FINANCIAL VIABILITY OF COCOA AGROFORESTRY SYSTEMS IN GHANA: THE CASE OF SEFWI WIAWSO DISTRICT

By

ISAAC NUNOO, BSc Agriculture (Hons)

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DECLARATION

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

ISAAC NUNOO ………………………….. ………….…………..
(PG5109410)

(Student's Name & ID) (Signature) (Date)

Certified by:

Dr. VICTOR OWUSU ………………………….. ………….…………..
(Major Supervisor) (Signature) (Date)

Dr. SIMON C. FIALOR ………………………….. ………….…………..
(Co- Supervisor) (Signature) (Date)

Dr. Dadson Awunyo-Vitor ………………………….. ………….…………..
(Head of Department) (Signature) (Date)

DEDICATION

This work is dedicated to my parents Mr. and Mrs. Anthony Nunoo for all their great effort and hard work in bringing me to this level and also for nurturing my passion for nature and the environment from an early age. I also dedicate it to my lovely sisters, for their unwavering support and constant source of inspiration, also to the READI team for their encouragement and the entire hard working cocoa farmer in Ghana.

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ABSTRACT

Despite the massive contribution of cocoa to the economy of Ghana it is been alleged to contribute to deforestation as new cocoa plantations in the Western Region of Ghana are planted without shade trees. Cocoa agroforestry system has been described as one of the best examples of permanent agriculture that preserves forest environment and biodiversity. A financial viability analysis of the various agroforestry systems (no shade, low shade, medium shade and heavy shade) in Ghana were undertaken to determine the most viable. A discounted cash flow analysis was carried out to estimate the benefit-cost ratio (BCR), net present value (NPV) and internal rate of return (IRR) at 20 percent interest rate. The result indicated that all the cocoa agroforestry systems were profitable. Although all the cocoa agroforestry system were viable the no shade had the highest revenue in the early years of the cocoa life but it was short lived whiles the revenue from the shade trees boosted the revenue for the heavy shade cocoa agroforestry system at the end of 50 years rotation period. Further analysis were done to determine the viability of the cocoa agroforestry systems by varying some variables like the price of cocoa, yield of cocoa and the cost of fertilizer. The viability indictors showed that all the systems were viable; the medium shade was the most viable and also ensures sustainable cocoa production over long period. Opportunity still exists for improvement in the profitability in cocoa agroforestry systems, introduction of extension education and access to credit policies are among policy options suggested by the study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ATTP's -Agroforestry Timber Tree Products

BCR- Benefit Cost Ratio

CBA-Cost Benefit Analysis

CI- Conservation International

COCOBOD- Ghana Cocoa Board

CODAPEC- Cocoa Disease and Pest Control Program

CRIG- Cocoa Research Institute of Ghana

FAO- Food and Agriculture Organisation

FOASTAT- Food and Agriculture Organisation Statistics

FORIG- Forestry Research Institute of Ghana

GBC- Ghana Broadcasting Cooperation

GDP- Gross Domestic Product

GFRA- Global Forest Resource Assessment

IRR- Internal Rate of Returns

ISSER- Institute of Statistical Social and Economic Research

MMYE- Ministry of Manpower Youth and Employment

MOFA- Ministry of Food and Agriculture

N.P.K- Nitrogen, Phosphorus and Potassium

NPV- Net Present Ration

SRID-MOFA- Statistical Research and Information Department of Ministry of Food and Agriculture

SWDA- Sefwi Wiawso District Assembly

UNEP- United Nation Environmental Program

USAID- United State Agency for International Development

CHAPTER ONE

INTRODUCTION

1.1 Background

Cocoa (*Theobroma cacao Linn*.) is an economic crop cultivated around the world, mostly in the humid tropics of Africa, Southeast Asia, South America and the Caribbean (Obiri et al., 2007). World annual cocoa production from these continents stands at about 3 million tones with a market value of US$6 billion and 68–70 percent of this production coming from West Africa (Obiri et al., 2007). According to Sonwa et al. (2005) cocoa plantations now cover more than five million hectares of land previously covered by forest in the region's four main cocoa-producing countries: Côte d'Ivoire, Ghana, Cameroon and Nigeria. Cocoa is essentially a smallholder crop, cultivated on 1.2–1.5 million farms ranging in size from 3 to 7 ha and employing 10 million people in West Africa (Obiri et al., 2007). Ghana is one of the major producers of cocoa and second to Côte d'Ivoire in the world. In Ghana cocoa contributes massively to the economy of the country as it constitute the largest source of revenue to the government and also the main source of the wealth to the people of the forest regions. Cocoa constituted about 85 percent of the foreign export earnings from the agricultural sector, compared to 8.2 percent and 6.9 percent contribute by timber and the non-traditional export sectors (ISSER, 2010). Despite this immense contribution of cocoa to the economy the average yield per hectare is 450 kg (MMYE, 2008) this yield rate is low compared to countries like Malaysia and Indonesia where average yield exceed 1000 Kg/hectare (Les Afriques, 2009).

