the statistical difference in mean yield across the 4 cocoa plot age categories in the 2 regions (presented in figure 4.1). The test as executed in Stata produces results from 4 different test statistics, namely Wilks' Lambda, Pillai's trace, Lawley-Hotelling trace and Roy's largest root. From the results, each of the test statistics agree that there is no statistical difference in in mean yield across the four plot age categories, between cocoa farm plots in the Western Region and plots in the Ashanti Region, despite the observed differences. In figure 4.1, the pooled yield is 409kg/ha compared to the regional yields of 448kg/ha for the Western region and 349kg/ha for the Ashanti region.

On average, farmers travel 3.29 kilometres to reach their farms. The extremes are the case of farmers who live on their farms, which is the case for the minimum value of 0. Other farmers have farms which are a significant distance away from their dwelling, for which case a maximum of 59.76 kilometres is observed.

Again, the average cocoa farm plot is 17.55 years old. The standard deviation of this variable is 8.92 years. From the data, the minimum farm plot age is two years, and the maximum of this variable is 40 years. Collectively, the data suggests that most farms sampled for this study (71.48%) are mature farms, that is between the ages of 8 to 30 years old. This will have implications for the output produced as well as the profit that farmers may be able to generate from these farms.

On the average, the sample of cocoa farmers used in this analysis from the cocoa farmers interviewed in the survey, owned 1.32 cocoa farm plots. From Knudsen & Fold, (2011), the possibility of acquiring cocoa farm plots by inheritance and through multiple land tenurial agreements enables the ownership or operation of multiple cocoa farm plots, as is seen in this study.

The cocoa varieties cultivated on the plots analysed for this study were classified into four, namely plots with Tetteh Quarshie variety only, Hybrid only, Amazonia only and other, including plots with a mixture of the main varieties (table 4.5). From the study, the main cocoa variety cultivated across the plots is the hybrid variety (48% of cocoa plots). In terms of distribution of the variety of cocoa types within the Ashanti and Western region plots, it is observed that whereas hybrid only is the clear predominant variety cultivated on cocoa farm plots in the Western region, in the Ashanti region, for the sample used for the analysis, hybrid only is not overwhelmingly the major variety cultivated. The data shows a number of farm plots have Tetteh Quarshie only and other varieties, most likely a mix of hybrid and Tetteh Quarshie.

Table 4.5: Distribution of Variety of Cocoa Cultivated by Region

Variety	**Western Region**	**Ashanti Region**	**Total**
Tetteh Quarshie only	19 (6%)	44 (22%)	63
Hybrid only	178 (57%)	66 (33%)	244
Amazonia only	44 (14%)	30 15%)	74
Other (including mixed)	69 (22%)	63 (31%)	132
Total	**310**	**203**	**513**

Source: Field Survey 2022

A multivariate test conducted shows that the observed differences in the varieties planted on the farm plots are significantly different (see Appendix 3).

The variety of cocoa cultivated has implications for yield achieved from the cocoa plots (Brako et al., 2021). A further breakdown of the yield per hectare per type of variety cultivated on the cocoa farm plots indicates an observable difference in the yield (table 4.6). Hybrid and Amazonia varieties exhibit relatively higher yields.

Table 4.6: Distribution of Yield of Variety of Cocoa Cultivated by Region

	Yield (kg/ha)		
Variety	**Western**	**Ashanti**	**Pooled**
Tetteh Quarshie only	310.98	365.21	348.85
Hybrid only	429.84	348.03	407.71
Amazonia only	498.29	367.24	445.16
Other (including mixed)	521.22	329.69	429.81
Pooled	452.61	348.90	411.57

Source: Field Survey 2022

A multivariate test of means conducted indicates that the difference in yield observed among the various groups is statistically significant (see Appendix 4).

The farm area variable measures the size of cocoa farms in hectares. The mean farm size is 2.23 hectares. This is consistent with a number of studies that also allude to the average farm sizes in the cocoa industry being about two to five hectares (Aneani & Padi, 2016; ICI, 2023; Yiridomoh et al., 2022). Farm plots in the sample were of variable sizes, with a standard deviation of 2.20 hectares, a minimum farm size of 0.4 hectares and a maximum of 20.24 hectares.

The yield variable measures the cocoa production of farmers for each plot owned in kilograms per hectare. On average, the farm plots produce 411.57 kilograms of cocoa per hectare. In comparison, studies by Iddrisu et al. (2020) and Aneani et al. (2011) recorded similar yields of 391kg/ha and 338kg/ha respectively. There's also a variation in yield, with a sample standard deviation of 301.03 $kgha^{-1}$, minimum of 0.51 $kgha^{-1}$, and maximum of 1,580.80 $kgha^{-1}$.

In Ghana, farmgate prices of cocoa per 64kg bag are set by the government through COCOBOD. Thus, there is no variation in prices received by farmers. At the time of this study (July 2022), the price per 64kg bag of cocoa was GHS660 ($89.31, at an exchange rate $1 to GHS 7.39 as at July 2022), which was the prevailing price for the 2021/2022 cocoa buying season.

On average, farmers earn GHS4,693.24 ($177.27) of revenue per hectare. There is some variability in revenue per hectare earned by farmers, with some farmers earning as much asGHS17,932.20 ($1,218.77) per hectare of cocoa farm and others earning nothing at all, implying no production for the period under study. Because the price is fixed, the observed variations in revenue per hectare are attributable to the variations in yield or productivity.

For this study, farm expenditures covered are for the 2021/2022 season and include expenditures on fertilizer, pesticides (including insecticides) fungicides, herbicides, labour, other expenses, and farm-related overheads such as rent, transportation and permanent labour. For each of these per hectare expenditure items, high standard deviations relative to the means were recorded, indicating that there is a wide variation in the expenditure incurred.

Farmers spent an average of GHS226.58 ($28.57) on fertilizer per hectare in the 2021/2022 season. The standard deviation of GHS620.59 ($78.26) implies that, similar to other expenditures recorded, there is a large variation in the expenditure on fertilizer among the farmers. The maximum recorded expenditure on fertilizer per hectare for the season was GHS6,298.50 ($794.26).

For pesticides, the average farmer spends GHS253.44 ($31.96) per hectare. Again, the standard deviation of GHS494.48 ($62.36) suggests that there is a large variation in the rate of use of pesticides among the farmers. The maximum expenditure per hectare on pesticide recorded is GHS5,928 ($747.54).

The other categories of agrochemicals which farmers expend on are fungicides and herbicides. Farmers spend GHS84.46 ($10.65) and GHS110.39 ($13.93) on fungicides and herbicides respectively. Fungicides are an essential agrochemical as they are used to control fungal diseases such as black pod disease. Herbicides are also used to control weeds as an alternative to manual forms of weed control (Danso-Abbeam et al., 2014). The maximum observed amount spent on fungicide and herbicide was GHS2,470 ($311.48) and GHS8,645 ($1,090.16) respectively.

Farmers spent GHS364.95 ($46.02) on labour per hectare. Some farmers also incur no labour costs, which implies that they may be using family or communal labour that does not carry immediate explicit costs but may be compensated for in kind.

Farmers incur expenditure on other costs & overheads, which may include land rent, equipment, transportation and others. The average spent on overheads was GHS389.80 ($49.16), with some farmers spending as high as GHS4,940 ($622.95).

Gross profit per hectare was chosen as the proxy for profitability in this study. The mean of this variable is GHS3,263.60 ($411.55). In comparison, Akrofi-Atitianti et al. (2018) reported an average cocoa farm income per hectare of GHS1,726 (approximately $454), which is similar to this study's findings.

Cocoa farmers in the study were observed to be diversified into various farm and non-farm activities in addition to their cocoa enterprises. For this study, only farm-based diversification strategies were considered. The study considers that the resources and human capital required for undertaking farm-based diversification are homogenous. However most non-farm-based livelihoods may require significant amounts of capital, knowledge and specialized training. This study sought to investigate if the choice of farm-based income diversification strategy affects the profit efficiency of cocoa farm plots. Farm-based diversification refers to the practice of expanding agricultural activities beyond cocoa production to include other crops or livestock (Iritié & Djaléga, 2016). Farm-based diversification has the potential to significantly impact the profitability of cocoa farms. By including other crops or livestock, farmers can spread their income sources, reduce the risks associated with relying solely on cocoa production and have access to funds during the minor season to reinvest in farm inputs such as fertilizer, thereby increasing their productivity and profitability (Iritié & Djaléga, 2016). However, diversification can also put a strain on farmers as they need to allocate more resources and time to manage multiple crops or livestock (Iritié & Djaléga, 2016). This can potentially increase expenses and reduce the time available for cocoa farming activities. In this study, 3 types of diversification options with cocoa were found: other tree crops, food crops and livestock.

Table 4.7 presents a breakdown of the on-farm income diversification options engaged in by the owners of the 513 cocoa plot farms surveyed for this study. Diversification includes activities taking place on the cocoa farm plot. Cocoa farmers in both regions who do not practice any diversification, that is specialized farmers, (68 in Ashanti (33.5%) and 98 in Western (31.7%), are in the minority (32.4%).

Table 4.7 Cocoa Plot Owners' On-Farm Income Diversification Strategies by Region

Diversification Strategy	**Ashanti Region**		**Western Region**		**Pooled**	
Cocoa only (not diversified)	68	33.5%	99	31.9%	167	32.6%
Cocoa with (diversified):						
Tree crop	*4*	*2.0%*	*17*	*5.5%*	*21*	*4.1%*
Food crop	*73*	*36.0%*	*73*	*23.6%*	*146*	*28.5%*
Tree crop+food crop	*7*	*3.4%*	*18*	*5.8%*	*25*	*4.9%*
Livestock	*5*	*2.5%*	*28*	*9.1%*	*33*	*6.4%*
Tree crop+livestock	*3*	*1.5%*	*4*	*1.3%*	*7*	*1.4%*
Food crop+livestock	*41*	*20.2%*	*49*	*15.9%*	*90*	*17.5%*
Tree crop + Food crop + Livestock	*2*	*1.0%*	*22*	*7.1%*	*24*	*4.7%*
	135	66.5%	211	68.3%	346	67.4%
	203	**100%**	**309**	**100%**	**513**	**100%**

Source: Author's Construct

The most common type of on-farm income diversification *with* cocoa in both regions is cocoa with food crops. This can provide food security and additional income for the cocoa farmers.

The least common type of diversification in both regions is cocoa in addition to tree crops, livestock, and food crops. This may be due to the high labour and capital requirements, as well as the potential competition among the different enterprises.

4.3. Financial Profitability Analysis of Cocoa Farm Plots

The first objective of this study was to estimate the financial and economic profitability of cocoa farm plots in the study areas. The economic profit as indicated in the methodology section, was calculated by estimating financial profit, and subtracting the implicit cost, which is profit from tree crop options of the same age category from the financial profit estimated. The gross profit of cocoa farm plots was computed based on the primary data collected from the cocoa farmers as the main measure of financial profitability of cocoa farm plots. As the price of cocoa at farmgate is fixed, yield is the main driver of variations in revenue. This section analyses the operating cost of farm plots in addition to the financial and economic profit of cocoa farm plots.

In all, 513 farm plots from the data collected were used for this computation. To ensure data quality, the study utilized data from currently productive cocoa farm plots only, implying that farms which had no output for the period under review were dropped from the sample being analyzed to arrive at the sample size of 513 plots. From Atkins & Eastin (2012), the analysis and comparison of financial and economic profit can be undertaken based on age categorization, with four distinct categories of cocoa farm plots: 3 -7 years, 8 – 15 years, 16 – 30 years and above 30 years. These categories represent different stages in the growth of cocoa trees over time, adapted from Atkins et al. (2012). Table 4.8 provides the summary statistics of data used for the computation of the financial profitability and economic profitability of cocoa farm plots surveyed.

Table 4.6 presents the total operating cost per hectare of cocoa farm plots disaggregated by age of plot category per region. The operating cost captures all the direct cost and overhead costs, excluding capital expenditures (purchase of assets which will be used across more than a year), depreciation and interest payments. The average operating cost recorded was GHS1,430.83 ($193.62) per hectare. Farmers in the Western Region spend significantly more on their cocoa farm plots compared to farmers in Ashanti region at each age category. Across the four categories, on average farmers in the Western region spends twice the expenditures, GHS1,857.59 ($251.37) compared to GHS781.23 ($105.71)] spent by farmers in the Ashanti region.

Table 4.8 Total Operating Cost per hectare (GHS/ha) of Cocoa farm Plots

	3 - 7years	8 - 15years	16 - 30years	31 years and above	Pooled
Ashanti Region	425.70	874.45	740.23	872.78	781.23
Western Region	1,765.37	1,980.37	1,886.71	1,433.87	1,857.59
Pooled	1,530.03	1,665.28	1,292.01	1,106.57	1,430.83

Source: Field Survey 2022

The multivariate test of means was adopted to investigate the statistical significance of the observed means. Results of the test are shown in Table 4.9.

Table 4.9 Multivariate Test of Means for Total Operating Cost per hectare Among 4 Plot Age Categories in Ashanti and Western Regions

Statistic	F	df 1	df 2	F	Prob>F
Wilks' Lambda	0.9854	3	509	2.51	0.0581
Pillai's trace	0.0146	3	509	2.51	0.0581
Lawley-Hotelling trace	0.0148	3	509	2.51	0.0581
Roy's largest root	0.0148	3	509	2.51	0.0581

Source: Author's Construct (2025)

The observed difference in mean operating cost across the different age groups in the different regions is confirmed to be statistically significant at 10% by all 4 test statistics used in the computation. This confirms that farmers in the Western Region have significantly higher operating costs than farmers in the Ashanti Region.

The mean yield observed in the two regions was also analysed. A test of means conducted as shown in Table 4.10 indicates that the observed differences between the mean yield per hectare among the 2 regions was not statistically significant. This means that despite the significant difference in expenditure levels, this did not translate into statistically significant higher yield in the Western Region, implying a potentially higher allocative inefficiency compared to farm plots in Ashanti Region.

Table 4.10 Multivariate Test of Mean Yield/ha between Western and Ashanti Region Plots

	Statistic	df1	df2	F	Prob>F
Wilks' lambda	0.9958	3	509	0.72	0.5411
Pillai's trace	0.0042	3	509	0.72	0.5411
Lawley-Hotelling trace	0.0042	3	509	0.72	0.5411
Roy's largest root	0.0042	3	509	0.72	0.5411

Source: Author's Construct (2025)

Overall, the pooled average Operating Profit per hectare (table 4.11) was GHS3,258.15 ($440.89). Studies identified on cocoa enterprises in Ghana focus on NPV and IRR as measures of profitability. For instance, Yahaya et al., (2015) conducted a net profit assessment of cocoa farm income in Ghana. The study found a net profit per hectare of GHS956.78 ($281.41) markedly lower than the levels computed for this study.

Table 4.11 Financial Profit (gross profit/ha) of Cocoa farm Plots (GHS)

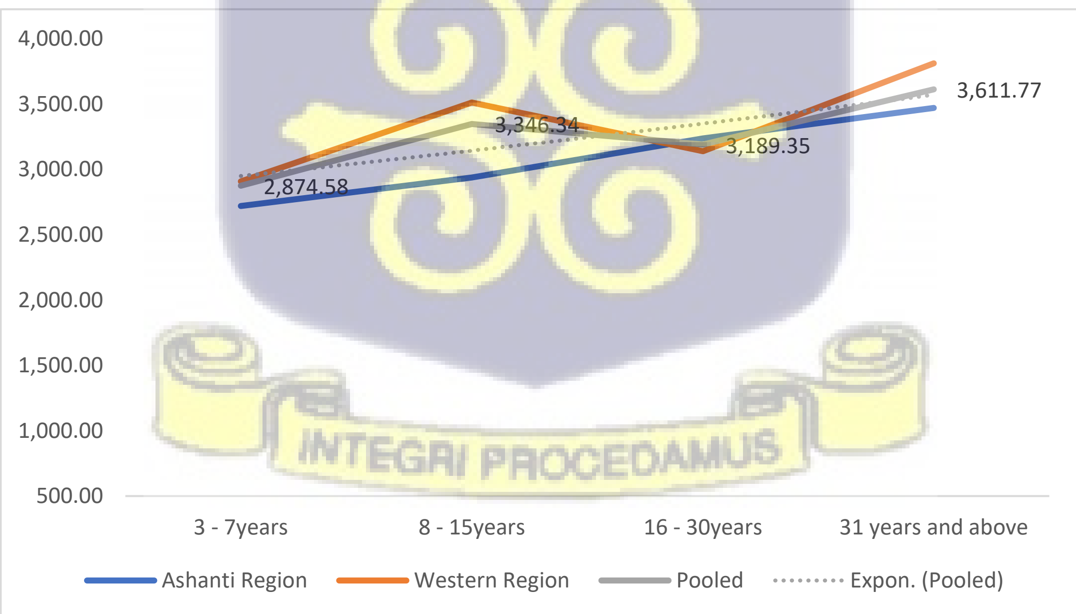
Region	3 - 7years	8 - 15years	16 - 30years	31 years and above	Pooled
Ashanti Region	2,719.34	2,936.19	3,237.42	3,469.56	3,176.59
Western Region	2,907.66	3,509.76	3,137.54	3,810.87	3,311.72
Pooled	2,874.58	3,346.34	3,189.35	3,611.77	3,258.15

Source: Author's Construct

Analyzing the gross profit/ha estimated, farmers earn an average gross profit margin of 69%, taking the pooled gross profit per hectare of GHS3,258.15 as a percentage of the pooled revenue per hectare of GHS4,693.23. From the Global Fairtrade Initiative's baseline study conducted in Ghana in 2017 (Fairtrade International, 2017), the gross margin on cocoa production was estimated at 70%, which is consistent with this study's results.

Farmers in the Western Region make a profit of GHS3,311.72.91 ($448.14) per hectare, whilst farmers in the Ashanti Region make a marginally lower profit of GHS3,176.59 ($429.85) per hectare. As presented in Table 4.11, across the 4 plot age categories, the mean gross profit per hectare for cocoa plots in the Western region was higher than that of the Ashanti region, except for plots aged 16 to 30 years and above. The highest mean gross profit per hectare in each region, which is GHS3,810.87 ($515.68) for the Western region, and GHS3,469.56 ($469.49) for the Ashanti Region, was observed for plots aged above 31 years. The lowest mean gross profit per hectare for each region was recorded for plots aged 3 to 7 years, which is GHS2,907.66 ($393.46) for plots in the Western region and GHS2,719.34 ($367.98) for plots in the Ashanti region. Overall, gross profit per hectare remains relatively flat as the plot age increases (See Figure 4.2). This trend is inconsistent with projections and recommendations from COCOBOD and GIRSAL. Operating costs are expected to remain relatively consistent even as yields grow, plateau, and decline with the cocoa farm plot age. Thus, profitability is also expected to follow a similar trend. However, farmers in the sample studies, fail to achieve the peak yields and thus associated profits during the peak maturity of the cocoa tree plots, which is between ages 7 to 20 years.