The FAO (GFRA) 2010 report revealed in the last decade (2000 to 2010) there has been an alarming rate of deforestation with a global loss of around 13 million hectares of forest each year, the report further indicated that Africa has the second highest rate of deforestation worldwide with 3.4 million hectares of forest loss annually. Ghana happens to have one of the highest deforestation rates in Africa at 2 percent annually. The rate of deforestation according to the Forestry Commission of Ghana stands at 65,000 hectares per annum with cocoa farming been alleged to be one of the factors that have contributed to deforestation in Ghana (Ministry of Science and Environment, 2002). In the last 50 years FAOSTAT gives a clear indication that the total area under cocoa cultivation has increased by 3 million hectares (4.4 million to 7.4 ha) (Clough et al., 2009). This progressive increase in the areas of production has caused the remaining forest cover in West Africa to constitute only one-fifth of its original extent (Niesten et al., 2004). Asare (2005) emphasized that this partially indicates the beginning of the end of expansion of cocoa farms into forested areas.

Cocoa agroforestry has been described as one of the best examples of permanent agriculture that preserves a forest environment (Ruf and Schroth, 2004) and also supports higher levels of biodiversity than most other tropical crops (Rice and Greenberg, 2000). With exploitation of forest trees for timber and other purposes, it has become necessary to plant alternative fast growing tree species to provide shade, thus cocoa cultivation is of great importance for the cultivation of the forest and the associated fauna in Africa.

1.2 Problem Statement

At a rate of 2 percent per annum, Ghana has one of the highest rates of deforestation in Africa. Between 1990 and 2005, Ghana has lost 26 percent of its forest cover which is about 1,931,000 hectares (UNEP, 2008) with cocoa farming being considered to be one of the factors that have contributed to the deforestation in Ghana (Ministry of Science and Environment, 2002).

In Ghana, there has been the quest to increase cocoa production. In an attempt to increase production, many policies which are aimed at reforming cocoa sector have been implemented by the government since the early 1990s. One of such development strategy by the government is improving the performance of the cocoa sector. Under this strategy, production levels were expected to reach 700,000 Mt by the year 2010 but in the 2010-2011 production season Ghana recorded an unprecedented production level of over one million metric tons (GBC, 2012). This increase has been the highest since the country joined the international market as a producer of cocoa and also exceeded the 2009-2010 season by almost 56 percent. In 2001 the government introduced the mass-spraying exercise under the Cocoa Disease and Pest Control Programme (CODAPEC) which was aimed at spraying all cocoa farms at no direct cost to the farmer. The government have also started an interest-free credit scheme called the cocoa 'Hi-Tech' Programme, which aims at increasing productivity by providing fertilizers and pesticides. All this programmes have been geared towards cocoa productivity with little emphases on sustainable cocoa production and biodiversity strategies such as the cocoa agroforestry systems. Cocoa production is supported by the natural forest environment, this favorable conditions have aided large tracts of tropical forest in Ghana been cleared to support increasing cocoa cultivation, this situation occurring have made cocoa farming both a direct and indirect driver of deforestation mostly in the forest areas (UNEP, 2008). According to Katoomba (2009) most new cocoa planting has been in the Western Region where approximately 80 percent has been established without shade or less than 10 percent canopy cover; in comparison, 50 percent of cocoa in the Eastern Region is grown with a 30-40 percent canopy cover. The group continued to argue that recent research reveals a pronounced trade-off between short-term cocoa productivity and ecosystem health as well as biodiversity. This research showed that the higher yielding short cycle hybrid cocoa varieties grown under full sun or minimal shade exhaust soil nutrients due partly to the loss of the arboreal nutrient cycle and degrade the ecosystem so that it becomes unsuitable for further cocoa farming or other productive agriculture. According to Uribe et al., (2001) cocoa is either grown in low production systems under shade of other vegetation or in intensive production systems where trees are completely exposed to sunlight. With varying effect of fertilizer on cocoa yield on the two production system, the researcher further explained that fertilization of shade cocoa commonly produces only modest yield increments whiles the fertilization of sunlight-exposed plantations generally results in significant yield responses because of greater photosynthetic activity. Despite their higher yield potential, sunlight exposed plantations grown without fertilizer experience rapid yield declines with time and often suffer from early senescence (Uribe et al., 2001). This current trend of cocoa production is making cocoa farming over time unproductive and degraded systems without the heavy application of chemical inputs, putting the long term future of cocoa farming, and farmers related rural livelihoods in Ghana in some doubt.