Figure 4.2 Operating Profit per hectare (GHS)



Source: Author's Construct

A multivariate test of means conducted to test the significance in observed difference in mean operating profit per hectare across the plot age categories and between the two regions shows that the observed differences are statistically not significant as shown in Table 4.12.

Table 4.12 Multivariate Test of Means for Operating Profit per hectare Among Plot Age Categories in Regions

Statistic	F	df1	df2	F	Prob>F
Wilks' Lambda	0.980	7	506	1.460	0.178
Pillai's trace	0.020	7	506	1.460	0.178
Lawley-Hotelling trace	0.020	7	506	1.460	0.178
Roy's largest root	0.020	7	506	1.460	0.178

Source: Author's Construct

Sensitivity Analysis of Operating Profit per Hectare for Cocoa Farm Plots

From the analysis, the average yield of farmers per hectare was 411.57kg/ha. Whilst this is consistent with smallholder yields from other studies (Aneani & Padi, 2016; Danso-Abbeam & Baiyegunhi, 2020) it is still below attainable yield levels. Comparing yields and costs of production of various farm plots to recommended attainable standard levels, it is below the COCOBOD and the Ghana Incentive-Based Risk-Sharing System for Agricultural (GIRSAL) recommended peak yield levels for smallholders (Amponsah-Doku et al., 2022). Table 4.13 presents the attainable yields per hectare and associated cost at every age of cocoa plots per the COCOBOD and GIRSAL standards.

Table 4.13 Attainable Cocoa Output per Hectare and Associated Operating Cost per Hectare

Year of cocoa farm plot	Expected Output (kg/ha)	Projected Operating Cost/ha
1	0	GHS 8,909.00
2	0	GHS 4,645.30
3	250	GHS 4,614.50
4	300	GHS 4,500.10
5	350	GHS 5,388.90
6	400	GHS 5,629.80
7	450	GHS 6,213.90
8	500	GHS 6,213.90
9	600	GHS 6,213.90
10	700	GHS 6,213.90
11	750	GHS 6,213.90
12	800	GHS 6,213.90
13	900	GHS 6,213.90
14	1000	GHS 6,213.90
15	1200	GHS 6,213.90
16	1200	GHS 6,213.90
17	1200	GHS 6,213.90
18	1000	GHS 6,213.90
19	900	GHS 6,213.90
20	800	GHS 6,213.90
21	650	GHS 6,213.90
22	875	GHS 6,213.90
23	650	GHS 6,213.90
24	650	GHS 6,213.90
25	650	GHS 6,213.90
26	650	GHS 6,213.90
27	650	GHS 6,213.90
28	650	GHS 6,213.90
29	650	GHS 6,213.90
30	650	GHS 6,213.90
31 and above	650	GHS 6,215.00

Source: Adapted from GIRSAL, 2022.

Further comparison of plot ages against the attainable yields and associated costs per plot age (Table 4.14) shows that on average, cocoa farm plots in the Ashanti Region attain only 52% of attainable yields and utilize only 21% of the recommended total operating cost required to achieve attainable yield levels. Cocoa farm plots in the Western Region attain only 62% of attainable yields whilst utilizing 67% recommended cost per hectare required to achieve the attainable yield levels.

Table 4.14 Percentage of Attainable Yield and Associated Operating Cost per Hectare Achieved by Region

Region	% of Recommended Cost Utilized	% of Attainable Yield Achieved
Ashanti Region	21%	52%
Western Region	67%	62%
Pooled	49%	58%

Source: Author's Construct

Based on this, a sensitivity analysis was conducted for this study, where yields of farmers were doubled. Also, operating costs per hectare were adjusted by a scale of 5 for farm plots in Ashanti Region and 1.66 for farm plots in Western Region. This is to simulate how financial profit would vary if farmers were, on average, attaining set yield levels and incurring the recommended associated operating cost per hectare, given the same price of cocoa.

Table 4.15 shows the yield in kg/ha for the Ashanti and Western Regions for the sampled farm plots for this study. From the table, it is noteworthy that whereas from previous analysis in this section, it was found that gross profit per hectare was higher in the Ashanti Region, yields are rather higher in the Western Region for the plots sampled under this scenario.

Table 4.15 Yield and Sensitivity Analysis Yield per Region

	Yield (kg/ha)	Yield from Sensitivity Analysis (kg/ha)
Ashanti Region	348.90	872.23
Western Region	452.61	1,131.53
Pooled	411.57	1,028.92

Source: Author's Construct

Table 4.16 shows the results of the sensitivity analysis of farm plots adjusted revenue, cost and gross profit per hectare under the scenario described. From the results, operating profit per hectare would be GHS12,835.80 ($1,736.92) in the Western region and GHS 9,894.40 ($1,338.89) in the Ashanti region. This would be reflective of the higher yields in the Western region as against the Ashanti region.

Table 4.16 Sensitivity Analysis of Operating Profit per hectare for Cocoa Farm Plots

Region	Adjusted Revenue	Adjusted Operating Costs	Gross Proft/ha
Ashanti Region	9,894.40	3,906.17	5,988.23
Western Region	12,835.80	2,966.77	9,869.03
Pooled	11,671.85	3,338.50	8,333.35

Source: Author's Construct

A t-test of means conducted indicates that the observed difference between the mean gross profit per hectare in the two regions is statistically significant at the 1 percent level (Table 4.17).

Table 4.17 T-test Results for Sensitivity Analysis Gross Profit per hectare by Region

Group	Obs	Mean	Std. err.	Std. dev.	[95% conf.	interval]
Ashanti Region	203	5988.23	500.98	7137.90	5000.40	6976.05
Western Region	310	9869.02	514.27	9054.82	8857.10	10880.96
Combined	513	8333.35	377.72	8555.22	7591.28	9075.43
Diff		-3880.79	753.89		-5361.90	-2399.70
T-value	-5.15					
Degrees of freedom	511					
Pr(T > t)	0.0000					

Source: Author's Construct

4.4. Economic Profitability Analysis of Cocoa Farm Plots

The study analysed the economic profit of farm plots taking into consideration the implicit cost, which is the returns from the alternatives forgone if farmers are producing at similar percentages of the attainable yields for each tree crop as they are achieving for their cocoa plots and with similar percentage of prescribed costs as they are incurring on their cocoa plots. For the Western and Ashanti regions, rubber and oil palm respectively were selected as the next best forgone alternatives to cocoa production based on key informant interviews and focus group discussions undertaken under the C4F Project.

From Table 4.18, the average economic profit in GHS/ha for the pool is GHS1,292.64 ($174.92). This implies that farmers are better off for producing cocoa in comparison with their respective forgone alternative tree crop options in general. For the Ashanti region, farmers are worse off by GHS-222.45 (-$30.10) per hectare for planting cocoa as against oil palm in the first seven (7) years of the crop. Beyond this, farmers in the Ashanti region are better off planting cocoa against oil palm at each age category. Farmers in the Western region are better off planting cocoa against rubber only for farm plots aged 3 to 15 years. After the age 15 years, cocoa farmers are worse off for planting cocoa than rubber, with negative economic profit values of -GHS1,014.63 (-$137.30) and -GHS1,091.23 (-$147.66) for plot age categories 16 - 30 years and 31 years and above respectively. For cocoa trees, especially hybrid varieties, Mahrizal et al (2014) proposed a phased replacement of trees, recommending the replacement of 5% - 7% of trees from as early as age 5 years. This approach was found to yield as high as 14.67% more economic gains compared to the typical mass replacement of cocoa tree plots after age 25 years.

Table 4.18 Mean Economic Profit per hectare

Region	Mean Economic Profit (GHS/ha) per Age Category				Pooled
	3 – 7 years	**8 – 15 years**	**16 – 30 years**	**31years & above**	
Ashanti Region+	-222.45	534.71	1,254.82	595.27	842.84
Western Region*	3,839.52	2,973.24	-1,014.63	-1,091.23	1,588.13
Pooled	3,125.93	2,278.47	162.57	-107.44	1,292.64

+*Oil Palm is forgone alternative; *Rubber is forgone alternative*

Source: Author's Construct

Again, a multivariate test of means was conducted to establish if observed differences in mean economic profit in the various regions for the different plot age categories was statistically significant. From the test results in Table 4.19, the observed difference in mean profit is significant for all four tests conducted. Also, the t-test conducted confirms that the observed higher economic profit for the Western region as compared to the Ashanti region is significant at 5%.

Table 4.19: Multivariate Test of Means and T-test for Economic Profit

(i) MV Test of means regions and plot age categories	**Statistic**	**F(df1,**	**df2)**	**F**	**Prob>F**
Wilks' lambda	0.768	7	505	21.75	0.000
Pillai's trace	0.232	7	505	21.75	0.000
Lawley-Hotelling trace	0.302	7	505	21.75	0.000
Roy's largest root	0.302	7	505	21.75	0.000

(ii) T-test between regions	**Observations**	**Mean**	**Std. err.**	**Std. dev.**
Ashanti Region	203	842.84	128.59	1832.18
Western Region	310	1607.66	243.90	4294.22
Combined	513	1305.02	156.68	3548.74
diff		-764.82	318.93	
T-value	-2.398			
Degrees of freedom	511			
Pr(T >t)	0.0168			

Source: Author's Construct

The hypothesis to be tested for this objective is as stated below:

H_o (Null hypothesis): Cocoa farm plots in the Ashanti and Western Cocoa Regions of Ghana are not financially and economically profitable.

H_1 (Alternate hypothesis): Cocoa farm plots in the Ashanti and Western Cocoa Regions of Ghana are financially and economically profitable.

The decision rule was:

> If financial and economic profit, estimated as GHS/ha, is greater than 0, reject the null hypothesis (i.e., Cocoa farm plots in the Ashanti and Western Cocoa Regions of Ghana are not financially and economically profitable);
>
> If financial and economic profit, estimated as GHS/ha, is less than or equal to 0, fail to reject the null hypothesis (i.e., Cocoa farm plots in the Ashanti and Western Cocoa Regions of Ghana are not financially and economically profitable).

From the estimation done, financial profitability for cocoa farm plots in the study was GHS3,176.59/ha and GHS3,311.72/ha for the Ashanti and Western regions respectively. Economic profitability of cocoa farm plots in both regions are also greater than zero (GHS842.84/ha for Ashanti region and GHS1,588.13/ha for Western region). Hence, we reject the null hypothesis and conclude that cocoa farmers in the Ashanti and Western regions of Ghana are financially and economically profitable.

Sensitivity Analysis of Economic Profit Estimation

A sensitivity analysis was carried out for the estimation of economic profitability with similar assumptions as adopted for the financial profit estimation. Yields were adjusted by a factor of 2.5 to ensure that farmers' average yield was 1000kg/ha, which is the proposed average attainable yield from the Ghana COCOBOD and the profit for the various forgone alternatives were set at the averages per the Tree Crop Development Authority (TCDA) levels. These are shown in Table 4.20

Table 4.20: Mean Profit (GHS/ha) per hectare for Oil Palm and Rubber

	Mean Profit (GHS/ha) per hectare for Oil Palm and Rubber				
Region	**3 - 7years**	**8 - 15years**	**16 - 30years**	**31 years and above**	**Pooled**
Oil Palm	-1,817.37	1,201.44	359.86	-232.10	309.39
Rubber	-2,679.56	2,504.34	6,161.10	6,161.10	2,901.08
Pooled	-2,528.10	2,133.12	3,151.90	2,431.73	1,873.51

Source: Adapted from GIRSAL/TCDA, 2021

Table 4.21 shows the adjusted economic profitability of cocoa farm plots per plot age group for the two regions. Under the adjusted conditions, cocoa farm plots would be economically more profitable compared to forgone alternatives in both regions. Cocoa production would be particularly more economically profitability when plots are aged 3 to 7 years with economic profit for farm plots in the Western region, where rubber is the selected alternative, being GHS11,367.88 ($1,538.28) per hectare and GHS7,551.47 ($1,021.85) per hectare for Ashanti region, where oil palm was the selected alternative.

Table 4.21 Sensitivity Adjusted Mean Economic Profit per Hectare

	Mean Economic Profit (GHS/ha) per Age Category				
Region	**3 - 7years**	**8 - 15years**	**16 - 30years**	**31 years and above**	**Pooled**
Ashanti Region	7,551.47	3,952.91	5,974.50	6,724.04	5,722.68
Western Region	11,367.88	8,052.41	3,380.80	4,656.55	7,016.56
Pooled	10,697.43	6,884.39	4,726.19	5,862.59	6,503.56

Source: Author's Construct

For Objective 1, the financial profitability of cocoa farm plots, measured as gross profit per hectare, was estimated. Subsequently, using crop budgets from literature, the financial profitability of potential alternatives in each region was also estimated and subtracted from the financial profitability of cocoa farm plots estimated, to obtain economic profitability for each cocoa farm plot. From the analysis conducted, we observe that at the present cocoa farm levels of yield, cocoa price, input costs and input use, cocoa farmers in the Western region where rubber is the alternative, farmers are relatively worse off producing cocoa as cocoa farm plots age. In the Ashanti region however, farmers are relatively better off producing cocoa as compared to oil palm. Studies point out that farmers may not be adopting all the required farm management practices at the plot level (Ehiakpor et al., 2016; Yamoah & Kaba, 2022), and this is confirmed by this study. The various sensitivity analyses point to a significant improvement in the returns per hectare farmers could make if they were to attain the achievable levels of yield for cocoa as set by the Ghana COCOBOD by expending the required levels of operating cost per hectare.

4.5 Profit Efficiency Estimation of Cocoa Farmers

The second objective of this study was to estimate the profit efficiency of cocoa farm plots in the study areas. This analysis enables the assessment of how efficient cocoa farmers are in allocating costs and generating the levels of financial profit estimated in Objective 1.

The stochastic frontier model with random coefficients was estimated using the STATA® application. The application undergoes multiple iterations to ensure convergence and arrive at a robust solution. The overall model is found to be significant at a 1% level, with a Wald chi-square estimate of 660.02 and a log-likelihood of -839.004.

The Stochastic Frontier Model provides two error terms: Sigma U, representing the inefficiencies that reduce profit; and Sigma V, representing the random error term. This allows the study to estimate more accurately, the inefficiencies associated with cocoa farm plots in the study sample.

4.5.1 Profit Efficiency Scores of Cocoa Farm Plots in the Western and Ashanti Regions of Ghana

The profit efficiency scores vary by region and diversification type (see table 4.22). The average profit efficiency score for farm plots in this study was 42.05%. In general, the profit efficiency scores are marginally higher in the Ashanti Region (44.26%) than in the Western Region (40.60%) (see Table 4.22).

Table 4.22 Profit Efficiency (PE) Scores by Diversification Type for Cocoa Farm Plots in Western and Ashanti Regions of Ghana

Diversification Type,	**Ashanti**		**Western**		**Pooled**	
Cocoa with:	**Count**	**PE**	**Count**	**PE**	**Count**	**PE**
Cocoa only	68	44.18%	98	33.38%	166	37.78%
Tree crop	4	50.42%	17	41.22%	21	42.97%
Food crop	73	37.72%	73	37.10%	146	37.41%
Tree crop+food crop	7	67.26%	18	57.05%	25	59.91%
Livestock	5	19.70%	28	38.73%	33	35.85%
Tree crop+livestock	3	75.94%	4	76.60%	7	76.32%
Food crop+livestock	41	51.21%	49	44.99%	90	47.83%
Tree crop+Food crop+Livestock	2	64.38%	22	56.60%	24	57.25%
Pooled	203	44.26%	309	40.60%	512	42.05%

Source: Author's Construct

The results of the estimation indicate that profit efficiency scores differ by the diversification type, which refers to the combination of crops or livestock that the farmers grow or raise along with cocoa. For both the Western and Ashanti regions, the diversification type that has the highest profit efficiency score is cocoa with tree crops and livestock, with a score of 75.94% and 76.60%. respectively.

For the Ashanti Region, the diversification type that has the lowest profit efficiency score is cocoa with livestock, with a score of 19.67%. For the Western Region, the diversification type that has the lowest profit efficiency score is cocoa only, with a score of 32.69%. The results also suggest that diversifying the cocoa production system with other crops or livestock can improve the profit efficiency of the farmers, depending on the region.

Table 4.23 Profit Efficiency Scores by Diversification Type, Age of Plot and Region

Diversification Type	**Age of Plot 3 - 7years**			**Age of Plot 8 - 15years**			**Age of Plot 16 - 30years**			**Age of Plot 31 years and above**		
Cocoa with:	**Ashanti**	**Western**	**Pooled**	**Ashanti**	**Western**	**Pooled**	**Ashanti**	**Western**	**Pooled**	**Ashanti**	**Western**	**Pooled**
None (non-diversified)	40.11%	34.95%	35.94%	45.20%	34.98%	38.61%	42.20%	26.77%	34.63%	47.88%	39.61%	44.06%
Tree crop		11.53%	11.53%	14.91%	39.14%	37.13%	46.14%	61.76%	58.64%	70.32%		70.32%
Food crop	49.77%	24.30%	32.40%	32.52%	37.60%	35.72%	37.99%	39.28%	38.51%	35.75%	50.90%	41.67%
Tree crop+food crop		71.18%	71.18%	66.22%	53.89%	56.35%	67.68%	47.99%	57.83%		5.89%	5.89%
Livestock		38.21%	38.21%	0.03%	40.42%	37.73%	24.62%	44.25%	37.70%	75.94%		75.94%
Tree crop+livestock		82.32%	82.32%		72.31%	72.31%		79.48%	79.48%	55.21%	61.66%	57.51%
Food crop+livestock	37.34%	34.69%	35.13%	55.79%	41.93%	46.29%	47.58%	47.78%	47.66%		39.43%	39.43%
Tree crop+Food crop+Livestock		61.70%	61.70%	76.46%	57.18%	59.59%	52.30%	54.51%	54.14%	48.48%	44.41%	46.78%
Pooled	**45.10%**	**39.01%**	**40.08%**	**44.21%**	**40.67%**	**41.68%**	**42.35%**	**40.30%**	**41.36%**	**47.63%**	**43.78%**	**46.03%**

Source: Author's Construct

From Table 4.23, profit efficiency scores vary by the age of the plot, the region, and the diversification type. In general, the profit efficiency scores are higher in the Ashanti Region than in the Western Region for all the age categories, once again indicating that the farmers in the Ashanti Region are more efficient in using their resources to produce cocoa. The pooled profit efficiency scores also tend to increase as the age of the plot increases. Plots that are 31 years and above have the highest profit efficiency scores. This may suggest that the older plots require less inputs, or that the farmers have more experience and knowledge in managing the older plots.