Ruf and Zadi (1998) noted that cocoa with less than optimum shade has a shorter life cycle and also under certain soil conditions and rainfall regimes shade cocoa may yield for 60-100 years whereas production may last for only 20 years without shade. Clay (2004) also discussed that high-yield varieties used in intensive production systems, and planting at high densities with or without intercrop species may serve as a means of alleviating the pressure to clear primary forest in order to expand production. However this may only be a short-term solution. Such varieties grown intensively tend to produce for a much shorter time period, often only 6–8 years and yields declining between 15 to 20 years after planting (Clay 2004), whereas shade varieties are reported to continue producing for 80–100 years (Bentley et al. 2004). According to Leiter and Harding (2004), the shade cocoa uses little to no chemical inputs, while intensive production systems require these inputs and farmers using such production techniques will be dependent on chemical inputs but not always able to afford them. Shade reduction has led to a number of deleterious effects including increase in *myrid*, *psyllid* and leafhopper damage, and young unshaded cocoa has been observed to produce high percentage of small, inferior beans (Adu-Amponsahet et al. 2002).

The tree tenure system in the past discouraged cocoa farmers to retain valuable trees on their farms, as shade trees with economic values when exploited for timber during lumbering destroy their cocoa farms with little or no compensation paid to the farmers. This also discouraged the practice of retaining valuable trees on cocoa fields as most farmers destroy such trees to avoid the risk of uncompensated damage. Although policy changes in the off-reserve concession arrangements and farm rights under the 1994 interim measures provided favorable financial incentive for cocoa farms to retain timber species (Bamfo, 2003). The researcher further recommended the need for other reforms in the policies to ensure equitable benefit flows to entice farmers to retain and plant trees on their cocoa farm land though the current policy provides some amount of financial incentive. A study done by Ruf and Zadi (1998) concluded that among all the major cocoa producing countries in the world, Ghana has the lowest amount of rainfall. Thus if the present trend of the decline in trees on cocoa fields is not checked and reforested to favor cocoa production the moist micro environment in which the crop thrives would be lost.

1.3 Research Questions

The following research questions are raised in the study:

1. What are the perceptions of cocoa farmers on cocoa agroforestry systems?
2. What is the yield trend under the different cocoa agroforestry systems?
3. What are the relative financial viability of the existing cocoa agroforestry systems?

1.4 Objectives of the Study

The main objective of this study is to assess the financial viability of cocoa agroforestry systems in Ghana. The specific objectives of the study are as follows:

1. To determine the demographic characteristics of cocoa agroforestry farmers in the study area.
2. To find out the perception of cocoa farmer on cocoa agroforestry systems.
3. To determine the yield trend under the various cocoa agroforestry systems.
4. To determine the relative financial viability of existing cocoa agroforestry systems in Ghana.

1.5 Justification of the Study

Most recent studies have failed to critically examine the importance of the different cocoa agroforestry systems with a view to ascertain the most economically viable method. If cocoa is to play a vital role in ensuring future income and livelihood sustainability it has to be develop in an economically viable and environmentally sustainable manner. Farmers and policy-makers face trade-offs between shorter-term economic maximization and long-term ecological sustainability. The trade-offs exist between an intensification of the cocoa cultivation with no shade plantations and higher economic returns and shade-grown, low intensity management cocoa with lower returns and biodiversity conservation (Seeberg-Elverfeldt et al., 2009). Whether a particular cocoa production system is considered economically and ecologically sustainable it is affected by the time scale (Baah et al., 2009). Zapfack et al. (2002) reported that the cocoa agroforest contains 116 plant species as against 160, 171 and 64 in the primary forest, in the secondary forest, and on farmland respectively.

Even though the cocoa grown in full sun has higher mean yields and results in substantially higher gross margin values in comparison with shade grown cocoa, in the long run the intensification is likely to be ecologically unsustainable. Results from studies show that tree crops which are grown in shaded systems tend to maintain productivity in the long run and are less susceptible to insect and disease losses than full-sun monocultures (Belsky and Siebert 2003). The production of cocoa under cocoa agroforestry systems can result in higher prices for the cocoa produced since buyers are willing to pay a premium for a products that is produced in a more environmentally sustainable manner, this assure a sustainable income for the producers under cocoa agroforestry system. Gockowski and Sonwa, (2008) indicated that due to the current state of the cocoa landscape, the best possible environmental alternative to the current cocoa-growing practices in Ghana would be a mixed agroforestry system, where the forest is selectively thinned and fruit trees with economic value are grown next to cocoa trees, providing both shade for the cocoa trees and food and income for the farming household. According to Steffan-Dewenter et al., (2007) and Donald (2004) asserted that because of the socio political and economic dimensions of cocoa, policy makers and smallholder cocoa farmers need to be familiar with the role of biodiversity in cocoa farming and the cost–benefit ratio associated with maintaining or reducing the shade canopy. Again there is the need to investigate the viability nature of cocoa agroforestry systems as it is a crucial incentive for propagation and adopting this sustainable cocoa production technology especially in Ghana where cocoa landscapes consist of 28 percent no shade; 42 percent low shade cocoa systems (UNDP, 2011).

1.6 Organization of Study

The study is structured into five chapters: In Chapter One, the introduction and background of the study are presented. In Chapter Two relevant literature on cocoa agroforestry systems are reviewed. These include concept of agroforestry, cocoa agroforestry in Ghana and Africa, cocoa agroforestry management systems and benefits of cocoa agroforestry, trees requirement on cocoa agroforestry farms, production figures and economic importance of cocoa to Ghana. Chapter Three presents the methodological framework. Chapter Four gives the empirical results and discussion of the results. The final chapter presents the summary, conclusions and recommendation of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition and Concept of Agroforestry

Agroforestry is an agriculture approach of using the interactive benefits from combining trees and shrubs with crops and/ or livestock. Agroforestry is "a collective name for all land-use systems and practices where woody perennial plants are deliberately grown on the same land management unit as agricultural crops and/or animals, either in spatial mixture or in temporal sequence" (Lundgren, 1982). Leakey (1996) also defined agroforestry as "a dynamic, ecologically based, natural resource management system through the integration of trees in farm and rangeland, diversifies and sustains small holder production for increased social, economic and environmental benefits." Agroforestry according to Schroth et al., (2004) is a practice that involves the integration of trees and other large woody perennial into farming systems through the conservation of existing tree, their active planting and tending or the tolerance of spontaneous tree re-growth. Agroforestry is a dynamic, ecologically based natural resource management practices that, through the integration of trees and other tall woody plants on farms and in the agricultural landscape, diversifies production for increased social, economic and environmental benefit (ICRAF, 1993). Agroforestry practice and concept is not new in Ghana as it has been practiced by farmers over the years. According to Nair (1993) and Bishaw and Abdulkadir (2003) the main components of agroforestry systems are trees and shrubs, crops, pasture, and livestock together with the environmental factors of climate, soil, and landform. Under this definition, a variety of combinations of plants may be possible. But there are two important features that identify agroforestry from other land-use systems: There must be a tree component deliberately grown or retained in the land-use system. There must be significant interaction, positive and/ or negative, between the woody and non-woody components of the system. Agroforestry, therefore, involves two or more species of plants and /or animals at least one of which is a woody perennial and with two or more outputs. Owing to the variety of mixtures, therefore, even the simplest agroforestry system is more complex both ecologically and economically than a mono-cropping system. The aim and rationale of agroforestry lies in optimizing production based on the interactions between the components and their physical environment. This will lead to higher sum total and a more diversified and /or sustainable production than from a monoculture of agriculture or forestry alone (Nair 1993).

2.2 Agroforestry Systems and Practices

Nair, (1993) indicated that "systems" and "practices" are often used interchangeably in agroforestry literature. However, there are some distinctions that can be made between these two concepts. An agroforestry practice, according to Gholz (1987) and Zeleke (2009), denotes a specific land management operation on a farm or other management unit, and consists of arrangements of agroforestry components in space and/ or time whiles agroforestry system consists of one or more agroforestry practices that are practiced extensively in a given locality or area; the system is usually described according to its biological composition and arrangement, level of technical management or socio- economic features. All agroforestry systems consist of at least two of the three major groups of agroforestry components; trees (including shrubs), agricultural crops, and pasture/livestock, with trees being present in all agro forestry system. Fishes, honey bees, among some others components, are occasionally incorporated. Based on these three basic components, agroforestry systems can also be classified for all practical purposes according to their component composition (Nair, 1993; Beetz 2002): Agrisilvicultural systems, Silvopastoral systems and Agrisilvopastoral systems. Other specialized agroforestry systems can also be defined, for example, apiculture with trees, aquaculture involving trees and shrubs, and multipurpose-tree lots.

2.2.1 Agrisilvopastoral Systems

This is an agroforestry practice by which food, pasture, and tree/shrub crops are combined on the same unit of land for the production of grass and browse feed, biomass for fuelwood and green manure, and food for human consumption. This system is practiced when the farmer needs all the benefits that would be obtained from silvipasture and agrisilviculture systems from a unit of land (Nair, 1993; Beetz, 2002). Usually, such a system is practiced on cultivated land. Agrisilvopasture is also practiced when the cropland is constrained by slope and threatened by erosion. These are very common problems of land use in most highlands in Ghana; therefore, this system has potential for use in various regions of the country.