A Multivariate Test of Means (table 4.24) was conducted to determine if the observed differences in the profit efficiencies scores (table 4.21) for the four plot age categories were statistically significant. The profit efficiency scores also differ by the diversification type, which refers to the combination of crops or livestock that the farmers grow or raise along with cocoa.

Table 4.24 Multivariate test of Means for Average Profit Efficiency by Plot Age

Test	**Statistic**	**df 1**	**df 2**	**F**	**Prob>F**
Wilks' lambda	0.9941	3	508	1.000	0.393
Pillai's trace	0.0059	3	508	1.000	0.393
Lawley-Hotelling trace	0.006	3	508	1.000	0.393
Roy's largest root	0.006	3	508	1.000	0.393

Source: Author's Construct

From Table 4.24, all four tests used show that the observed differences are not statistically significant at 1%.

In table 4.23, for plots that are 3 to 7 years old, the diversification type that has the highest pooled profit efficiency score is cocoa with tree crops and livestock, with a score of 81.95%. For plots that are 8 to 15 years old, the diversification type that has the highest pooled profit efficiency score is cocoa with tree crops and livestock, with a score of 70.27%. For plots that are 16 to 30 years old, the diversification type that has the highest profit efficiency score is cocoa with tree crop and livestock, with a score of 79.30% in the Western Region and cocoa with tree crop and food crop of a score of 66.56% in the Ashanti Region.

For plots that are 31 years and above, the diversification type that has the highest profit efficiency score is cocoa with tree crop and livestock, with a score of 75.35% in the Ashanti Region and in the Western Region, cocoa with food crop and livestock (61.51%).

The analyses suggest that diversifying the cocoa production system with other crops or livestock can improve the profit efficiency of the farmers, depending on the age of the plot and the region. However, the diversification type that is optimal for one plot age or region may not be optimal for another. Therefore, the farmers need to consider the trade-offs and synergies between the different diversification options and their effects on their profit efficiency and welfare. A study by Danso-Abbeam and Baiyegunhi (2020) similarly found that improved technical efficiency and welfare of cocoa farmers are crucial for the sustainable growth of Ghana's cocoa sector, as they complement each other. Therefore, just as Danso-Abbeam and Baiyegunhi (2020) recommended, policies and programs that enhance the farm efficiency and household welfare of cocoa farmers should be strengthened and implemented.

4.5.2 Profit Efficiency of Diversified and Non-Diversified/Specialized Farmers

The observed number of cocoa farm plots under some of the diversification strategies is small. Hence this can lead to errors in the specification of models and other analyses (Miyoshi et al., 2013). Hence, a comparison of profit efficiency scores between non-diversified and diversified farm plot owners in general was conducted (table 4.25).

Table 4.25 Mean Profit Efficiency Scores of Diversified and Non-Diversified Farmers' Plots by Region

Diversification Status	**Ashanti**		**Western**		**Pooled**	
	Count	PE	Count	PE	Count	PE
Non-Diversified	68	44.18%	98	33.38%	166	37.78%
Diversified	135	44.30%	212	44.00%	347	44.12%
Pooled	203	44.26%	310	40.60%	513	42.05%

Source: Author's Construct

Diversified cocoa farmers have higher profit efficiency than non-diversified cocoa farmers in both regions (table 4.25). This may imply that diversified farmers are more able to cope with risks and uncertainties, such as the seasonal nature of cashflows, pests and diseases, climate change, and land degradation, by growing other crops or livestock along with cocoa.

Table 4.25 also shows that the Ashanti region has higher profit efficiency than the Western region for both diversified and non-diversified cocoa farmers. This may be a reflection of the different agroecology and the socio-economic conditions of the two regions, farmers' managerial ability, access and use of inputs and extension services contact (Victor et al., 2010).

To confirm the statistical significance of the observed differences in mean profit efficiency, two sets of t-tests were performed (table 4.26) to:

i. compare the difference in profit efficiency among diversified farmers within each region.
ii. compare the difference in profit efficiency scores of diversified farmers by region and non-diversified farmers also by region.

Table 4.26 Comparison of Profit Efficiency Scores by Diversification Type Within Regions

Region	Mean: Non-Diversified	Mean: Diversified	difference	t value	p-value
Western Region	0.334 (n=99)	0.440 (n=210)	-0.106	-3.246	0.001
Ashanti Region	0.442 (n=68)	0.443 ((n=134)	-0.001	-0.0328	0.974

Source: Author's Construct

The results from the two-sample t-tests with equal variances for comparing the difference in profit efficiency scores between plots of diversified and non-diversified farmers are shown in Table 4.26. For the Western region, the test shows that there is a significant difference between the mean profit efficiency of plots owned by diversified and non-diversified farmers. The mean profit efficiency for non-diversified farmers in the Western Region is 0.334 and the mean profit efficiency for diversified cocoa farmers' plots is 0.440. The difference is -0.106, which means that plots of non-diversified farmers have a lower mean profit efficiency than plots of diversified farmers. The t-value is -3.246 and the p-value is 0.001, implying that the difference is statistically significant at 1%. This indicates that the difference between the means is significant.

For the Ashanti region, the test shows that there is no significant difference between the mean profit efficiency of cocoa plots of non-diversified and diversified farmers. The mean profit efficiency for non-diversified farmers' plots is 0.442 and the mean profit efficiency for diversified farmers' plots is 0.443. The difference is -0.001, which means that non-diversified farmers' plots have slightly lower mean profit efficiency than plots of diversified farmers. The t-value is -0.0328 and the p-value is 0.974, which means that the difference is not statistically significant.

Table 4.27 Cocoa Farm Plot Profit Efficiency for Diversified and Non-Diversified Cocoa Farmers' Plots by Region

Diversification Status	Mean: Ashanti Region	Mean: Western Region	difference	t value	p-value
Non-Diversified	0.441 (n=68)	0.334 (n=99)	0.108	2.188	0.0054
Diversified	0.443 (n=134)	0.440 (n=210)	0.003	0.104	0.917

Source: Author's Construct

For non-diversified farmers' cocoa plots, the difference in mean profit efficiency of non-diversified farmers' cocoa plots in the Ashanti region (0.441) and the mean profit efficiency for non-diversified farmers' cocoa plots in the Western region (0.334) is 0.108. The t-value is 2.188 and the p-value is 0.0054, which means that the difference is statistically significant at 1%. Therefore, among non-diversified farmers' cocoa plots, there is a statistical difference in profit efficiency scores across the two regions.

For the comparison between regions, the results of the t-test as shown in Table 4.27 indicate that there is a significant difference between the mean profit efficiency of diversified cocoa plots in the different regions. The mean profit efficiency for diversified farmers' cocoa plots in the Ashanti region is 0.443 and the mean profit efficiency for diversified farmers' cocoa plots in the Western region is 0.440. The difference is 0.003, which means that the Ashanti region has a higher mean profit efficiency than the Western region. The t-value is 0.104 and the p-value is 0.917, which means that the difference is statistically insignificant.

From the results of the t-tests conducted, cocoa farm plots of non-diversified cocoa farmers in the Western region tend to be significantly more profit-inefficient than plots of non-diversified cocoa farmers in the Ashanti Region.

4.5.3 Factors Affecting Profit Efficiency of Cocoa Farm Plots

The stochastic frontier model estimation was also used to estimate factors that account for the variation observed in levels of profit inefficiency of farm plots. This used a translog linear regression model with the log of profit, expressed here as gross profit per hectare as the dependent variable.

The results as shown in Table 4.28 indicate the socioeconomic, farm characteristics, location, and diversification type variables that have a significant effect on profit inefficiency.

Table 4.28 Factors Affecting Profit Inefficiency of Cocoa Farmers

Wald chi2(28)	660.02	
Prob > chi2	0.000	
Log likelihood	-839.004	
VARIABLES; n = 511⁺	**Coefficient**	**Robust Standard Error**
Household Size	2.181	(1.745)
Migrant/Native	-10.131	(7.788)
Age	-1.867*	(1.033)
Age sq.	0.0191**	(0.00967)
Gender	-7.792	(7.412)
Education (no formal education is base, omitted)		
At least primary	-0.658	(8.398)
At least JHS	-1.608	(8.328)
At least SHS	5.730	(11.03)
Tertiary	4.301	(21.34)
FBO membership	7.886	(7.863)
Credit access in past year	-4.921	(6.846)
Farm distance from dwelling	0.248	(0.592)
Farm Area (hectares)	1.306	(1.269)
Training in past 5 years	-4.220	(7.507)
Certification program participation	-2.117	(12.48)
Age of Plot		
8 - 15 years	-11.422	(8.174)
16 - 30 years	-8.514	(9.497)
31 years and above	-9.809	(13.60)
Cocoa variety (Tetteh Quarshie only is base, ommitted)		
Hybrid only	-18.877**	(9.468)
Amazonia	-9.684	(11.63)
Other	-42.160***	(11.69)
District (Elembelle is base, omitted)		
Wassa Amenfi Central	22.901***	(8.138)
Afigya Kwabre North	-18.547	(11.50)
Diversification type (Cocoa only base, omitted)		
Tree crop	-4.445	(17.83)
Food crop	6.026	(7.825)
Tree crop+food crop	-118.000***	(34.69)
Livestock	10.050	(12.49)
Tree crop+livestock	-293.0**	(136.7)
Food crop+livestock	-10.150	(12.44)
Tree crop+Food crop+Livestock	-86.182***	(30.75)
Constant	6.564***	(0.675)
Usigma	4.632***	(0.121)
Vsigma	-1.906***	(0.156)

[+] *2 observations dropped by model estimation software.*

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's Construct

Table 4.28 presents result of the estimation of factors influencing the profit inefficiency of cocoa farmers in the study area. The parameters of the inefficiency levels are used in the production function model as dependent variables. As indicated, a variable with a negative sign in the inefficiency parameters is considered to either decrease inefficiency and hence increase efficiency, while a positive variable in the inefficiency model is viewed to increase inefficiency and have a negative effect on efficiency.

The results in Table 4.28 indicate that both age of farmer and its squared term are significant, suggesting a non-linear relationship with profit inefficiency. Age exhibits a negative coefficient, of -1.867, while its squared term shows a positive coefficient of 0.0191. This analysis of profit inefficiency among cocoa farmers implies a non-linear association with age, as evidenced by the negative coefficient for age and the positive coefficient for the squared term of age. Initially, farmers tend to have lower profit inefficiency, but this effect diminishes as farmers age further. This finding aligns with Akben-Selcuk (2016) study on the non-linear relationship between firm age and profitability. Additionally, Hassan et al. (2014) observed a negative relationship between age and gross profit margin of cocoa farmers, suggesting that older individuals may encounter challenges in maintaining profitability. This underscores a positive correlation between farmers' age and inefficiency, implying that inefficiency tends to increase as farmers age (Rouf et al., 2021). The direction of the signs of the coefficients of age and age square aligns with the apriori expectations specified.

The district was a set of categorical variables that captured the regional differences in profit inefficiency, with Elembelle district (Western region) as the base category. The coefficient of Wassa Amenfi Central is positive and significant at 1% significance level, while the coefficient of Afigya Kwabre North (Ashanti region) is not significant. This implies that farmers in Wassa Amenfi Central are more profit-inefficient than farmers in Elembelle, while farmers in Afigya

Kwabre North do not differ significantly from farmers in Elembelle in terms of profit efficiency. This could reflect the variation in the various districts' plot level factors.

From table 4.29, farm plots in the Afigya Kwabre North and Elembelle districts are older than those in the Wassa Amenfi district. 48% and 21% of farms in Afigya Kwabre North are aged 16 – 30 and 31 years and above respectively, 30% and 14% of farms in Elembelle district are aged 16 – 30 and 31 years and above respectively, in comparison with 28% and 3% of farms in Wassa Amenfi Central being aged 16 – 30 and 31 years and above respectively.

In terms of variety, only one-third of farms in Afigya Kwabre North and 52% of farm plots in the Elembelle district are of the hybrid cocoa variety, compared to 65% for Wassa Amenfi Central. This has significant impact on yields (Wongnaa et al., 2022). This can be seen in the average yield per hectare of farms in each of these districts as presented in Figure 4.1. Furthermore, from the analysis undertaken in objective 1, it was observed that farmers' operating costs per hectare in the Elembelle and Wassa Amenfi Central districts were significantly higher than for farmers' operating costs per hectare in the Afigya Kwabre North district (see table 4.6). This implies that there is a significantly higher cost associated with managing mostly hybrid variety farm plots in the two Western region districts. Given that the price of cocoa is fixed in all three districts, differences in profit efficiency are attributable to allocative efficiency in costs of operation. This implies that, comparatively, farmers in the Western region are inefficient in allocation of resources to the various cost elements associated with the management of cocoa farm plots.

Table 4.29: Selected District Level Demographic and Plot Characteristics

Age of Plot	**3 - 7 years**	**8 - 15years**	**16 - 30years**	**31years & above**	**Pooled**
Ellembelle	32 (18%)	70 (38%)	54 (30%)	26 (14%)	182 (100%)
Wassa Amenfi Central	29 (23%)	58 (46%)	36 (28%)	4 (3%)	127 (100%)
Afigya Kwabre North	13 (6%)	51 (25%)	97 (48%)	42 (21%)	203 (100%)
Pooled	74 (14%)	179 (35%)	187 (37%)	72 (14%)	512 (100%)

Variety of Cocoa	**Tetteh Quarshie**	**Hybrid**	**Amazonia**	**Others (Mixed)**	**Pooled**
Ellembelle	13 (7%)	96 (52%)	23 (13%)	51 (28%)	183 (100%)
Wassa Amenfi Central	6 (5%)	82 (65%)	21 (17%)	18 (14%)	127 (100%)
Afigya Kwabre North	44 (22%)	66 (33%)	30 (15%)	63 (31%)	203 (100%)
Pooled	63 (12%)	244 (48%)	74 (14%)	132 (26%)	513 (100%)

Source: Author's Construct

The cocoa varieties variable was measured as a set of dummy variables to explain the varieties' difference in profit inefficiency, with Tetteh Quarshie only as the base category. Results show that variables for hybrid only and other cocoa varieties have negative coefficients and are statistically significant at 5% and 1%, respectively while the coefficient of the Amazonia cocoa variety is not statistically significant. This indicates that farmers cultivating hybrid-only and other cocoa varieties are less likely to be profit-inefficient compared to those growing Tetteh Quarshie-only cocoa varieties. Hybrid cocoa varieties are commonly grown for their high yields, disease resistance, and adaptability to diverse environmental conditions. These enhanced traits promote higher productivity and reduce production costs, as hybrids often demand fewer inputs for pest and disease management and can thrive across a broader range of climates and soil conditions (Wongnaa et al., 2022).

There were eight different identified diversification strategies with cocoa, excluding cocoa only or specialized farmers. In the model, the inefficiency of the seven identified diversification strategies was compared to cocoa only. From the estimation, the coefficients of cocoa with tree crops and livestock, cocoa with tree crops and food crops and cocoa with all three diversification options were all negative and significant. This implies that farm plots of farmers who are diversified into cocoa with tree crop and livestock, cocoa with tree crop and food crop, and cocoa with all three diversification options are less profit inefficient in comparison to farm plots of farmers who cultivate cocoa only.

The coefficient of inefficiency, Usigma, was statistically significant at 1% and had a positive coefficient greater than 1. This implies that generally farm plots analysed are operating below the most efficient frontier possible (Fusco et al., 2023).

From the analysis undertaken for Objective 2 of this study, that is, to estimate the profit efficiency of cocoa farm plots in the Western and Ashanti Regions of Ghana, the average profit efficiency of cocoa farm plots under study was found to be 42.05%. However, farm plots of diversified farmers were found to be statistically more profit-efficient than farm plots of specialized farmers. Also, the plot located in the Wassa Amenfi Central district in comparison to the Elembelle district, planting hybrid variety and some diversification options, specifically cocoa with tree crop and livestock, cocoa with tree crop and food crop, and cocoa with all livestock, food crop and tree diversification, were found to be significant in determining profit inefficiency. Farm plots are, on average, operating below the most efficient frontier.

For objective 2 analyzed above, the hypothesis to be tested was:

> H_o (Null hypothesis): Cocoa farmers in the Ashanti and Western Cocoa Regions of Ghana are not profit-inefficient in their cocoa production operations.
>
> H_1 (Alternate hypothesis): Cocoa farmers in the Ashanti and Western Cocoa Regions of Ghana are profit-inefficient in their cocoa production operations.

The decision rule given was that:

> If the probability value (p-value, represented as Prob > chi2) is less than the significance level (0.05), reject the null hypothesis (i.e., there is no strong evidence of inefficiency);

If Prob > chi2 value is greater than or equal to the significance level, fail to reject the null hypothesis (i.e., there is no strong evidence of inefficiency).

From the results of the estimation as shown in the Table 4.26, Prob > chi2 is significant at 1%, which is less than 0.05, indicating that there is there is strong evidence of inefficiency. Thus, we reject the null hypothesis and conclude that there is evidence of inefficiency among the sampled farmers.

4.6. Analysing the Relationship Between Diversification and Financial Profitability

The third objective of the study is to analyse the relationship between diversification and financial profitability of farmers. Here, the study investigated whether the diversification status of farmers has an impact on profitability, and if financial profitability also has an effect on diversification status. The conditional mixed process approach was used to model these two scenarios simultaneously as a system.

Table 4.30 shows the results of the conditional mixed-process (CMP) estimation of the relationship between diversification and profitability for cocoa farmers in the Ashanti and Western regions of Ghana. As explained in the methodology section (Chapter Three) of this study, the CMP model is a general framework that allows for different types of dependent variables in multiple equations. The CMP model results shown in Table 4.30 consist of two equations.

The model's Wald Chi^2 statistic (1.28×10^7, $p < 0.001$) shows that the overall system is highly significant, implying good joint explanatory power.

The first equation is a probit model that estimates the probability of being diversified or otherwise as a function of household and farm characteristics. The coefficient of 0.4090 on profitability indicates that more profitable farmers are more likely to diversify their crops. The coefficient of log of profitability from the marginal effects estimation, which was 0.1284, implies that diversified farmers are 12.84% more likely to be profitable, in comparison to farmers who specialize in cocoa production only. This agrees with Sánchez et al. (2022), who conducted a meta-analysis to establish the relationship between financial profitability and diversified farming systems. Sanchez et al (2022) concluded that gross margins and net income are, on average, higher in diversified farming systems. Systems that feature a mix of high-value crops, such as vegetables and tree crops were found to be the most profitable. In the case of systems that feature tree crops/perennials, even when yields are low, incomes are still high and the working capital required on an annual basis may not be as intense as that required for some annual crops (Jezeer et al., 2017). However, managing a multi-enterprises agricultural system may require the purchase of special inputs such as fungicides and insecticides, as well as specialist knowledge, which, when not managed appropriately may affect the profitability of the system (de Roest et al., 2018).