2.2.2 Silvopastoral Systems

This is an agroforestry system where a range of crops and/or animals and trees are combined for better production of grasses and fodder. This combination can be arranged as a pure stand with fodder trees/shrubs planted as a protein bank and/or mixed in different configurations such as living fences of fodder trees and hedges. The trees and shrubs and grass components are arranged in such a way that their healthy coexistence is not disrupted. This system can be practiced on both range and forest lands for the production of both feed and woody materials. This system could also be practiced on sloping ground by growing grasses and trees/shrubs together for soil conservation purposes. The main objective of this practice is to supply feed for livestock during the dry season with high quality tree leaves and pods. This will substantially increase the productive capacity of poor and scarce pasture lands common on the Highlands. Fuelwood and construction poles can also be produced with this system (Nair, 1993; Beetz 2002).

2.2.3 Agrisilvicultural Systems

This is an agroforestry system where agronomic crops are combined with shrubs/trees on the same unit of land for higher or better-sustained production of annual crops, fodder, and wood. In any one agroforestry system, there can be more than one agroforestry practice. An agroforestry system is identified by certain types of practices that, taken as a whole, form a dominant land-use system in a particular locality, characterized by environment, plant species and arrangement, management, and social and economic functions. Although an agroforestry practice is a distinctive arrangement of components in space and time, when the combinations are arranged in time sequence, such practice is called taungya practice. The combinations can also be arranged in space, such as the hedgerow/mixed intercropping practice (Nair, 1993; Beetz 2002).

2.3 Cocoa Agroforestry Systems

Cocoa agroforestry system is a type of agrisilviculture, where crops are combined with shrubs/trees. Cocoa agroforestry is the intercropping of cocoa with several high value tree species and in addition to other crops which provide additional income and product for the farmers (Duguma et al., 2001). This system is also very common in Central and South America. Cocoa agroforest systems in Ghana is similar to if not the same, to one of the spectrum of cocoa production strategy known as the ‘‘rustic cacao'' where primary or secondary forests are thinned and cocoa is planted beneath the remaining canopy of native tree species (Rice and Greenberg, 2000). Franzen et al., (2007) also indicated that a similar cocoa agroforestry system known as *cabruca*, is used in Brazil and typically has native trees thinned to approximately 10 percent of their original abundance. The researcher again stated that ''planted shade'' which is similar to cocoa agroforestry denote systems where there is greater intercropping of cocoa trees with fruit, commercial timber, or fast-growing shade trees to various degrees.

The cocoa agroforests of the cocoa growing regions like Ghana and Cameroon are a very good example of multistrata agroforestry in which tree species produce Agroforestry Tree Products (AFTPs), including high quality timber. In cocoa agroforestry, cocoa is intercropped with forest remnant species and a relatively high number of native timber trees. This system of cocoa production closely resembles the ecological functioning of a secondary forest, particularly important in areas of wide spread deforestation (Asare, 2006). The diversity, botanical composition and structural complexity of cocoa shade canopies vary widely between cocoa growing regions, between farms within a region, and even between sections within a plantation (Somarriba et al., 2001). It has been pointed out by Donald (2004) that cocoa agroforests do not equate with primary forests, but this system of cocoa production is more environmentally preferable to other cocoa cultivation system as well as other agricultural activities in tropical forest regions. Cocoa agroforestry has been described as one of the best examples of permanent agriculture that in some way preserve a forest environment and its diversity (Ruf and Schroth, 2004). Cocoa is also commonly cultivated in association with other perennial tree crops, such as rubber (*Hevea* *brasiliensis*), coconuts (*Cocos nucifera*), oil palm (*Elaeis guianeensis*), kola (*Cola nitida*), mango (*Manguifera indica*), cashews (*Anacardium occidentale*), avocado (*Persea americana*), breadfruit (*Artocarpus communis*), peach palm (*Bactris gasipaes*), Citrus spp. and other valuable species (Osei-Bonsu et al., 2003). Shaded cocoa according to Leakey et al., (2001) provide valuable ecological service to wildlife than do many other cultivated land uses as well as considerable potential that contribute to farmers livelihoods through sales of timber and non-timber products (Obiri et al., 2007).

Duguma et al., (2001) in the Cameroon context categorized cocoa agroforestry systems into three based on the management intensity and commercialization of secondary fruit products. The variations are: the low input system with commercial fruit tree production; this system is mostly practiced by small holder cocoa farmers with the local cocoa variety that's the forestero, this system became very popular when there was a shift from intensive management system when the cocoa market price experience a drastic fall in the 1980's: the second variation is the low input system with no commercial fruit tree component; the management practices in this kind of system is also minimal with little cost incurred on agrochemicals to control pest and diseases, it's also assumed that this system is prevalent in remote areas distant from urban market. Duguma et al., (2001) again indicated medium input intensity with commercial fruit production as the third variation in the system; this system involves the intensive management practices such as pest and diseases. In Ghana there are four cocoa agroforestry systems: the no shade, low shade, medium shade and heavy shade system (UNDP, 2011). These systems are classified based on canopy cover proportions, number of shade trees as well as management intensity.