The second equation is an ordinary least squares log-linear regression model that estimates the natural logarithm of gross profit per hectare as a function of diversification status and other covariates. The coefficient of 0.235 of diversification status is not statistically significant, suggesting that there is no clear effect of diversification on profitability.

Table 4.30 Results of Conditional Mixed Process Estimation of the Relationship Between Diversification and Profitability

VARIABLES n = 511	(1) Diversification status Coefficient	(1) Diversification status Robust Standard Error	(2) Profitability Coefficient	(2) Profitability Robust Standard Error
Household Size	0.018	0.021	-0.043	0.053
Migrant/Native	-0.063	0.120	0.155	0.268
Age	-0.033 **	0.016	0.081**	0.041
Age sq.	0.0003**	0.0002	-0.0008**	0.0004
Gender	-0.119	0.103	0.292	0.251
Education (no formal education is base, omitted)				
At least primary	0.0009	0.133	-0.002	0.325
At least JHS	-0.005	0.130	0.013	0.318
At least SHS	0.121	0.170	0.298	0.416
Tertiary	0.079	0.258	-0.193	0.632
FBO membership	0.049	0.108	-0.120	0.265
Credit access in past year	-0.022	0.086	0.053	0.210
Farm distance from dwelling	0.023	0.021	-0.057	0.050
Farm Area (hectares)	0.003	0.022	-0.007	0.055
Training in past 5 years	-0.073	0.103	0.180	0.251
Certification program participation	0.060	0.267	-0.148	0.653
Age of Plot (3 - 7 years is base, omitted)				
8 - 15 years	-0.217	0.146	0.531	0.356
16 - 30 years	-0.151	0.151	0.369	0.377
31 years and above	-0.173	0.186	0.424	0.454
Profitability (ln Gross profit/ha)	0.409***	0.020	-	-
Diversification status (Non-diversified is base, omitted)	-	-	0.235	0.243
Region (Western region is base, omitted)	0.236**	0.121	-0.578**	0.300
Cocoa variety				
Hybrid only	-0.300*	0.177	0.734*	0.434
Amazonia	-0.188	0.203	0.459	0.496
Other	-0.498**	0.161	1.218**	0.399
Constant	-1.817**	0.585	4.326	1.369
Wald Chi^2	1.28e+07			
Prob>Chi^2	0.0000			
rho_12	-1.0000	0.0001		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's Construct

4.6.1. Marginal Effects of Probit Estimation

For the probit model (diversification model), the estimated marginal effects (table 4.31) are used to interpret the effects of the independent variables on the probability of being diversified. The significant variables were age, age squared, region, profitability, hybrid only and other cocoa variety. It is important to provide a marginal effects estimation for a probit model and not for an OLS model because the coefficients of a probit model are not directly interpretable as the effects of the explanatory variables on the outcome variable.

Table 4.31 Marginal Effects Estimate of Probit Model (Diversification equation)

Variable n=511	**dy/dx (marginal effects)**	**std. err.**	**z**	**P>z**
Household Size	0.006	0.007	0.82	0.410
Migrant/Native (Native =1)	-0.020	0.035	-0.58	0.564
Age	-0.010**	0.005	-2.01	0.044
Age sq.	0.0001**	0.0000	2.13	0.033
Gender	-0.038	0.033	-1.15	0.249
Education				
At least primary	0.003	0.042	0.01	0.995
At least JHS	-0.002	0.041	-0.04	0.969
At least SHS	0.038	0.052	0.72	0.471
Tertiary	0.025	0.080	0.31	0.757
FBO membership	0.015	0.034	0.45	0.650
Credit access in past year	-0.007	0.027	-0.25	0.799
Farm distance from dwelling	0.0073	0.007	1.12	0.261
Farm Area (hectares)	-0.009	0.007	-0.12	0.901
Training in past 5 years	-0.023	0.032	-0.71	0.476
Certification program participation	0.019	0.084	0.22	0.822
Age of Plot				
8 - 15 years	-0.067	0.044	-1.52	0.129
16 - 30 years	-0.046	0.047	-0.98	0.325
31 years and above	-0.053	0.057	-0.93	0.352
Profitability (ln Gross profit/ha)	0.128***	0.006	20.27	0.000
Region	0.074**	0.038	1.98	0.048
Diversification status	0	(omitted)		
Cocoa variety				
Hybrid only	-0.090**	0.051	-1.77	0.076
Amazonia	-0.055	0.059	-0.93	0.350
Other	-0.153***	0.046	-3.33	0.001

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author's Construct

In this model, age has a negative and nonlinear effect on the probability of diversification, as indicated by the negative coefficient of age and the positive coefficient of age squared. This means that the probability of diversification decreases with age at a decreasing rate. From Aneani et al., (2011), farmers grow cocoa initially as it is seen as a secure source of income during old age. However other studies show that as farmers grow older and become more experienced, they are likely to diversify into other farm-based livelihoods (Ashfaq et al., 2008). The coefficients of age and age squared are both statistically significant at the 5% level. From the marginal effects estimation, an additional year increase in age decreases the probability that a farmer is diversified by 1.04%. A unit increase in age squared (older farmers) however increases the probability that a farmer is diversified by a positive measure of about 0.01%.

Region of the farm plot was also found to have a significant effect on diversification status of farmers. Farmers in the Ashanti region is 7.42% more likely to be diversified into other farm-based enterprises, in comparison to farmers in the Western region. This is consistent with a study by Aneani et al. (2011) who similarly found that cocoa farmers in the Western region were less likely to diversify as compared to cocoa farmers in the Ashanti, Eastern and Volta regions. Prior research on farm diversification (Bradshaw et al., 2004; Ilbery, 1991; Meraner et al., 2018) has emphasized the significance of being close to major roads and urban areas for the growth of other farm activities. It is believed that having such access will stimulate the market and help farm enterprises grow. Also, in urban areas, the larger popular size drives demand for food crops, Thus, this may be the case for this study as the districts in the Western region for this study are predominantly rural while the location of plots in Ashanti selected for this study are in a mostly urban district.

Hybrid and other (hybrid mixed with other varieties) cocoa variety was also found to have a significant and negative effect on diversification status of farmers. Farmers that cultivated hybrid only and other cocoa variety are less likely to diversified into other farm-based enterprises. Whereas no studies were found that address the effect of variety choice on diversification, Wongnaa et al. (2022) establishes a positive relationship between variety and profitability.

For the log-linear OLS model, the significant variables were age, age squared and region of farm’s location, hybrid only and other cocoa variety. Age has a positive and nonlinear effect on profitability, as indicated by the positive coefficient of age and the negative coefficient of age squared. An increase in age (young farmers) increases the percentage of profitability of a farm plot by 8.06%, whereas an increase in age squared (older farmer) reduces profitability of farm plots by 0.08%. The implication of this result is that profitability increases with age at a decreasing rate. Whereas a study by Katchova (2010) found that farm profitability increases with age of the farmer, Mishra et al., (2009) found an inverted U-shaped relationship between age and profitability of farmers by similarly incorporating the linear and quadratic forms of the age of farmer variable in his estimation. As farmers age, they can apply the experience gained to become comparatively more profitable. However, as they get older, they may become less agile, and strong and thus their ability to carry out tasks on their farms reduces, which may make them less profitable (Katchova, 2010; Mishra et al., 2009).

The region variable represents the effect of the location characteristics of the farm plots. Farm plots in the Ashanti region are 57.78% less profitable, in comparison to farm plots in the Western region. Whereas the magnitude of the difference in profitability of farm plots in the two regions is not exactly as found in the results of Objective 1 of this study, the direction is consistent; farm plots in the Western region were found to be financial more profitable than plots in the Ashanti region. Despite the significantly higher operating costs observed in this study for cocoa plots in the Western region, yield, which is the driver of revenue, is higher in the Western region (452.61 kg/ha) than in the Ashanti region (348.90 kg/ha). Ghana's largest yields are found in the northern areas of the Western Region (GCB, 2022). This can be attributed to the resilience of their tree stocks, which are predominantly made up of recently planted hybrids developed by CRIG, with low or no permanent shade, high soil nutrient levels following forest conversion, and higher rates of applied fertilizers, insecticides, and fungicides that were purchased (Victor et al., 2010). This is reflected in the sample selected for this study, where there is a significantly higher rate of fertilizer and agrochemical use, compared to farmers and farm plots in the Ashanti Region.

For the CMP model, the inverse hyperbolic tangent transformation is the indicator of the strength and direction of the correlation between the two equations estimated. The correlation between the error terms of diversification and profitability equation variables (table 4.28) is -1.0, as indicated by the rho_12 coefficient. This means that there is a very strong and negative association between the error terms of the two equations. The unobserved factors that affect the diversification status and the profitability variables are inversely related. This effect is statistically significant at 1%.

Furthermore, to test the hypothesis that the correlation between the two equations' error terms is zero, the CMP model here employs a likelihood ratio test. The likelihood ratio test (table 4.28) rejects the null hypothesis that the correlation is zero, as indicated by the chi^2 statistic and the p-value. This means that the two equations are not independent, and that the CMP estimation is more appropriate than separate estimations (Roodman et al., 2022).

For Objective 3, the hypothesis to be tested was:

> H_o (Null hypothesis): There is a no positive covariation between profitability and on-farm income diversification and between on-farm income diversification and profitability among cocoa farmers in the Ashanti and Western regions of Ghana.
>
> H_1 (Alternate hypothesis): There is a positive covariation between profitability and on-farm income diversification and between on-farm income diversification and profitability among cocoa farmers in the Ashanti and Western regions of Ghana.

The decision rule was that If Prob>Chi^2 for Diversification is less than the critical value in the Profitability equation AND Prob>Chi^2 for Profitability is less than the critical value in the Diversification equation is less than the critical value, then we reject the Null hypothesis.

From the analysis done on this objective, diversification status was not statistically significant in the profitability equation suggesting that there is no clear effect of diversification on profitability. Thus, we fail to reject the null hypothesis and conclude that there is a no positive covariation between profitability and diversification and between diversification and profitability among cocoa farmers in the Ashanti and Western regions of Ghana.

In summary, this chapter presented the socioeconomic characteristics of the sample of farmers used for this study and their plot characteristics. The chapter also presented the results of the three specific objectives of the study. The hypothesis stated for each objective was tested and conclusions were made based on the results of the analysis conducted. The next chapter concludes the study by summarizing the findings of the study and deducing conclusions thereof. Based on this, policy recommendations are made.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

This chapter provides a summary of key findings for each of the objectives set out to be investigated. Based on these findings conclusions are made that drive policy recommendations and suggestions for future research.

Cocoa production is a very important economic activity for Ghana; at the macro level, it is important for fiscal stability as foreign exchange earned from the sale of cocoa beans each year helps to stabilize the local currency and provide revenue to undertake key government projects. At the individual economic unit level, revenue from cocoa is the main source of income for over 850,000 cocoa farming households.

In recent years, there has been observed diversification of livelihoods by cocoa farmers both with cocoa and away from cocoa, with other tree crops such as rubber and oil palm. As the welfare of the cocoa farmer is important in creating a sustained cocoa sector for the country, it is important to establish the true state of the profitability of cocoa production, considering both implicit and explicit costs under different diversification regimes, and also to consider the factors drive both diversification and profitability of cocoa farming as an enterprise at the plot. Thus, this study analyzed the profitability of cocoa farm plots in the Western and Ashanti regions of Ghana, specifically with data from 552 farm plots in the Elembelle and Wassa Amenfi Central districts in the Western Region and from Afigya Kwabre Central district in the Ashanti region.

The study estimated the gross profit per hectare for cocoa farm plots, classified into different age groups and discussed by diversification status and by region. The study also estimated the profit efficiency of cocoa farmers per plot and the factors that affect the profit inefficiency of cocoa farmers' plots. The study also simultaneously examined the relationship between diversification and profitability by estimating the determinants and effects of the two variables on each other using the Conditional Mixed Process.

5.2. Summary of Key Findings

The key findings from the study are discussed as follows:

Financial Profitability of Cocoa Farm Plots

From the analysis done, the pooled gross profit per hectare of cocoa farm plots in the Western region was GHS3,311.72 compared to an average pooled gross profit per hectare of GHS3,176.59 for cocoa farm plots in the Ashanti region. Furthermore, analyzing the profitability of cocoa farm plots in the various regions by age, the study found that for the Western region, financial profit for plots of age categories 3 – 7 years, 8 – 15 years, 16 – 30 years and 31 years and above was GHS2,907.66, GHS3,509.76, GHS3,137.54 and GHS3,810.87 respectively, implying that the most profitable cocoa farm plots in the Western region were those that were above their productive age. For the Ashanti region, financial profit for plots of age categories 3 – 7 years, 8 – 15 years, 16 – 30 years and 31 years and above was GHS2,719.34, GHS2,936.19, GHS3,237.42 and GHS3,469.56 respectively, indicating that, likewise, the most profitable farm plots were those in the oldest category of farm plot age.

Economic Profitability of Cocoa Farm Plots

Economic profit here considers the implicit cost of producing cocoa as against the forgone alternative. For the Western region, this study assumes the next best alternative to cocoa to be rubber and oil palm for the Ashanti region. From the analysis, the economic profit for plots of age categories 3 – 7 years, 8 – 15 years, 16 – 30 years, and 31 years and above in the Western region was GHS3,839.52, GHS2,973.24, GHS-1,014.63, and GHS-1,091.23 respectively, with an average of GHS1,588.13. This implies that under current conditions, cocoa farmers are worse off for producing cocoa than producing rubber as cocoa trees age beyond 15 years. For the Ashanti region, the economic profit recorded for plots of age categories 3 – 7 years, 8 – 15 years, 16 – 30 years, and 31 years and above GHS-222.45, GHS534.71, GHS1,254.82, and GHS595.27 respectively. On the average, the economic profit for plots in the Ashanti region across all age groups was GHS842.84. This shows that in comparison to growing oil palm, cocoa farmers in the Ashanti region are better off after plots attain 7 years.

Profit Efficiency Estimation

This study also estimated the profit efficiency of cocoa farm plots in the study areas. From the translog stochastic frontier model estimation, cocoa farm plots in the Ashanti Region are more profit-efficient than cocoa farm plots in the Western region. The average profit efficiency score for cocoa farm plots overall was 42.05%, with farm plots in the Ashanti region recording a profit efficiency score of 44.26% compared to 40.60% in the Western region. The profit efficiency estimates were subsequently estimated for diversified and non-diversified farmers in the two regions. In both regions, diversified farmers' plots had a higher profit efficiency score.

Determinants of Profit Inefficiency

In estimating the profit efficiency scores, the factors that account for observed differences in inefficiency were also determined. It was found that age, age squared, and farm plot being located in the Wassa Amenfi Central district as against Elembelle district, had a positive effect on profit inefficiency. Age squared had a negative and significant coefficient, indicating that there is a non-linear relationship between age and profit inefficiency. In other words, whilst profit inefficiency increases with age, beyond a point or as farmers get older, age has a negative effect on profit inefficiency, implying that farmers become more profit efficient. The equation had a Usigma value of 4.632. This value being larger than 1 indicates that the farmers are operating below the most efficient frontier.

Relationship Between Diversification and Profitability of Cocoa Farm Plots

The study also sought to simultaneously investigate if profitability has an impact on diversification status, and if diversification status affects profitability. From the results, it was found that the more profitable a farm plot is, the more likely it is that the farmer is diversified. However, the diversification status of farmers did not have a statistically significant impact on profitability. Age, age squared, the region of the farm plot's location, and the cocoa variety all have a statistically significant relationship with both diversification status and profitability. However, the diversification status of the farmer has a significant association with profitability. From the CMP model, the unobserved factors that influence diversification status have a perfect negative relationship with profitability and vice versa.

5.3. Conclusions

The hypothesis set out to be tested by this study and the conclusions on these hypotheses based on analysis conducted are discussed below.

i. *Cocoa farmers in the Ashanti and Western Regions of Ghana are financially and economically profitable.*

Cocoa farm plots in the Ashanti and Western Regions of Ghana are financially and economically profitable. This implies that the study concludes that the benefits of producing cocoa outweigh the opportunity cost in both regions. Probing further, cocoa farm plots in the Western region are not economically profitability beyond the age of 16 years if rubber is taken as the next best alternative. Similarly, Cocoa farm plots in the Ashanti region are economically profitable only after 8 years if oil palm is taken as the next best alternative.

ii. *Cocoa farmers in the Ashanti and Western Regions of Ghana are profit-efficient in their cocoa production operations.*

Cocoa farm plots in both the Western and Ashanti regions are operating significantly below the most efficient profit frontier. However, cocoa farm plots in the Ashanti region are significantly more profit-efficient compared to cocoa farm plots in the Western region.

iii. *There is a positive covariation between profitability and on-farm income diversification, and between on-farm income diversification and profitability among cocoa farmers in the Ashanti and Western regions of Ghana.*

Whereas farm plots which are profitable are more likely to be owned by farmers who engage in on-farm income diversification, on-farm income diversification does not affect the profitability of cocoa farm plots.

5.4. Recommendations

Based on the conclusions made from this study, the following recommendations are made. The results of this study paint an austere picture of the future of cocoa in the Western region, especially with the emergence of rubber as a popular viable alternative. Given the low yields of cocoa in both regions, which result in low profits, COCOBOD's current strategies for the distribution of seedlings, fertilizer and agrochemicals must be reviewed to ensure that farmers have easier access to agrochemicals to improve yields and profits. Given that cocoa farm plots aged over 16 years, especially hybrid varieties, are not economically profitable after 16years, farmers should look to replace their cocoa trees after the trees are at most 20 years old.

Also, the low profit efficiency scores imply that farmers may not be managing their costs efficiently. As the choice of cocoa varieties affects profit efficiency, farmers should be sensitized to adopt hybrid cocoa varieties and educated on how to manage costs of maintaining hybrid cocoa tree plots to attain the maximum possible yield.

Profitable farmers are more likely to be diversified, and profit efficiency of diversified farmers is higher. Therefore, farmers need to be encouraged and supported by COCOBOD and other development projects, to venture into other farm-based livelihoods. This allows farmers to earn more revenue to support the operations of their coca farm enterprises.

5.5. Suggestions for Future Research

This study makes significant strides in estimating the profitability of cocoa farm plots relative to forgone alternatives or competing tree crops, namely, rubber and oil palm. The study is limited by the sample size and therefore and some methodological approach such as the Meta-profit efficiency, in comparing financial profitability and economic profitability for different types of farm-based diversification options.

The study could also be expanded in terms of geography to include cocoa farm plots in other regions, both rural and urban, to assess whether the findings can be replicated and conclusions can be made regarding the profitability and profit efficiency of farmers and farm plots based in predominantly rural districts or regions versus those based in predominantly urban districts or regions.