2.3.1 The No Shade System

This system has no shade trees and management under this system is very intensive. The system is characterised with high use of agrochemicals as well as labour making the system the most expensive to practice among all the other cocoa agroforestry systems. Although it is capital intensive the associated yield is high in the early years of production, followed by a sharp fall in yield as compared to the other cocoa agroforestry systems (Ruf and Zadi, 1998). A recent study by Sonwa (2004) in Cameroon revealed that 768 Kg/Ha of cocoa can be obtained under direct sun as against 258 to 445 under shade. Currently Ghana's cocoa landscapes consist of 28 percent no shade system (UNDP, 2011). This system is common in Malaysia and Cote d'Ivoire and is becoming more widespread in Ghana and parts of Colombia and Peru.

2.3.2 The Low Shade System

The low shade system exhibits a low density of a shade tree layer with a canopy cover between 36–65 percent (Seeberg-Elverfeldt et al., 2009). Under the current cocoa landscape in Ghana, Ghana has 42 percent of its cocoa under the low shade system (UNDP, 2011). This system is characterised by intensive management but not as intensive and input demanding as that of the no shade system. This system has timber tree numbering between 1-9 trees/Ha.

2.3.3 The Medium Shade System

Ghana's cocoa landscape is currently made up of 25 percent medium shade (UNDP, 2011).It has a shade cover of approximately 66–85 percent and is shaded by a diverse spectrum of planted trees and naturally grown after clear-cutting (Seeberg-Elverfeldt et al. 2009). The level of management is low compared to the no shade and low shade systems. This system is the most recommended among all the cocoa agroforestry systems since it maintains an average amount of timber tree coupled with high yield over a long period of the productive life of the cocoa. The number of shade tree under this system ranges between 10 to 15 trees/Ha and it is recommended in Ghana (Padi and Owusu, 2003).

2.3.4 The Heavy Shade System

The heavy shade systems exhibits a high degree of shading with natural forest trees and a canopy cover above 85 percent (Seeberg-Elverfeldt et al., 2009). Very few agricultural inputs like labour and agrochemicals are required for management under this system. The cocoa landscape in Ghana stands at 5 percent heavy shade (UNDP, 2011). Cocoa farms under this system have trees exceeding 15 trees/Ha. The level of yield is relatively low as compared to the other agroforestry systems. Cocoa tree under the heavy shade is prone to pest and disease as a result of the high humid environment favorable for the growth and development of the pest and disease (Konam et al.,2008).

2.4 Cocoa Agroforestry Establishment

The establishment of cocoa agroforestry begins with farmers clearing and/or burning the understory vegetation, and either thinning or completely eliminating the over-story trees to make growing space for their cocoa and food crops (Ruf and Zadi, 1998). Young cocoa plants require certain amount of shade to avoid severe physiological stress that would arise as a result of excessive exposure to direct sun, fertile soil and protection from competing weeds in due of these majority of cocoa are planted into thinned forest where shade, fertile soils and a low weed pressure occur (Ruf and Zadi, 1998; Greenberg, 1998). Food crops like plantain, cocoa yam, maize, and cassava are planted first, followed by the cocoa, to provide key initial shade to the cocoa seedlings, exploiting the fertile soil and to provide food and income to the farm family over the next growing season instead of clearing all of the vegetation. Farmers sometimes deliberately choose to protect certain mature trees for shade, instead of removing them from their farms through cutting, ring-barking, or burning. According to Asare (2008) the maturity of the cocoa farm is associated with weeds and seedlings of non-cocoa trees establishing rapidly and occupying the growing space along-side the cocoa seedlings and relic trees that were retained during cultivation. While it is most likely that the open conditions will favor species from highly shade intolerant to moderately shade intolerant guilds, it is difficult to entirely predict which trees will emerge as part of the initiating cohort. Just as natural disturbances occur at various scales, the scale and intensity of land clearing and/or weeding regimes have a significant impact on those tree seedlings that are able to regenerate. The species of trees that emerge are also determined by the species of trees that were retained within the farm, the species of trees growing in the surrounding landscape, differences in tree's regeneration mechanisms, and the presence of birds or other mammals that play a role in pollination and seed distribution (Finegan and Nasi, 2004).