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APPENDICES

Appendix 1: Questionnaire

Cocoa4Future Project Baseline Questionnaire 2022

Page/Section	Question	Question Code	Type	Options
Introduction	Name of Respondent		text	
Introduction	Consent		single-select	1 I Consent 2 I do not consent
Introduction	Enumerator Name		single-select	Jeronne Kouame Bini Ekenlebie Lee Robert Kaku Osman Sauba Ali Abdul Mumin Dwamena Asamoah Kassim Alhassan Sulemana Abdul Nana Okyir Baidoo Nana Anima Akrofi Chris Chapman Japhet Okunor Emmanuel Kove Dr Yaw Osei Asare Prof Daniel Bruce Sarpong
FARMER LOCATION	Farmer location		option-tree	
FARMER LOCATION	Region	ID1a	option-tree	001 Western Region 002 Ashanti Region
FARMER LOCATION	District	ID2a	option-tree	001 Wassa Amenfi Central 002 Ellembelle 003 Afigya Kwabre North
FARMER LOCATION	Village/camp	ID3a	option-tree	Kramokrom Aku Nkwanta Anwifutu K Boateng Subriho/Gyabra Nkwanta Abubrim Adubrim Ayawura Dump Ngabawe Nkropong Tandan Ebi Amoako Soko Abroma Adukro Tetrem
FARMER LOCATION	Community Code	Community Code	option-tree	1106 1107 1108 1109 1110 1201

Page/Section	Question	Question Code	Type	Options
				1202 1203 1204 1205 2311 2312 2313 2314 2315
HOUSEHOLD COMPOSITION	Number of persons in household	hh_count	number	
HOUSEHOLD COMPOSITION	MODULE A - HOUSEHOLD COMPOSITION		sub-form	
	Full name	A1	text	
	Family relationship of respondent	A2	single-select	1 Head of household 2 Spouse 3 Child 4 Father or mother of head or spouse 5 Grandson/granddaughter 6 Other relative 7 Not related
	Phone Number of Household head	phone_#	phone	
	Gps coordinates of dwelling	gps	gis	
	Sex	A3	single-select	1 Male 2 Female 3 Prefer not to answer
	Age	A4	number	
	Months of presence during the last year	A5	multi-select	January February March March April May June July August September

Page/Section	Question	Question Code	Type	Options
				October November December Year Round insyt_other
	Nationality	A6	single-select	1 Ghanaian 2 Burkinabe 3 Malian 4 Guinea 5 Ivorian 6 Beninese 6 Other
	What ethnicity	A7	single-select	1 Akan 2 Ewe 3 Ga-Adangbe 4 Guan 6 Mole-Dagbani 7 Other
	Religion	A8	single-select	1 Christian 2 Muslim 3 Tradionalist 4 Atheist 5 Budhist 6 Other
	Place of birth	A9	text	
	Indicate if this place is located in:	A10	single-select	1 the same village 2 a nearby village 3 the same district 4 the same region 5 Ghana-Other Regions 6 Burkina 7 Mali 8 Ivory Coast 9 Guinea 10 Liberia 11 Other
	Educational level	A11	single-select	1 None 2 Some Primary Education 3 Completed Primary Education 4 Some JHS/MSLC 5 Completed JHS/MSLC 6 Some Secondary Education 7 Completed Secondary Education 8 Tertiary 9 Quranic
	Marital status	A12	single-select	1 Single 2 Married (Civil) 3 Married (Traditional)

Page/Section	Question	Question Code	Type	Options
				4 Widowed 5 Divorced or separated 6 Cohabitation
	Economic activity of the members of the household	A13	single-select	1 Active 2 Inactive (dependent)
	If active, main activity (Single answer only)	A14a	single-select	1 Cocoa farming 2 Rubber cultivation 3 Palm cultivation 4 Other perennial crop 5 Food-producing (cereal, vegetables..) 6 Breeding Livestock 7 Lumbering 8 Fishing/fish farming 9 Mine (formal or informal) 10 Trade (fixed store) 11 Trade (itinerant) 12 Collector/tracker 13 Employee (craftsman, mechanic, driver) 15 Domestic employee (cleaning, babysitting, cooking, etc.) 16 Business manager (with employees) 18 Other, give details 17 Public Official (Government, administration, teacher, nurse…) 19 Retirement (with pension) insyt_other Other Company employee, specify
	specify for other	A14b	text	
	If active, secondary activity	A15a	single-select	1 Cocoa farming2 Rubber cultivation3 Palm cultivation4 Other perennial crop5 Food-producing (cereal,

Page/Section	Question	Question Code	Type	Options
				vegetables..)6 Breeding Livestock7 Lumbering8 Fishing/fish farming9 Mine (formal or informal)10 Trade (fixed store)11 Trade (itinerant)12 Collector/tracker13 Employee (craftsman, mechanic, driver) 15 Domestic employee (cleaning, babysitting, cooking, etc.)16 Business manager (with employees)18 Other, give details17 Public Official (Government, administration, teacher, nurse…)19 Retirement (with pension)insyt_other Other Company employee, specify
	specify for other	A15b	text	
	Is this the selected respondent?		single-select	Yes No
	If yes, provide farmer number		number	
MODULE B - HOUSING & LIVING CONDITION	The household lives	B1	single-select	1 In the village 2 Farm camp
MODULE B - HOUSING & LIVING CONDITION	Does the household have electricity(national network)?	B2	single-select	1 Yes 2 No
MODULE B - HOUSING & LIVING CONDITION	The house is	B3	single-select	1 owned 2 rented 3 Other Family house Not rented or owned but living in house for free
MODULE B - HOUSING & LIVING CONDITION	Type of wall	B4	single-select	1 Brick/block2 wood boards3 Metal sheet4 mud5 other
MODULE B - HOUSING & LIVING CONDITION	Roof type	B5	single-select	1 Sheet 2 Tiles 3 Thatch 4 other
STANDARD OF LIVING INDICATOR	Give the number of Radio owned	B6	number	
STANDARD OF LIVING INDICATOR	Give the number of Cable channel/Satellite subscription owned	B7	number	
STANDARD OF LIVING INDICATOR	Give the number of Standard mobile phone owned	B8	number	
STANDARD OF LIVING INDICATOR	Give the number of Television owned	B9	number	
STANDARD OF LIVING INDICATOR	Give the number of smartphone mobile phone owned	B10	number	
STANDARD OF LIVING INDICATOR	Give the number of Personal car owned	B11	number	
STANDARD OF LIVING INDICATOR	Give the number of living Room/Armchair owned	B12	number	
STANDARD OF LIVING INDICATOR	Give the number of motorbike owned	B13	number	
STANDARD OF LIVING INDICATOR	Give the number of table owned	B14	number	
STANDARD OF LIVING INDICATOR	Give the number of bicycle owned	B15	number	

Page/Section	Question	Question Code	Type	Options
STANDARD OF LIVING INDICATOR	Give the number of hi fi/stereo system owned	B16	number	
STANDARD OF LIVING INDICATOR	Give the number of Computer/Tablet owned	B17	number	
STANDARD OF LIVING INDICATOR	Give the number of Solar panels	B18	number	
STANDARD OF LIVING INDICATOR	Give the number of Beds (with a foam mattress)	B19	number	
GENERAL INFORMATION ABOUT THE PLANTATION	How long have you been growing cocoa?		number	
GENERAL INFORMATION ABOUT THE PLANTATION	What are the two main sources you use to learn new techniques or solve a technical problem on your farm?	C12	multi-select	1 Personal experience/observation2 Family 3 Exchange with other producers4 Group of producers – to be specified5 Technician/adviser for a project6 Extension agent/agricultural adviser from Ministry services7 Radio8 Television9 Newspapers10 Traders11 Demonstration site19 Other
GENERAL INFORMATION ABOUT THE PLANTATION	Have you already benefited from training in cultivation techniques for cocoa in the last 5 years?	C13	single-select	1 Yes 2 No
GENERAL INFORMATION ABOUT THE PLANTATION	If so, which techniques?	C14	multi-select	C14a Nursery C14b planting C14c Harvest C14d Prunning C14e Pollination C14f Spraying C14g Shelling C14h Fertilizer spreading C14i Phyto treatment C14j Other
GENERAL INFORMATION ABOUT THE PLANTATION	Are you in a certification project	C15	single-select	1 Yes 2 No
GENERAL INFORMATION ABOUT THE PLANTATION	If yes which ?	C16	single-select	C16a UTZ-RA C16b DoTrade C16c Ethical C16d FairTrade C16e Cocoa Practices CP C16h Don't know C16g Other
GENERAL INFORMATION ABOUT THE PLANTATION	Are you a member of any farmer-based cooperative group?		single-select	Yes No
CREDIT AND TRANSFER INCOME	Have you borrowed money in the past 12 months?	C26	single-select	1 Yes2 No
CREDIT AND TRANSFER INCOME	If so, from whom?	C27	multi-select	1 Bank 2 Microfinance 3 Cooperative 4 Trader 5 Exporter 6 Family/Friends 7 Input Credit 8 Money lenders

Page/Section	Question	Question Code	Type	Options
				9 Other Purchasing Purchasing Clerk
CREDIT AND TRANSFER INCOME	How much interest was charged on your loans on the average?	C28	number	
CREDIT AND TRANSFER INCOME	What collateral was required before you could assess the loan ?	C29	multi-select	Land Cocoa farm Farm Car House Other agricultural equipment Livestock None insyt_other Other
ADOPTION OF GOOD FARM MANAGEMENT PRACTI	Do you currently have a bank account that you use to deposit money from cocoa or other farm sales?	C34	single-select	1 Yes 2 No 998 Don't know
ADOPTION OF GOOD FARM MANAGEMENT PRACTI	In the last 12 months, did you take out any crop insurance?	C35	single-select	1 Yes 2 No 998 Don't know
ADOPTION OF GOOD FARM MANAGEMENT PRACTI	Do you currently keep written record of the following?	C36	multi-select	1 Cocoa harvested and sold 990 Other crop harvested and sold Crop production Crop production expenses None insyt_other Other
ACTIVITY SYSTEM AND HOUSEHOLD INCOME	In the past 12 months, what income-generating activities have you carried out?	D1	multi-select	daily or piecework agricultural workagricultural wage earnerlivestock (livestock or small livestock)trade (fixed shop)trade (itinerant)civil servantoffice work (except civil servant) employeepersonal services (domestic help cleaning, babysitting/vigil, etc.) transport (driver)company manager (transport, other formal company)employee of a companyOtherNone
	ACTIVITY SYSTEM AND HOUSEHOLD INCOME		sub-form	
	In the past 12 months, income-generating activities have you carried out?	D1	single-select	daily or piecework agricultural work agricultural wage earner livestock (livestock or small livestock) trade (fixed shop) trade (itinerant) civil servant office work (except civil servant) employee personal services (domestic help cleaning, babysitting/vigil, etc.) transport (driver) company manager (transport, other formal company) employee of a company Other
	Specify for other		text	

Page/Section	Question	Question Code	Type	Options
	In the past 12 months, what is the units for the work on this task?	D3b	single-select	1 days 2 weeks 3 months
	In the past 12 months, how many days/weeks/months have you worked on this task?	D3a	number	
	What is the amount of the last payment received (GHS) for this work?	D4a	number	
	Monetary income over 12 months (GHS)	D5	number	
	Is the person paying you a member of the household?	D6	single-select	1 Yes 2 No
Non-Labor Earnings or Revenues in the Last 12 Mont	Select types of income	D7	multi-select	1 Retirement pension 2 Widow's pension 3 Invalidity pension 4 Maintenance pension 5 Other pension 6 Rent for dwelling house 7 Rent for agricultural land 8 Rent for rental of agricultural equipment (tractor, tiller, trailer, etc.) or non-agricultural (hi-fi, TV, car, trucks, etc.) 9 Transfer income ((money received by the household from a person not living in the household) None insyt_other Other
	Non-Labor Earnings or Revenues in the Last 12 Months		sub-form	
	Selected type of income	D7	single-select	1 Retirement pension2 Widow's pension3 Invalidity pension4 Maintenance pension5 Other pension6 Rent for dwelling house7 Rent for agricultural land8 Rent for rental of agricultural equipment (tractor, tiller, trailer, etc.) or non-agricultural (hi-fi, TV, car, trucks, etc.)9 Transfer income ((money received by the household from a person not living in the household)
	Number of payments in the last 12 months	D8	number	
	Total amount for all household members for the last 12 months (GHS)	D9	number	
	Relationship to sender	D10	single-select	1 Spouse 2 Child 3 Father or mother 4 Brother or sister 5 Other relative 6 Not related
	Place of residence of the sender	D11	single-select	1 Same locality 2 In the district 3 In the region

Page/Section	Question	Question Code	Type	Options
				4 elsewhere in Côte d'Ivoire 5 In Burkina Faso 6 Ghana 7 Mali 8 Other African country 9 France 10 Other European country 11 Other
	Main reason for the transfer	D12	single-select	1 schooling2 Illness3 Routine support4 Field work support5 Non-agricultural business support6 Events7 Other
MODULE E - HOUSEHOLD LAND HOLDING	How many are operated by you or members of your household ?	E2	number	
MODULE E - HOUSEHOLD LAND HOLDING	How many plots in your possession are used by other households?	E3	number	
MODULE E - HOUSEHOLD LAND HOLDING	How many parcels do you own today ?	E1	calculation	
MODULE E - HOUSEHOLD LAND HOLDING	How many plots are operated on under a tenural arrangement (Abunu, abusa, cash rent, etc.) but not owned?		number	
PLOT DETAILS	PLOT DETAILS		sub-form	
	Status of plots owned or used by household	plot_ownership_status	single-select	parcels of land owned and managed by household Parcels of land owned and managed by household property 2 – plots under different tenurial arrangements Plots under different tenurial arrangements plots not owned but managed under contract Plots not owned but managed under contract plot owned but not cultivated by the household
	Parcel order number	ID_PARC	text	
	Name of the plot	F1a	text	
	location description	F1b	text	
	Describe type of contractual agreement		single-select	AbunuAbusaFixed cash paymentinsyt_other Other
MODULE F	Where is the plot located?	F2a	single-select	1 Near the village 2 In another village of the district 3 In another district of the region, specify 4 In another region, specify 5 In another country, specify
MODULE F	In another district of the region, specify	F2b	text	
MODULE F	In another region, specify	F2c	text	
MODULE F	In another country, specify	F2d	text	
MODULE F	Type of tenurial arrangement	H2	single-select	1 Take in Sharecropping (Abusa) 1/3 -2/3 2 Take in sharecropping (Abunu) 50-50 3 Rent in

Page/Section	Question	Question Code	Type	Options
				4 Take in on loan (Delegation of parents free of charge) 5 Take in on loan (extra-family) 6 Land taken as collateral/pledge 7 take in "planting and sharing" (share of the plantation/trees) 8 take in "planting and sharing" (sharing of harvest products 9 Other
MODULE F	Precisions/ Details about the tenurial arrangement	H3	text	
MODULE F	How many miles from your house is the plot ?	F3	number	
MODULE F	How did you get this parcel ?	F4	single-select	1 Purchase2 Inheritance to the head by family member 3 Inheritance to the spouse by family member 4 Definitive donation to the head by family member5 Definitive donation to the spouse by family member6 Cleaning free land (pioneer)7 Other
MODULE F	What are the main current land use on this parcel?	F6	single-select	1 Cocoa 2 Other Perennial crop 3 Cocoa and associated perennial crops 4 Lowland rice 5 Other Cereals (maize) 6 Tubers (Yam, Cocoyam, cassava, sweet potatoes) 7 Vegetables 8 Pastureland /Livestock 9 Fallow 10 Secondary forest 11 Pasture 12 Mining 13 Other
MODULE F	If perennial crop excluding cocoa, specify	F7	multi-select	Coffee Cashew Rubber tree Palm Coconut tree insyt_other Other
MODULE F	If food crop alone, specify	F8	multi-select	1 Cereals (Rice, Maize…), specify 2 Tubers (Yam, Cocoyam, Cassava, sweet potato, etc.), specify 3 Vegetables, 4 Other
MODULE F	If livestock alone	F9	multi-select	1 Poultry2 Cattle3 Sheep4 Goats5 Pigs6 Other
MODULE F	If Cocoa and associated perennial crops, Specify the associated crop below		text	
	What is its area (acres)? (declarative)	F1	number	

Page/Section	Question	Question Code	Type	Options
	What is the main document that can prove your rights to the plot?	F4	single-select	1 Land title obtained 2 Land title requested (procedure in progress) 3 Payment receipt 4 Indenture obtained 5 Indenture in progress 6 Commitment form 7 Tax receipt 8 Deed of sale signed with the former owner only 9 Deed of sale signed with the former owner and validated by an institution 10 Act of donation or testament 11 No written document
	Are you worried that your right will be challenged? (Land insecurity on the plot)	F7	single-select	1 Yes 2 No
	On the plots you currently own/work on, have you ever been in conflict?	F8	single-select	Yes No
	If so, with whom?	F9	single-select	1 A member of the family 2 A neighbor (non-family) 3 The former owner (non-family) 4 A laborer 5 A tenant/sharecropper insyt_other Other
	If so, when?	F10	single-select	Before 80's80's. 90's 90's 2000's2010's2020's
	Is the conflict resolved today?	F11	single-select	1 Yes 2 No
	If yes, how were they resolved?	F12	single-select	1 Family 2 Courts 3 Chief 4 ADR
	If there is conflict on the land today, how do you intend to resolve it ?	F13	single-select	Family Courts ADR Chief Don't know
	If rent out – Price per year (if the contract is for multiple years, convert the price for one year.)	I5	number	
	Years of beginning of the contract	I7	number	
	Year of end of the contract	I8	single-select	999 not defined insyt_other Other
	Does the lessee have the right to cut down trees?	I9	single-select	1 Yes 2 Yes, he just has to let me know before 3 No, it's me who makes this type of decision
	Have you the right to cut down trees?	I14	single-select	1 Yes 2 Yes, he just has to let me know before 3 No, it's me who makes this type of decision
	Does the lessee have the right to decide alone to plant trees?	I10	single-select	1 Yes 2 Yes, he just has to let me know before

Page/Section	Question	Question Code	Type	Options
				3 No, it's me who makes this type of decision
	Have the right to decide alone to plant trees?	I15	single-select	1 Yes 2 Yes, he just has to let me know before 3 No, it's me who makes this type of decision
MODULE G - Property 2 – plots under different tenu	What is the current use of land?	G2	single-select	1 Cocoa2 Perennial crop excluding cocoa3 Associated crops: perennial + Cocoa4 Associated crop: food crop + cocoa5 Associated crop: food crop + perennial + cocoa6 Other associated crops7 Food-producing cultures8 Fallow9 Livestock10 Uncultivated forest; wasteland11 Pasture12 Farmyard for small breeding13 Mining14 Other, give details...15 Do not know
MODULE G - Property 2 – plots under different tenu	If perennial crop excluding cocoa (or associated), specify	G3	single-select	1 Coffee 2 Cashew 3 Rubber tree 4 Palm 5 Other
MODULE G - Property 2 – plots under different tenu	If food crop alone or associated, specify	G4	single-select	1 Rice 2 Corn 3 Yam 4 Cocoyam 6 Cassava 7 Pineapple 8 Other
MODULE G - Property 2 – plots under different tenu	If for animal rearing, specify	G5	single-select	1 Poultry 2 Cattle 3 Sheep 4 Goats 5 Pigs 6 Other
MODULE G - Property 2 – plots under different tenu	What is its area (acres)?	G6	number	
	Does the lessee have the right to cut down trees?	G24	single-select	YesYes, he just has to let me know beforeNo, it's me who makes this type of decisionNot applicable
	Does the lessee have the right to decide alone to plant trees?	G25	single-select	Yes Yes, he just has to let me know before No, it's me who makes this type of decision Not applicable
MODULE J - MAINTENANCE OF CULTIVATED COCOA PLOTS	In the last 12 months, what type of weeding did you do in the field ?	J1	multi-select	1 Chemical 2 Manual 3 Mechanical 4 Both 5 None
MODULE J - MAINTENANCE OF CULTIVATED COCOA PLOTS	If chemical, how many times per year	J2	number	
MODULE J - MAINTENANCE OF	If manual, how many treatments in the last 12 months?	J3	number	

Page/Section	Question	Question Code	Type	Options
CULTIVATED COCOA PLOTS				
MODULE J - MAINTENANCE OF CULTIVATED COCOA PLOTS	In the last 12 months, have you used fungicides in this field?	J5	single-select	1 Yes 2 No
MODULE J - MAINTENANCE OF CULTIVATED COCOA PLOTS	If you used fungicide, how many treatments per year?	J6	number	
MODULE J - MAINTENANCE OF CULTIVATED COCOA PLOTS	What is the name of the fungicide ?	J7	single-select	xxx Ridomil Gold Funguran-OH Kocide 2000 Nordox 75 WG Champion insyt_other Other
MODULE J - MAINTENANCE OF CULTIVATED COCOA PLOTS	In the past 12 months, have you used insecticides in this field?	J8	single-select	1 Yes 2 No
MODULE J - MAINTENANCE OF CULTIVATED COCOA PLOTS	If insecticides, how many treatments per year?	J9	number	
MODULE J - MAINTENANCE OF CULTIVATED COCOA PLOTS	What is the name of the insecticide ?	J10	single-select	yyy LambdaKilsect Sampiritons Duraban Confidor TermicostAkate SuroDont knowinsyt_other Other
	In the last 12 months, what type of fertilizer have you applied on the field?	J11	single-select	Chemical Organic Both None insyt_other Other
	If chemical, how many applications per year?	J12	number	
	What is the name of the fertilizer ?	J13	single-select	zzz Asaase Wura Cocofeed Confidor Organic insyt_other Other
	If organic, how many applications per year?	J14	number	
MODULE I - COCOA CULTIVATION	Year of Establishment of Cocoa plot		number	
MODULE I - COCOA CULTIVATION	Area under production (not just the farm size)	M3	number	
MODULE I - COCOA CULTIVATION	Previous crop at the time of planting?	M4	single-select	Primary forest; Secondary forest; Fallow Unproductive cocoa plantation Other perennial crop plantationàSpecify question below Food crop, specify Livestock, specify Do not know insyt_other Other
MODULE I - COCOA CULTIVATION	If land has other plantation of perennial crop in production, specify	M5	multi-select	1 Coffee 2 Cashew 3 rubber trees 4 palm tree

Page/Section	Question	Question Code	Type	Options
				5 fruit trees 6 Timber 7 Coconut 8 Other dont know
MODULE I - COCOA CULTIVATION	What variety of cocoa is planted on the plot?	M6	multi-select	1 Tetteh Qurshiehybrid2 Criollo 6 Amazonia 7 Don't knowinsyt_other Other
	Does your cocoa field include	M7	multi-select	Trees Food crops None)pure stand cocoa only) None (pure stand cocoa only) insyt_other Other
	There are trees in the field that were preserved when the cocoa farm was created	M8	single-select	1 Yes 2 No 3 Don't know
	Have you introduced trees into the field since the creation of the cocoa plantation ?	M9	single-select	1 Yes 2 No
	Are there any trees you don't like that are left in your field	M11	single-select	Yes No
	If yes, why ?	M12	single-select	because I don't have the right to cut it because I didn't have the time or the money to cut them because I expect to need wood because it doesn't bother me insyt_other Other
	Does your farm include other types of trees?		single-select	Yes No
	If your cocoa farm includes other types of trees, which ones?		multi-select	Plantain Coffee Orange Mango Oil Palm Coconut Rubber Timber species None insyt_other Other
Cocoa Production and Yield	What is the area of your cocoa farm that is in production (declarative or measured?).	M16	number	
Cocoa Production and Yield	If land has other plantation of perennial crop in production, specify	M16b	single-select	Coffee Cashew rubber trees palm tree fruit trees Timber Coconut Dont know insyt_other Other
Cocoa Production and Yield	In which months of the year do you harvest?	M18	multi-select	January February March April May June July August September

Page/Section	Question	Question Code	Type	Options
				October November December
2022-PRODUCTION	Production during the major season in bags in 2021	M28	number	
2022-PRODUCTION	Production during the minor season in bags in 2022	M29	number	
2022-PRODUCTION	Selling price per bags during the major season 2021	M30	single-select	620 660
2022-PRODUCTION	Selling price per bags during the minor season 2022	M30	single-select	620 660
2022-PRODUCTION	Total revenue for major season 2021	2021_revenue	calculation	
2022-PRODUCTION	Total revenue for minor season 2022	2022_revenue	calculation	
Cocoa Conversion and Reconversion	In the last 12 months, have you cut down any of your cocoa tree(s)?		single-select	Yes No
Cocoa Conversion and Reconversion	If, yes, in the last 12 months, how much cocoa trees have you cut down ?		number	
Cocoa Conversion and Reconversion	Why did you cut down your cocoa tree(s)?		single-select	1 Cocoa trees were too old / not producing 2 cocoa trees were diseased 3 cocoa trees were dead 4 Cocoa trees planted too close together 5 Land tenure problems/conflicts 6 Producing trees, but need space for another crop 7 Other
Cocoa Conversion and Reconversion	If yes, did you replace the cut cocoa trees ?		single-select	1 No 2 Yes, To make room for new cocoa / rehabilitation of plot 3 Yes, To make room for other crops,
Cocoa Conversion and Reconversion	If replace for other crop, name		single-select	1 Coffee 2 Cashew 3 Rubber 4 Palm tree 5 Fruit trees 6 Timber 7 Coconut 8 Food crops 9 Other
Cocoa Conversion and Reconversion	In the last 12 months, how many new cocoa trees have you plant to replace older ones ?		number	
Cocoa Conversion and Reconversion	Which variety ?		single-select	1 Hybrid/AGRIC/New Variety 2 Local/Traditional Variety 3 Grafted Seedling 998 Don't know
Cocoa Conversion and Reconversion	In the last 12 months, have you cut down any perennial crops to plant cocoa tree(s)?		single-select	1 Yes 2 No
Cocoa Conversion and Reconversion	If yes, what perennial crop did you cut down?		single-select	CashewRubberPalm treeFruit treesTimberCoconutFood crops, specifyinsyt_other Other

Page/Section	Question	Question Code	Type	Options
Cocoa Conversion and Reconversion	Why did you cut this perennial crop down to plant cocoa?		single-select	1 too old / not producing 2 diseased 3 dead 4 Other
Fertilizer	Select fertilizer type on this farm plot for last cocoa season 2021/2022		multi-select	A Asaase Wura B Cocofeed C Sidalco D Confidor E Organic None insyt_other Other
Fertilizer	Enter the Quantity of Asaase Wura fertilizer (bags)		number	
Fertilizer	Enter the Quantity of Cocofeed fertilizer (bags)		number	
Fertilizer	Enter the Quantity of Sidalco fertilizer (bags)		number	
Fertilizer	Enter the Quantity of Confidor fertilizer (bags)		number	
Fertilizer	Enter the Quantity of Organic fertilizer (bags)		number	
Fertilizer	Enter the Quantity of Others fertilizer (bags)		number	
Fertilizer	Enter the Price/unit (GHS) of Asaase Wura fertilizer		number	
Fertilizer	Enter the Price/unit (GHS) of Cocofeed fertilizer		number	
Fertilizer	Enter the Price/unit (GHS) of Confidor fertilizer		number	
Fertilizer	Enter the Price/unit (GHS) of Sidalco fertilizer		number	
Fertilizer	Enter the Price/unit (GHS) of Organic fertilizer		number	
Fertilizer	Enter the Price/unit (GHS) of Others fertilizer		number	
Fertilizer	Total (GHS) of Asaase Wura fertilizer		calculation	
Fertilizer	Total (GHS) of Sidalco fertilizer input		calculation	
Fertilizer	Total (GHS) of Cocofeed fertilizer input		calculation	
Fertilizer	Total (GHS) of Confidor fertilizer input		calculation	
Fertilizer	Total (GHS) of Organic fertilizer input		calculation	
Fertilizer	Total (GHS) of Others fertilizer input		calculation	
Pesticides	Select Pesticides input type on this farm plot for last cocoa season 2021/2022		multi-select	A Akate Master B Actara None insyt_other Other
Pesticides	Enter the Quantity of Akate Master Pesticides input type		number	
Pesticides	Enter the Quantity of Actara Pesticides input type		number	
Pesticides	Enter the Quantity of Others Pesticides input type		number	
Pesticides	Enter the Price/unit (GHS) of Akate Master Pesticides input type		number	
Pesticides	Enter the Price/unit (GHS) of Actara Pesticides input type		number	

Page/Section	Question	Question Code	Type	Options
Pesticides	Enter the Price/unit (GHS) of Others Pesticides input type		number	
Pesticides	Total (GHS) of Akate Master Pesticides input type		calculation	
Pesticides	Total (GHS) of Actara Pesticides input type		calculation	
Pesticides	Total (GHS) of Others Pesticides input type		calculation	
Fungicides	Select Fungicides input type on this farm plot for last cocoa season 2021/2022		multi-select	1 Ridomil Gold2 Funguran-OH3 Kocide 20004 Nordox 75 WG5 ChampionNoneinsyt_other Other
Fungicides	Enter the Quantity of Ridomil Gold Fungicides input type		number	
Fungicides	Enter the Price/unit (GHS) of Ridomil Gold Fungicides input type		number	
Fungicides	Total (GHS) of Ridomil Gold Fungicides input		calculation	
Fungicides	Enter the Quantity of Funguran-OH Fungicides input type		number	
Fungicides	Enter the Price/unit (GHS) of Funguran-OH Fungicides input type		number	
Fungicides	Total (GHS) of Funguran-OH Fungicides input		calculation	
Fungicides	Enter the Quantity of Kocide 2000 Fungicides input type		number	
Fungicides	Enter the Price/unit (GHS) of Kocide 2000 Fungicides input type		number	
Fungicides	Total (GHS) of Kocide 2000 Fungicides input		calculation	
Fungicides	Enter the Quantity of Nordox 75 WG Fungicides input type		number	
Fungicides	Enter the Price/unit (GHS) of Nordox 75 WG Fungicides input type		number	
Fungicides	Total (GHS) of Nordox 75 WG Fungicides input		calculation	
Fungicides	Enter the Quantity of Champion Fungicides input type		number	
Fungicides	Enter the Price/unit (GHS) of Champion Fungicides input type		number	
Fungicides	Total (GHS) of Champion Fungicides input		calculation	
Fungicides	Enter the Quantity of Others Fungicides input type		number	
Fungicides	Enter the Price/unit (GHS) of Others Fungicides input type		number	
Fungicides	Total (GHS) of Others Fungicides input		calculation	
Herbicides	Select Herbicides input type on this farm plot for last cocoa season 2021/2022		multi-select	A Round up B Gramoxone None insyt_other Other
Herbicides	Enter the Quantity of Round up Herbicides input type		number	

Page/Section	Question	Question Code	Type	Options
Herbicides	Enter the Price/unit (GHS) of Round up Herbicides input type		number	
Herbicides	Total (GHS) of Round up Herbicides input		calculation	
Herbicides	Enter the Quantity of Gramoxone Herbicides input type		number	
Herbicides	Enter the Price/unit (GHS) of Gramoxone Herbicides input type		number	
Herbicides	Total (GHS) of Gramoxone input		calculation	
Herbicides	Enter the Quantity of Others Herbicides input type		number	
Herbicides	Enter the Price/unit (GHS) of Others Herbicides input type		number	
Herbicides	Total (GHS) of Others Herbicides input		calculation	
Labour (Paid)	Select Labour (Paid) for input type on this farm plot for last cocoa season 2021/2022		multi-select	A Clearing /weeding B Pruning (including mistletoe) C Spraying : Fungicides D Spraying : pesticides E Spraying : Herbicides F Fertilizer Application G Harvesting H Transport of beans I Other Labour Cost None
Labour (Paid)	Enter the Quantity of Clearing /weeding Labour (Paid)		number	
Labour (Paid)	Enter the Price/unit (GHS) for Clearing /weeding Labour (Paid)		number	
Labour (Paid)	Enter the Quantity of Pruning (including mistletoe) Labour (Paid)		number	
Labour (Paid)	Enter the Price/unit (GHS) for Pruning (including mistletoe) Labour (Paid)		number	
Labour (Paid)	Enter the Quantity of Spraying : Fungicides Labour (Paid)		number	
Labour (Paid)	Enter the Price/unit (GHS) for Spraying : Fungicides Labour (Paid)		number	
Labour (Paid)	Enter the Quantity of Spraying : pesticides Labour (Paid)		number	
Labour (Paid)	Enter the Price/unit (GHS) for Spraying : pesticides Labour (Paid)		number	
Labour (Paid)	Enter the Quantity of Spraying : Herbicides Labour (Paid)		number	
Labour (Paid)	Enter the Price/unit (GHS) for Spraying : Herbicides Labour (Paid)		number	
Labour (Paid)	Enter the Quantity of Fertilizer Application Labour (Paid)		number	

Page/Section	Question	Question Code	Type	Options
Labour (Paid)	Enter the Price/unit (GHS) for Fertilizer Application Labour (Paid)		number	
Labour (Paid)	Enter the Quantity of Harvesting Labour (Paid)		number	
Labour (Paid)	Enter the Price/unit (GHS) for Harvesting Labour (Paid)		number	
Labour (Paid)	Enter the Quantity of Transport of beans Labour (Paid)		number	
Labour (Paid)	Enter the Price/unit (GHS) for Transport of beans Labour (Paid)		number	
Labour (Paid)	Enter the Quantity of Other Labour Cost Labour (Paid)		number	
Labour (Paid)	Enter the Price/unit (GHS) for Other Labour Cost Labour (Paid)		number	
Labour (Paid)	Total (GHS) for Clearing /weeding Labour (Paid)		calculation	
Labour (Paid)	Total (GHS) for Pruning (including mistletoe) Labour (Paid)		calculation	
Labour (Paid)	Total (GHS) for Spraying : Fungicides Labour (Paid)		calculation	
Labour (Paid)	Total (GHS) for Spraying : pesticides Labour (Paid)		calculation	
Labour (Paid)	Total (GHS) for Spraying : Herbicides Labour (Paid)		calculation	
Labour (Paid)	Total (GHS) for Fertilizer Application Labour (Paid)		calculation	
Labour (Paid)	Total (GHS) for Harvesting Labour (Paid)		calculation	
Labour (Paid)	Total (GHS) for Transport of beans Labour (Paid)		calculation	
Labour (Paid)	Total (GHS) for Other Labour Cost (Paid)		calculation	
	On the average how many days per week did you and your family (or any unpaid labour) work on this plot in the 2021/2022 cropping season		number	
	How many hours per day did you and your family combined (or any unpaid labour) work on this plot in the 2021/2022 cropping season?		number	
Cocoa Sales	What are your main considerations for selling to a selected LBC?		single-select	ProximityAccess to cash and input loansRelationship with purchasing clerkBrand name integritymember of LBC grouppeer influenceinsyt_other Other
Cocoa Sales	Which LBCs did you sell to		multi-select	PBC Armajaro Olam Akuafo Adamfo Kuapa Kooko Kumankuma insyt_other Other

Page/Section	Question	Question Code	Type	Options
	State the farm related costs[GHS] on LAND RENT incurred in the past 12months on this plot		number	
	State the farm related costs[GHS] on MACHINERY REPAIRS/MAINTENANCE incurred in the 12months on this plot		number	
	State the farm related costs[GHS] on ACQUISITION OF PROPERTY/ASSETS incurred in the 12months on this plot		number	
	State the farm related costs[GHS] on ACQUISITION OF WORK TOOLS incurred in the 12months on this plot		number	
	State the farm related costs[GHS] on TRANSPORT incurred in the 12months on this plot		number	
	State the farm related costs[GHS] on OTHERS incurred in the 12months on this plot		number	
MODULE P: Small Tools	Small Tools	inventory	multi-select	Hoe Cutlass Pickaxe Sickle Shovel Hand Fork SawAxe Watering Can Wheebarrow Weeder Knapsack sprayer Manual seeder Noneinsyt_other Other
MODULE P: Small Tools	Inventory of Agricultural Equipment Used	inventory	sub-form	
	Small Tools	inventory	single-select	Hoe Cutlass Pickaxe sickle Sickle shovel Shovel Hand Fork Saw Axe Watering Can Wheelbarrow Weeder Knapscack sprayer Knapsack sprayer Manual seeder
	Quantity owned		number	
	Year Acquired		number	
	Acquisition mode		single-select	Purchased in cash Received as an inheritance Gift received from a project Donation received from family Self made
	Acquisition Unit Price		number	
	Total Amount (or Value at time of acquisition if not purchased) if		number	