Major changes arise in the cocoa agroforestry system as the cocoa tree matures, farmers select certain naturally regenerated forest tree samples and coppice sprouts to grow in association with the cocoa and provide essential shade for the young cocoa trees. Forest seedlings that sprout in the cocoa farms are eliminated during the weeding process in an effort to reduce competition and release growing space to the planted cocoa seedlings and the remaining shade trees. As the cocoa canopy is formed and closes, making it less independent on the shaded trees, some of these trees are removed whiles others are reserved, farmers keep trees that have economic, domestic, or environmental value, and many trees are able to serve multiple functions (Asare, 2005). Cocoa farmers in Ghana, according to Anglaaere (2005), also actively nurture and manage the regeneration of forest species in their farms for their ecological, economic, or cultural value. As the cocoa matures into full production, farmers continue to eliminate or integrate trees according to their priorities and the changing conditions within the farm (Asare, 2008).

The conscious effort to retain or plant timber trees on cocoa farm is comparatively rare because of tree tenure problem, where the exploitation of economic value trees for timber has tended to destroy cocoa farms during logging by concessionaires, with little or no compensation paid to the farmers (Obiri et al., 2007). Majority of Nigerian and Cameroonian producers affirmed the purposive maintenance of timber species in cocoa farms, while in Ghana and Côte d'Ivoire the overall percentage of farmers was less than 50 percent according to a study by Gockowski et al., (2004). Farmers sometimes perceive that the presence of shade on cocoa plantation is responsible for the phytosanitary problem by increasing the humidity and thus susceptibility to disease infection, and that shade trees act as a source for pest and disease thus motivating farmers to cut down or poison trees. On the other hand shade removal in cocoa farm is associated with higher yields in the early years of the cocoa plantation followed by a sharp fall in yield which is associated to physiological stress, susceptibility to certain disease and pests and consequently the amount of inputs (fertilizer and insecticides) required.

2.5 Trees Requirements on Cocoa Agroforestry Farms

Cocoa Agroforestry systems are complex systems in which cocoa trees interact with other trees and crops to provide wide range of outputs of goods and services. Due to the sensitive nature of cocoa to light and relative humidity the tree requirements differs from other tree used in agriculture or forestry (Wood et al., 2001). A number of individuals and organizations such as CRIG, FORIG, and CI have conducted research into the required tree species that are compatible with cocoa. According to Asare (2006) farmers often disagree with researchers about the desirable characteristics for selecting trees for their cocoa farms, especially when undesired physiological or technical aspects of the management of a tree occur in species with high social, economic or traditional value for the farmer.

2.6 Management of Cocoa Agroforestry System

The manipulation of shade in cocoa agroforestry is a key management parameter of the system, which is influenced by social, economic, and agro-ecological factors. Duguma et al., (2001) states that farmers in West Africa are quite familiar with the importance of shade in cocoa cultivation but they receive little assistance, if any, on how to better manage shade at various stages of the plant development, this creates knowledge gap between the management of this system. According to Konam et al., (2008) too little shade results in poor cocoa tree health and weed problems while too much shade increases pest and disease problem but both will result in low cocoa production.

However, adequate management of shade trees is required for optimum cocoa productivity. This therefore shows that the level of management systems in cocoa agroforestry depends on the knowledge relating to the interaction between the cocoa and shade trees. The management of cocoa plantations does not follow the classic pattern of large-scale forest projects and therefore shade removal to achieve short-term increases in cocoa yield will have negative long-term effects that jeopardize the sustainability of cocoa production. Sonwa et al., (2005) stated that, the complex influence of the forest component in cocoa agroforestry systems makes it difficult for cocoa farmers to undertake shade trees management. Shade control is very essential in the management systems but complete shade removal is not recommended since the presence of shade trees insure cocoa farmer whose whole livelihood depend on cocoa against the short-term and large-scale, long-term cocoa boom-and-bust cycles (Clough et al., 2010). The level of shade management and requirement vary from region to region as well as place to place, depending on the age of the tree and the intensity of light.