Page/Section	Question	Question Code	Type	Options
	Condition When Acquired		single-select	New Used/Secondhand
MODULE P: Mechanical Tools	Mechanical tools	mechanical_tools	multi-select	Cart Plough Harrow Pen rollerOther animal traction equipment TractorMotocultivatorMotor pump Other irrigation equipment Chainsaw Motor tractor Milking equipment Power tillerNoneinsyt_other Other
MODULE Q -FOOD SECURITY	During which months of the year did you encounter difficulties in ensuring the household's staple food consumption?	FAS1	multi-select	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec None
MODULE Q -FOOD SECURITY	In total how many months?	FAS2	number	
MODULE Q -FOOD SECURITY	During which months of the year did you encounter difficulties which resulted in a reduction in the quantity consumed per day, compared to what you would have liked?	FAS3	multi-select	Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec None
MODULE Q -FOOD SECURITY	In total how many months?	FAS4	number	
MODULE R - Household Perception of Food Security (	Over the last 4 weeks, Were you concerned that your household did not have enough food?	PFS1	single-select	NeverRarely (1 to 2 times) Sometimes (3 to 10 times)Often (more than 10 times)
MODULE R - Household Perception of Food Security (	Over the last 4 weeks, Have you or someone in your household been unable to eat the types of food you prefer because of lack of resources?	PFS2	single-select	Never Rarely (1 to 2 times) Sometimes (3 to 10 times) Often (more than 10 times)
MODULE R - Household Perception of Food Security (	Over the last 4 weeks, Did you or someone in your household eat a limited variety of foods because of insufficient resources?	PFS3	single-select	Never Rarely (1 to 2 times) Sometimes (3 to 10 times) Often (more than 10 times)
MODULE R - Household Perception of Food Security (	Over the last 4 weeks, Did you or someone in your household eat food that you did not want to eat due to lack of resources to obtain other types of food?	PFS4	single-select	Never Rarely (1 to 2 times) Sometimes (3 to 10 times) Often (more than 10 times)

Page/Section	Question	Question Code	Type	Options
MODULE R - Household Perception of Food Security (	Over the last 4 weeks, Did you or someone in your household eat a smaller meal than you wanted because there was not enough food?	PFS5	single-select	Never Rarely (1 to 2 times) Sometimes (3 to 10 times) Often (more than 10 times)
MODULE R - Household Perception of Food Security (	Over the last 4 weeks, Did you or any member of your household eat fewer meals per day because there was not enough food?	PFS6	single-select	Never Rarely (1 to 2 times) Sometimes (3 to 10 times) Often (more than 10 times)
MODULE R - Household Perception of Food Security (	Over the last 4 weeks, Has the household ever been completely without food because there were no resources to buy it?	PFS7	single-select	Never Rarely (1 to 2 times) Sometimes (3 to 10 times) Often (more than 10 times)
MODULE R - Household Perception of Food Security (	Over the last 4 weeks, Did you or any member of your household go to bed hungry because there was not enough food?	PFS8	single-select	NeverRarely (1 to 2 times) Sometimes (3 to 10 times)Often (more than 10 times)
MODULE R - Household Perception of Food Security (	Over the last 4 weeks, Did you or any member of your household go all day and all night without eating because there was not enough food?	PFS9	single-select	Never Rarely (1 to 2 times) Sometimes (3 to 10 times) Often (more than 10 times)
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Cereals (Corn, rice, wheat, sorghum, millet and other cereal like or bread, noodles, porridge, spaghetti, biscuits, etc.)	SDAF_G1	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Roots, white tubers and plantain (White sweet potatoes, cassava, potatoes, yams or all white roots and tubers, plantain bananas)	SDAF_G2	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Vitamin-rich vegetables and tubers (Any food such as pumpkins, carrots, or sweet potatoes that has a yellow pigment, including local yellow corn)	SDAF_G3	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Dark green leafy vegetables (Dark green leafy vegetables as well as local vegetables including leaf amaranth, cassava, sweet potato, mustard, pumpkin, cowpea, bean, etc.)	SDAF_G4	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Other vegetables (Any leafy vegetables such as Chinese cabbage, cabbage, tomatoes, onions, green pepper and green beans, leeks, cucurbits)	SDAF_G5	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Fruits rich in vitamin A (Ripe mango, melon, apricot (fresh or dried), ripe papaya, dried peach and pure juice obtained from these same fruits)	SDAF_G6	single-select	1 Yes2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Offal (Meats of liver, kidney, heart, or other blood-based organs or foods.)	SDAF_G7	single-select	1 Yes 2 No

Page/Section	Question	Question Code	Type	Options
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Meat (muscle) (Any meat, e.g. beef, lamb, pork, goat, rabbit, mouse, wild game, poultry, duck, flying insects, etc..)	SDAF_G8	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Eggs (all sorts)	SDAF_G9	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Fish / seafood (fresh or died)	SDAF_G10	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Beans, peas and lentils (Any type of beans and ground peas, cowpeas, soybeans)	SDAF_G11	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Nuts and seeds (Peanuts, pumpkin seeds, sunflower seeds, cashews, macadamia nuts)	SDAF_G12	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Milk and dairy products (Milk and milk-based foods such as yogurts and cheeses)	SDAF_G13	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Oils and fats (Such as cooking oil, animal fats and margarine used for cooking or added to food)	SDAF_G14	single-select	1 Yes 2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Sweets (Any sweet product, sugar, honey, soft drinks (fanta, coca cola, sprite) drinks to which such a product has been added or sweet food, chocolate, sweets)	SDAF_G15	single-select	1 Yes2 No
MODULE S - WOMEN'S DIETARY DIVERSITY (WDDS)	Spices, condiments, drinks (Spices (black pepper, salt), condiments, hot sauce, Any tea or coffee.)	SDAF_G16	single-select	1 Yes 2 No
MODULE T - Migratory Trajectory of the FARMER	Your father was born in:	T1	single-select	1 This village 2 A nearby village 3 This district 4 Another district in the region, specify 5 another region, specify 6 Another country, specify 8 Don't Know
MODULE T - Migratory Trajectory of the FARMER	Another district in the region, specify	T1a	text	
MODULE T - Migratory Trajectory of the FARMER	Another region, specify	T1b	text	
MODULE T - Migratory Trajectory of the FARMER	Another country, specify	T1c	text	
MODULE T - Migratory Trajectory of the FARMER	Ethnic group of father	T2	single-select	1 Akan 2 Ewe 3 Ga Adangbe 4 Guan 6 Mole Dagani 7 Other
MODULE T - Migratory Trajectory of the FARMER	Your mother was born in:	T3	single-select	1 This village 2 A nearby village 3 This district 4 Another district in the

Page/Section	Question	Question Code	Type	Options
				region, specify 5 another region, specify 6 Another country, specify 8 Don't Know
MODULE T - Migratory Trajectory of the FARMER	Another district in the region, specify	T3a	text	
MODULE T - Migratory Trajectory of the FARMER	Another region, specify	T3b	text	
MODULE T - Migratory Trajectory of the FARMER	Another country, specify	T3c	text	
MODULE T - Migratory Trajectory of the FARMER	Ethnic group of mother	T4	single-select	1 Akan 2 Ewe 3 Ga Adangbe 4 Guan 6 Mole Dagani 7 Other
	Are you a native of this village	T5	single-select	1 Yes 2 No
	If the respondent is not native to the village, place of birth:	T6	single-select	1 Other village in the locality 2 This district 3 This region 4 in Ivory Coast 5 In Burkina Faso 6 Ghana 7 Mali 8 Other
	Last migratory experience (before settling here) - Before arriving here, did you live	T7	single-select	1 In the locality 2 In this district 3 in this region 4 in Ivory Coast 5 In Burkina Faso 6 Ghana 7 Mali 8 Other country, specify
	How many times have you migrated in your life before settling here?	T8	number	
	If not native, year of settlement (habitat) here?	T9	number	
	Ae you a native of another country?		single-select	Yes No
	If native of another country, year of arrival in Ghana?	T10	number	
	Year of starting an economic activity in this village	T11	number	
	When you arrived, did you know anyone in the village?	T12	single-select	1 Yes 2 No
	If yes, who?	T13	single-select	1 immediate family 2 Close family of the spouse(s) 3 distant relatives 4 Distant relatives of the spouse(s) 5 An acquaintance from my region of origin 6 Other
	Did this knowledge (person you knew) give you work?	T14	single-select	1 Yes 2 No
	Main reason for migration	T15	single-select	1 Economic reason (related to agriculture)

Page/Section	Question	Question Code	Type	Options
				2 Economic reason (unrelated to agriculture) 3 Crisis/conflict 4 Followed husband/wife 5 Other family reunification 6 Other
	In the last 12 months have you sent money to your village/country of origin?	T16	single-select	1 Yes 2 No
	How many times in the last 12 months?	T16b	single-select	1 2 3 4 5 6 7 8 9 10 11 12
	If yes, total amount per year (in GHS)?		number	
	In the past 12 months, who have you sent money to? (Two possible answers)	T17	multi-select	1 To yourself on an account (bank or telephone) in your village/country2 Family3 Friend4 Creditors5 Other
	If you sent money to the family, to whom?	T18	single-select	1 Father 2 Mother 3 Brothers 4 Sister 5 Son 6 Daughter 7 Uncle/aunt/nephews/, Other family of father 8 Parents-in-law 9 Brothers/sisters-in-law 10 Other family of mother
	If agricultural investment in the village, is the money earned here used to finance cocoa farming?	T21	single-select	1 Yes 2 No
MODULE U-AGRICULTURAL PRODUCTION (PERENNIAL CROP)	Over the past 12 months, what have been the main agricultural productions from perennial crops?	agric_produce	multi-select	1= Rubber Rubber , 2= African palm Oil palm , 3= Cashew Cashew 4= Coconut Coconut , 5=Orange, Orange, 6=Avocado Avocado 7=Coffee Coffee None insyt_other Other
	Agricultural Production (Perennial Crops)	agric_produce	sub-form	
	Over the past 12 months, what have been the main agricultural productions from perennial crops?	agric_produce	single-select	1= Rubber Rubber , 2= African palm African palm , 3= Cashew Cashew 4= Coconut Coconut , 5=Orange, Orange, 6=Avocado Avocado 7=Coffee Coffee insyt_other Other

Page/Section	Question	Question Code	Type	Options
	Who manages this culture within the household?		single-select	1= head of household Head of household; 2=spouse of the head Spouse of the head 3= child Childinsyt_other Other member of the household5= the couple; The Couple 6=all household members together; All household members together; 7=Sharecropper; Sharecropper8=Salaried crop manager; Salaried crop manager 9=other other
	Total area in production		number	
	Year of Establishment of productive area		number	
	Estimated proportion of produce sold %		single-select	1=100% marketed; 100% marketed 2=3/4 marketed; 3/4 marketed 3=50/50; 50/50 4=1/3 marketed 1/3 marketed 4=¼ marketed; ¼ marketed 5=less than a quarter of production is marketed less than a quarter of production is marketed 6=no marketing, own consumption no marketing, own consumption
	Quantity produced (sold + self consumed) (last 12 months)		number	
	Unit of Quantity sold		multi-select	kg bags insyt_other Other
	Quantity sold		number	
	price per (GHS)		number	
	Annual Revenue	annaul_revenur	calculation	
	What was the total number of bags of fertilizer purchased for this production		number	
	What was the total amount (GHS) spent on fertilizer		number	
	What was the quantity (lts) of pesticide purchased?		number	
	Whats was the total amount (GHS) spent on pesticide?		number	
	What was the quantity (lts) of insecticide purchased?		number	
	Whats was the total amount (GHS) spent on insecticide?		number	
	What was the quantity (lts) of fungicides purchased?		number	
	Whats was the total amount (GHS) spent on fungicides?		number	
	What was the quantity (lts) of other agrochemicals purchased?		number	
	Whats was the total amount (GHS) spent on agrochemicals?		number	

Page/Section	Question	Question Code	Type	Options
	Amount spent on inventory/consumables/materials		number	
	Amount spent on labour		number	
	Amount spent on utilities (water, electricity, sanitation)		number	
	Amount spent on transport (for business purposes only)		number	
	Amount spent on maintenance/repairs		number	
	Amount spent on rentals		number	
	Amount spent on other expenses		number	
MODULE V - AGRICULTURAL PRODUCTION (FOOD CROPS)	Over the past 12 months, select the main agricultural productions from food crops?	food_crop_type	multi-select	1 rice 2 Plantain 3 Yam 4 Cassava 5 Vegetables None insyt_other Other
	Fill in selected agricultural productions from food crops	food_crop	sub-form	
	Over the past 12 months, select the main agricultural productions from food crops?	food_crop_type	single-select	1 rice 2 Plantain 3 Yam 4 Cassava 5 Vegetables
	Who manages this production within the household?		single-select	1 head of household 2 spouse of the head 3 child 5 the couple 6 all household members together 7 Sharecropper 8 Salaried crop manager 9 Other 4 Other member of the household
	Estimated proportion of produce sold %		single-select	1 100% marketed 2 3/4 marketed 3 50/50 4 1/3 marketed 5 ¼ marketed 6 less than a quarter of production is marketed 7 no marketing, own consumption
	Area in production		number	
	Units produced		multi-select	kg bags insyt_other Other
	Quantity sold		number	
	Unit price		number	
	Annual Revenue	annual_revenue_2	calculation	
	What was the total number of bags of fertilizer purchased		number	
	What was the total amount (GHS) spent on fertilizer		number	
	What was the quantity (lts) of pesticide purchased?		number	
	Whats was the total amount (GHS) spent on pesticide?		number	

Page/Section	Question	Question Code	Type	Options
	What was the quantity (lts) of insecticide purchased?		number	
	Whats was the total amount (GHS) spent on insecticide?		single-select	
	What was the quantity (lts) of fungicides purchased?		single-select	
	Whats was the total amount (GHS) spent on fungicides?		single-select	
	What was the quantity (lts) of other agrochemicals purchased?		single-select	
	Whats was the total amount (GHS) spent on agrochemicals?		number	
	Amount spent on inventory/consumables/materials		number	
	Amount spent on labour		number	
	Amount spent on utilities (water, electricity, sanitation)		number	
	Amount spent on transport (for business purposes only)		number	
	Amount spent on maintenance/repairs		number	
	Amount spent on rentals		number	
	Amount spent on other expenses		number	
MODULE W - AGRICULTURAL PRODUCTION (LIVESTOCK)	Over the past 12 months, select the main agricultural productions from livestocks?	livstock_type	multi-select	1 Poultry2 Cattle3 Sheep4 Goats5 Pigs6 Non-traditional animalsNone
MODULE W - AGRICULTURAL PRODUCTION (LIVESTOCK)	Fill in selected agricultural productions from livestock	livestock_type	sub-form	
	Over the past 12 months, select the main agricultural productions from livestock	livstock_type	single-select	1 Poultry 2 Cattle 3 Sheep 4 Goats 5 Pigs 6 Non-traditional animals
	Who manages this production within the household?		single-select	1 head of household 2 spouse of the head 3 child 5 the couple 6 all household members together 7 Sharecropper 8 Salaried crop manager 9 Other 4 Other member of the household
	Estimated proportion of produce sold %		single-select	1 100% marketed 2 3/4 marketed 3 50/50 4 1/3 marketed 5 ¼ marketed 6 less than a quarter of production is marketed 7 no marketing, own consumption
	Quantity produced		number	
	Units sold		number	

Page/Section	Question	Question Code	Type	Options
	Unit price		number	
	Annual revenue	annual_revenue_sold	calculation	
	What was the total amount spent on feed		number	
	What was the total amount spent on vaccinations		number	
	What was the total amount spent on medications		number	
	What was the total amount spent on animal supplements and concentrates		number	
	Amount spent on labour		number	
	Amount spent on utilities (water, electricity, sanitation)		number	
	Amount spent on transport (for business purposes only)		number	
	Amount spent on maintenance/repairs		number	
	Amount spent on rentals		number	
	Amount spent on other expenses		number	
Non Agricultural Income	In the past 12 months, have you had any non-agricultural income?		single-select	Yes No
Non Agricultural Income	Fill in selected non-agricultural income		sub-form	
	Over the past 12 months, select the main non agricultural income?		single-select	Trading Small scale mining Artisan/craft Provision of labour Motor/taxi driver Rental income Barnering/Hardressing Barbering/Hairdressing Tailoring/Dressmaking None insyt_other Other
	Who manages this production within the household?		single-select	Head of Household Spouse Child Other household member salaried manager insyt_other Other
	Estimated average monthly sales (GHS)		number	
	Amount spent on inventory/consumables/materials		number	
	Amount spent on labour		number	
	Amount spent on utilities (water, electricity, sanitation)		number	
	Amount spent on transport (for business purposes only)		number	
	Amount spent on maintenance/repairs		number	
	Amount spent on rentals		number	
	Amount spent on other expenses		number	
	Total expenses	total_expense	calculation	
MODULE X - IDENTIFICATION OF SHOCKS	DOMESTIC SHOCKS - Identify major changes in the	C37	single-select	Yes No

Page/Section	Question	Question Code	Type	Options
	daily life of the household over the past 3 yearss.			
MODULE X - IDENTIFICATION OF SHOCKS	Select all major changes in the daily life of the household over the past 3 yearss.	C2	multi-select	C2a A death of one or more household members C2b Illness or serious accident of one or more members of the household C2c Birth C2d Divorced C2e Departure of one or more children C2f Other
PRODUCTION SHOCK	Over the past 3 years, have you experienced any exceptional events that have had a significant impact on your cocoa farm?	C38	single-select	1 Yes 2 No
PRODUCTION SHOCK	Select all exceptional events that have had a significant impact on your cocoa farm?	C3	multi-select	C3a Wandering of animals involving notable lossesC3b Tree felling by loggers involving lossesC3c Swollen ShootC3d Other cocoa pests/pestsC3e Fire in the plantationC3f Severe droughtC3g Significant floodingC3h Lag in the seasons (late rains) having an effect on productioninsyt_other Other
OTHER ECONOMIC SHOCK	Over the last 3 years, has your household suffered an event that has had a negative and lasting effect on the operation?	C39	single-select	1 Yes 2 No
OTHER ECONOMIC SHOCK	Select all economic shock your household suffered an event that has had a negative and lasting effect on the operation?	C4	multi-select	C4a Loss of family labor (departure, illness, accident, death) C4b Exceptional loss of money (theft, repayment of debt or other) C4c Investment in other activities that has had a negative and lasting effect on the operation? C4d Reduced activity related to old age C4e Land conflict C4f Lack of labor (or significant increase in its cost) C4g Rising input prices C4h Other
OTHER ECONOMIC SHOCK	Over the past 3 years, has an exceptional event positively affected operations?	C40	single-select	1 Yes 2 No
OTHER ECONOMIC SHOCK	If so, what event? Specify in full	C41	text	
MODULE X - DISEASE PODS – BLACK POD AND SWOLLEN SH	Which of these types of Disease/problems did you find in your cocoa plantations?	disease_pods	multi-select	Stem borer diseaseCapsid CSSVBlackpodMistletoeTer mitesinsyt_other Other
MODULE X - DISEASE PODS – BLACK POD AND SWOLLEN...	Black Pod and Swollen Shoot Virus	disease_pods	sub-form	

Page/Section	Question	Question Code	Type	Options
	For how many years have you had this problem?		number	
	What do you do when you find these disease/problem on your farm		single-select	A) 1= Remove the pods from the farm and bury them; Remove the pods from the farm and bury them; 2= Remove the pods from the farm and burn them Remove the pods from the farm and burn them 3= Bury the pods on my farm Bury the pods on my farm 4= Burn the pods on my farm; Burn the pods on my farm; 5= Remove pods from the trees and leave them on the ground Remove pods from the trees and leave them on the ground 6= Leave the pods on the trees Leave the pods on the trees 7= Spray with Agrochemicals Spray with Agrochemicals 8= No diseased pods No diseased pods Don't know Cut down affected trees
	How much of the farm is affected		single-select	1 - 25% 26 - 50% 51 - 75% 76 - 100%
	How many plots		number	
	Which ones		text	
MODULE Y - OTHER DISASTERS	Type Disease/Problem	other_disasters	multi-select	Theft Damage as a result of lumbering Weather related disasters eg. flood, drought. None insyt_other Other
OTHER DISASTERS	Other Disasters	other_disasters	sub-form	
	What do you do when you find these problems on your farm		single-select	1= Report to the Police; 2= Report to the Forestry Commission 3= Invite National Disaster Manaagement Organization 4= Burn the pods on my farm; 5= Remove pods from the trees and leave them on the ground 6= Leave the pods on the trees 7= Spray with Agrochemicals 8= No diseased pods 998= Don't know Report to the Police 2= Report to the Forestry Commission Report to the Forestry Commission 3= Invite National Disaster Management Organization Invite National Disaster Management Organization 4= Burn the pods on my farm; Burn the pods on my farm

Page/Section	Question	Question Code	Type	Options
				5= Remove pods from the trees and leave them on the ground Remove pods from the trees and leave them on the ground 6= Leave the pods on the trees Leave the pods on the trees 7= Spray with Agrochemical Spray with Agrochemicals No diseased pods Don't know Report to chief or community leader Do nothing insyt_other Other
	How much of the farm is affected		single-select	1-25% 26-50% 51-75% 76-100%
	How many plots		number	
MODULE Z: Climate Change Perception	Have you noticed any long-term changes (>=20years) in temperature?	Z1	single-select	1 Yes2 No998 Don't know
MODULE Z: Climate Change Perception	If yes please indicate the changes you observed on temperature	Z2	multi-select	Z2a Increase of average temperature Z2b Decrease of average temperature Z2c Increase of the minimum level compared to the last 2 decades Z2d Decrease of the minimum level compared to the last 2 decades Z2d Increase of the maximum level compared to the last 2 decades Z2e Decrease of the maximum level compared to the last 2 decades Z2e Refused to answer 998 Don't know
MODULE Z: Climate Change Perception	Have you noticed any long-term changes (i.e. >=20years) in rainfall?	Z3	single-select	1 Yes 2 No 998 Don't know
MODULE Z: Climate Change Perception	If yes please indicate the changes you observed on rain	Z4	multi-select	Z4a Increase of the variability of the rainZ4b Decrease of the variability of the rainZ4c Late rainZ4d Early rainZ4e Increase of the intensity of rainZ4f Decrease of the intensity of rainZ4g Increase of average rainfallZ4h Decrease of average rainfallZ4i Increase of minimum rainfallZ4j Decrease of the minimum rainfallZ4k Increase of maximum rainfallZ4l Decrease of maximum rainfall
MODULE Z: Climate Change Perception	Have these changes had any effect on your livelihood in terms of losses incurred in the past (5-10years)	Z5	single-select	1 Yes 2 No 998 Don't know

Page/Section	Question	Question Code	Type	Options
MODULE Z: Climate Change Perception	If yes indicate the extent to which climate variability is responsible for reduced income in your household	Z6	single-select	Z6a 1-25% Z6b 26-50% Z6c 51-75% Z6d 76-100%
MODULE Z: Climate Change Perception	Have you experienced flooding, drought or any natural disaster in the past (5-10years)	Z7	single-select	1 Yes 2 No 998 Don't know
MODULE Z: Climate Change Perception	How many times have you experienced flooding	Z8a	number	
MODULE Z: Climate Change Perception	How many times have you experienced drought	Z8b	number	
MODULE Z: Climate Change Perception	Did you receive any warning about the aforementioned disaster before it happened?	Z9	single-select	1 Yes 2 No 998 Don't know
	Was any one in your household injured during those events?	Z10	single-select	1 Yes2 No
	Did any member in your household die during those events?	Z11	single-select	1 Yes 2 No
	Were you displaced from your home during this events?	Z12	single-select	1 Yes 2 No
	If yes, where did you go to?	Z13	single-select	Z13a Friends' Z13b Relations Z13c Neighbors Z13d Refugee camp insyt_other Other
	Has this event had any effect on your livelihood in terms of losses incurred in the past (5-10years)	Z14	single-select	1 Yes 2 No
	If yes indicate the extent to which these events are responsible for reduced income in your household	Z15	single-select	Z15a 1-25% Z15b 26-50% Z15c 51-75% Z15d 76-100%
	Do you get information from the media on climate change variations?	Z16	single-select	1 Yes 2 No
	What media channels do you use to obtain general information?	Z17	multi-select	Local Radio National Radio TV Mobile phones Newspaper Magazine SMS Services InternetSocial media insyt_other Other
	Do you think the government is adequately helping farmers to adjust to impact of climate change?	Z18	single-select	1 Yes 2 No
	What should be done by the government to help address climate change on your farming activities?	Z19	multi-select	Timely information/education for farming activities Provide more inputs to increase productionProvide credit Provide drought resistant seeds/crops for planting insyt_other Other
LEVEL OF AGREEMENT	The weather is changing	X20a	single-select	1 Strongly disagree 2 disagree 3 Neither agree nor disagree

Page/Section	Question	Question Code	Type	Options
				4 Agree 5 Strongly agree
LEVEL OF AGREEMENT	Change in weather will induce increase of temperature and decrease of rainfall	X20b	single-select	1 Strongly disagree 2 disagree 3 Neither agree nor disagree 4 Agree 5 Strongly agree
LEVEL OF AGREEMENT	Change in weather will increased the variability of precipitation	X20c	single-select	1 Strongly disagree 2 disagree 3 Neither agree nor disagree 4 Agree 5 Strongly agree
LEVEL OF AGREEMENT	Change in weather will reduce the availability of water	X20d	single-select	1 Strongly disagree 2 disagree 3 Neither agree nor disagree 4 Agree 5 Strongly agree
LEVEL OF AGREEMENT	Change in weather will increase land erosion	X20e	single-select	1 Strongly disagree 2 disagree 3 Neither agree nor disagree 4 Agree 5 Strongly agree
LEVEL OF AGREEMENT	Change in weather will increase the likelihood of drought and flood	X20f	single-select	1 Strongly disagree 2 disagree 3 Neither agree nor disagree 4 Agree 5 Strongly agree
LEVEL OF AGREEMENT	Change in weather will affect agricultural production	X20g	single-select	1 Strongly disagree2 disagree3 Neither agree nor disagree4 Agree5 Strongly agree
	What recommendations would you make for enhancing farmer's adaptation to climate change? (tick all that apply)	X21	multi-select	1 Avoid deforestation 2 Avoid bush burning 3 Plant more trees 4 Less use of agro-chemicals 5 Desist galamsey 6 Plant soil cover crops 7 Practice diversification.. 8 Other

Appendix 2: Multivariate test of Means – Education Status between Farmers in Ashanti and Western Regions

Test	Statistic	F(df1,	df2)	F	Prob>F
Wilks' lambda	0.9806	1	511	10.12	0.0016
Pillai's trace	0.0194	1	511	10.12	0.0016
Lawley-Hotelling trace	0.0198	1	511	10.12	0.0016
Roy's largest root	0.0198	1	511	10.12	0.0016

Appendix 3: Multivariate test of Means – Variety Planted between Farmers in Ashanti and Western Regions

Test	Statistic	F(df1,	df2)	F	Prob>F
Wilks' lambda	0.9998	1	511	0.08	0.7756
Pillai's trace	0.0002	1	511	0.08	0.7756
Lawley-Hotelling trace	0.0002	1	511	0.08	0.7756
Roy's largest root	0.0002	1	511	0.08	0.7756

Appendix 4: Multivariate Test of Means – Yield per Variety Planted between Farmers in Ashanti and Western Regions

mvtest means Whatvarietyofcocoaisplanted, by(Region) Test for equality of 2 group means, assuming homogeneity

	Statistic	F(df1,	df2)	= F	Prob>F
Wilks' lambda	0.9998	1.0	511.0	0.08	0.7756
Pillai's trace	0.0002	1.0	511.0	0.08	0.7756
Lawley-Hotelling trace	0.0002	1.0	511.0	0.08	0.7756
Roy's largest root	0.0002	1.0	511.0	0.08	0.7756

Appendix 5: Cost and Revenue Estimates of Tree Crops

i. Tree Crop Production Information: Cocoa

Year	Expected Output (mt/ha)	Output as weight of total lifetime production	Cumulative of Output as weight of total
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.31	0.02	0.02
4	0.31	0.02	0.03
5	0.31	0.02	0.05
6	0.38	0.02	0.07
7	0.44	0.02	0.10
8	0.50	0.03	0.12
9	0.56	0.03	0.15
10	0.69	0.04	0.19
11	0.75	0.04	0.23
12	0.81	0.04	0.28
13	0.81	0.04	0.32
14	0.88	0.05	0.37
15	0.94	0.05	0.42
16	1.00	0.05	0.47
17	1.00	0.05	0.53
18	1.00	0.05	0.58
19	0.88	0.05	0.63
20	0.88	0.05	0.68
21	0.88	0.05	0.73
22	0.63	0.03	0.76
23	0.63	0.03	0.80
24	0.63	0.03	0.83
25	0.63	0.03	0.86
26	0.63	0.03	0.90
27	0.63	0.03	0.93
28	0.63	0.03	0.97
29	0.31	0.02	0.98
30	0.31	0.02	1.00
31	0.39	0.02	1.00
			1.00
	18.31	1.00	

ii. Tree Crop Production Information: Rubber

Year	Expected Output (mt/ha)	Output as weight of total lifetime production	Cumulative of Output as weight of total
1	0.00		0.00
2	0.00		0.00
3	0.00		0.00
4	0.00		0.00
5	0.00		0.00
6	0.77	0.01	0.01
7	0.77	0.01	0.02
8	0.96	0.01	0.03
9	1.16	0.01	0.04
10	1.76	0.02	0.06
11	2.48	0.03	0.09
12	2.48	0.03	0.12
13	3.85	0.05	0.17
14	3.85	0.05	0.22
15	3.85	0.05	0.26
16	3.85	0.05	0.31
17	3.85	0.05	0.35
18	3.85	0.05	0.40
19	3.85	0.05	0.45
20	3.85	0.05	0.49
21	3.85	0.05	0.54
22	3.85	0.05	0.59
23	3.85	0.05	0.63
24	3.85	0.05	0.68
25	3.85	0.05	0.72
26	3.85	0.05	0.77
27	3.85	0.05	0.82
28	3.85	0.05	0.86
29	3.85	0.05	0.91
30	3.85	0.05	0.95
31	3.85	0.05	1.00
			0.95
	83.52	1.00	

iii. Tree Crop Production Information: Oil Palm

Year	Expected Output (mt/ha)	Output as weight of total lifetime production	Cumulative of Output as weight of total
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	3.00	0.01	0.01
4	5.00	0.02	0.03
5	6.00	0.02	0.05
6	7.00	0.02	0.07
7	7.00	0.02	0.10
8	10.00	0.03	0.13
9	10.00	0.03	0.17
10	11.00	0.04	0.20
11	12.00	0.04	0.25
12	12.00	0.04	0.29
13	14.00	0.05	0.34
14	14.00	0.05	0.39
15	14.00	0.05	0.43
16	14.00	0.05	0.48
17	14.00	0.05	0.53
18	12.00	0.04	0.57
19	12.00	0.04	0.61
20	11.00	0.04	0.65
21	10.00	0.03	0.69
22	10.00	0.03	0.72
23	10.00	0.03	0.76
24	10.00	0.03	0.79
25	10.00	0.03	0.83
26	10.00	0.03	0.86
27	10.00	0.03	0.90
28	10.00	0.03	0.93
29	10.00	0.03	0.97
30	10.00	0.03	1.00
31	10.00	0.03	1.03
			1.00
	288.00	1.00	

Appendix 6: Full Results of Stochastic Frontier Estimation

Stoc. frontier normal/tnormal model Number of obs = 512
Wald chi2(28) = 660.02
Prob > chi2 = 0.0000

Log likelihood = -839.0040

lngrossprofitha	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
Frontier						
lnmrev	.5727545	.2698261	2.12	0.034	.043905	1.101604
lnmfert	.0354135	.0952024	0.37	0.710	-.1511798	.2220068
lnmpest	.0869141	.1167625	0.74	0.457	-.1419363	.3157644
lnmfung	.0389636	.0933152	0.42	0.676	-.1439308	.221858
lnmherb	.2333794	.1094924	2.13	0.033	.0187782	.4479806
lnmlabour	-.0334449	.0780549	-0.43	0.668	-.1864297	.1195399
lnmovhds	-.1043343	.0988228	-1.06	0.291	-.2980235	.0893548
lnmtotrevsq	-2.60e-10	.	.	.	.	.
lnmfertsq	.0366956	.0414462	0.89	0.376	-.0445375	.1179287
lnmpestsq	.1525857	.0394924	3.86	0.000	.075182	.2299895
lnmfungsq	.0584153	.0277037	2.11	0.035	.004117	.1127135
lnmherbsq	.1696618	.0538708	3.15	0.002	.0640769	.2752467
lnmlabsq	.0751927	.0310761	2.42	0.016	.0142847	.1361007
lnmovhdsq	.0544929	.0333356	1.63	0.102	-.0108437	.1198295
lntotrev_fert	2.13e-11	.	.	.	.	.
lntotrev_pest	-5.48e-12	.	.	.	.	.
lntotrev_fung	1.16e-11	.	.	.	.	.
lntotrev_herb	2.54e-11	.	.	.	.	.
lntotrev_lab	7.17e-12	.	.	.	.	.
lntotrev_ovhd	-1.81e-11	.	.	.	.	.
lnfert_pest	-.0056924	.0151858	-0.37	0.708	-.035456	.0240712
lnfert_fung	-.0026991	.0135841	-0.20	0.842	-.0293234	.0239252
lnfert_herb	-.0125564	.014073	-0.89	0.372	-.040139	.0150261
lnfert_lab	.0143305	.0138865	1.03	0.302	-.0128866	.0415476
lnfert_ovhd	-.0066372	.0187308	-0.35	0.723	-.0433488	.0300744
lnpest_fung	-.0131396	.0130545	-1.01	0.314	-.038726	.0124469
lnpest_herb	.0040747	.0140421	0.29	0.772	-.0234474	.0315968
lnpest_lab	-.0107559	.0142168	-0.76	0.449	-.0386203	.0171085
lnpest_ovhd	-.0349518	.0220708	-1.58	0.113	-.0782098	.0083062
lnfung_herb	.0028606	.0110267	0.26	0.795	-.0187514	.0244725
lnfung_lab	.009897	.0122019	0.81	0.417	-.0140182	.0338123
lnfung_ovhd	-.0225537	.0158164	-1.43	0.154	-.0535533	.0084459
lnherb_lab	-.0482415	.016115	-2.99	0.003	-.0798263	-.0166567
lnherb_ovhd	.0222297	.0220446	1.01	0.313	-.0209771	.0654364
lnlab_ovhd	-.0380415	.0196953	-1.93	0.053	-.0766436	.0005606
_cons	6.563747	.6752461	9.72	0.000	5.240289	7.887205
Mu						

HH_Size	2.180975	1.745055	1.25	0.211	-1.23927	5.601219
Migrant	-10.12804	7.788143	-1.30	0.193	-25.39251	5.136443
Age	-1.866871	1.033178	-1.81	0.071	-3.891863	.1581211
Age2	.0191289	.0096663	1.98	0.048	.0001832	.0380745
Gender	-7.792252	7.412208	-1.05	0.293	-22.31991	6.735408
Education1						
0	-1.24e-14		.	.	.	.
1	-.657666	8.398361	-0.08	0.938	-17.11815	15.80282
2	-1.607868	8.328404	-0.19	0.847	-17.93124	14.7155
3	5.73035	11.03148	0.52	0.603	-15.89095	27.35165
4	4.301164	21.34049	0.20	0.840	-37.52542	46.12775
FBO	7.886477	7.862989	1.00	0.316	-7.524698	23.29765
Credit	-4.920941	6.846478	-0.72	0.472	-18.33979	8.49791
Howmanymilesfromyourhousei	.2476364	.5918587	0.42	0.676	-.9123854	1.407658
FarmArea_ha	1.305794	1.268937	1.03	0.303	-1.181276	3.792865
Haveyoualreadybenefitedfrom	-4.220438	7.506788	-0.56	0.574	-18.93347	10.4926
Areyouinacertificationproje	-2.11746	12.47854	-0.17	0.865	-26.57494	22.34003
AgeofPlotcut						
3	3.40e-15		.	.	.	.
8	-11.41571	8.173591	-1.40	0.163	-27.43565	4.604236
16	-8.513658	9.496758	-0.90	0.370	-27.12696	10.09965
31	-9.808842	13.59543	-0.72	0.471	-36.4554	16.83772
Whatvarietyofcocoaisplanted						
1	-3.83e-15		.	.	.	.
2	-18.87843	9.467558	-1.99	0.046	-37.4345	-.3223566
3	-9.683805	11.62815	-0.83	0.405	-32.47455	13.10694
4	-42.16395	11.69293	-3.61	0.000	-65.08168	-19.24623
District						
11	1.58e-15		.	.	.	.
12	22.89756	8.13799	2.81	0.005	6.947395	38.84773
23	-18.54784	11.50082	-1.61	0.107	-41.08904	3.993348
Divers_type						
0	-1.38e-16		.	.	.	.
1	-4.445418	17.82831	-0.25	0.803	-39.38827	30.49743
2	6.025843	7.825263	0.77	0.441	-9.31139	21.36308
3	-117.9511	34.69361	-3.40	0.001	-185.9493	-49.95288
4	10.0453	12.4886	0.80	0.421	-14.43191	34.52252
5	-292.9986	136.7194	-2.14	0.032	-560.9636	-25.03358
6	-10.15479	12.43772	-0.82	0.414	-34.53227	14.22269
7	-86.18181	30.74511	-2.80	0.005	-146.4411	-25.92249
_cons	4.773784	33.92772	0.14	0.888	-61.72332	71.27089
Usigma						
_cons	4.631608	.1214797	38.13	0.000	4.393512	4.869703
Vsigma						
_cons	-1.906333	.1561475	-12.21	0.000	-2.212377	-1.60029
sigma_u	10.13306	.6154806	16.46	0.000	8.995783	11.41413
sigma_v	.3855183	.0300989	12.81	0.000	.3308175	.4492639
lambda	26.28426	.6245226	42.09	0.000	25.06022	27.50831