The microclimatic condition of cocoa agroforestry can be managed to avoid high humidity by controlling the cocoa canopy through pruning, but many farmers are reluctant to conduct heavy pruning. Initial mismanagement such as inappropriate planting distance and insufficient pruning in the first few years is widespread among the inexperienced frontier cocoa farmers and makes corrective management extremely difficult (Clough et al. 2010). Maintaining high shade levels in young cocoa plantations with a stepwise increase in pruning when cocoa trees grow older is a pragmatic and sustainable management strategy. According to Konam et al., (2008) correct pruning is very important as it creates trees with an even, open canopy that allows air and sunlight to penetrate. This helps to prevent and reduce pests and diseases. Poor pruning can reduce the yield of cocoa for many months and even years, and increase disease levels and weed growth. In Ghana cocoa is mostly established under filtered shade and interplant with food crops, this prevents stern weed growth. Weeding is the primary task to be undertaken in cocoa agroforestry after planting, which is mostly done traditionally by slashing. Other farmers remove weeds from the base of the cocoa trees manually or by using chemicals. The choice of weed control depends on the resources available to the farmer. Frequent weeding on cocoa farm is necessary to check competition for growth resources between the cocoa and the weeds, especially during cocoa establishment (Ofori-Frimpong et al., 2007). The main aim of many farmers is to improve crop production at minimum cost in order to maximize profit but their major problem is how to maintain soil fertility. As reported by Opeyemi et al., (2005) that the effective use of fertilizer on cocoa would help not only to improve yield but also has the advantages of profitability, product quality and environmental protection. This implies that fertilizer usage is a primary factor to be considered in maximizing cocoa production. According to Ghana Cocoa Board (2002) fertilizer application increased yields from 250kg per hectare to 1,500 kg per hectare after the 4th year of fertilizer application this gives indication that fertilizer application is inevitable in agricultural production as adequate use of fertilizer increases agricultural output.

2.7 Benefits of Shade Trees on Cocoa

The use of shade trees on perennial crops such as cocoa is dated back to the domestication of crops (Anglaree, 2005). Traditionally, shade-grown cocoa has tended to be well integrated with local agricultural practices and traditions, and compatible with biodiversity conservation (Beer etal., 1998). In countries and regions like Ghana where the natural forest is under threat and pressure from timber lumbers cocoa agroforestry systems holds massive potential for environmental and cultural conservation in these regions. The outcome of adding shade trees to cocoa plantation depends on many factors, the most important of which are related to the following influence: production objectives, input available and environmental characteristics.

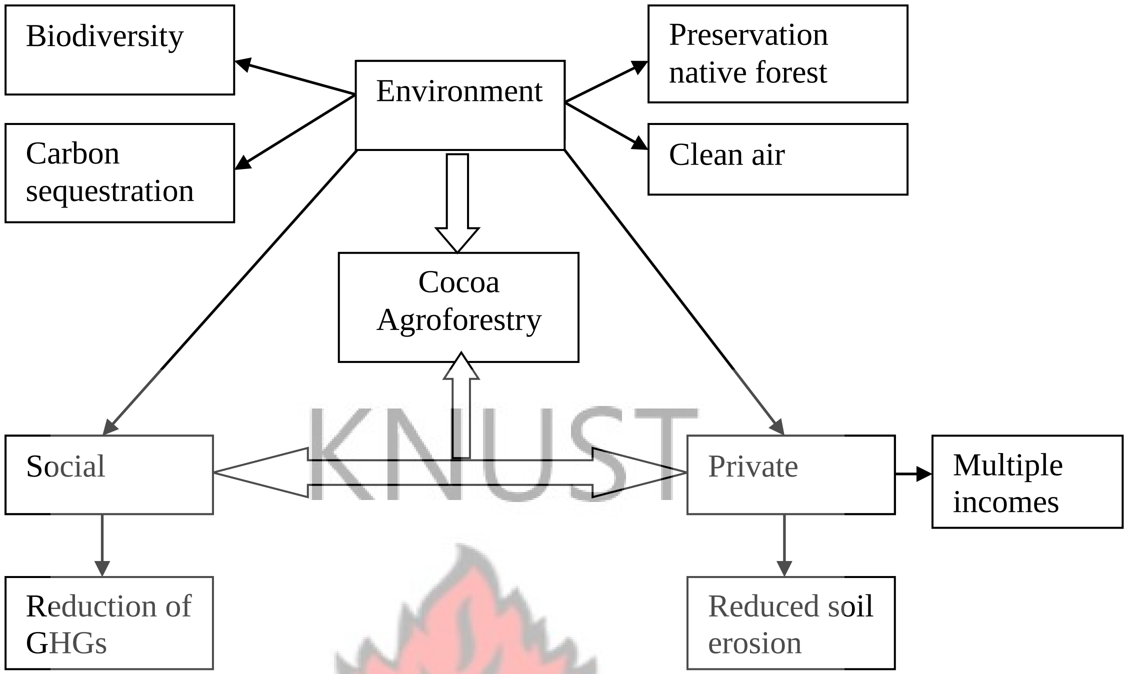

Figure 1: Private and External Benefits of Cocoa Agroforestry System

Source: Author's construct

2.7.1 Shade Trees as Multiple Revenue Sources

One reason for maintaining trees on perennial crops plantation is the income provided by their fruits and/ or timber; these products may supplement farmer's income when cocoa prices are low. In well-managed cocoa agroforestry systems, much of the annually produced shade tree wood is pruned and used as firewood; reducing the pressure on natural forest wood. Timber is a significant resource in cocoa agroforestry system, timber from cocoa agroforestry system contributes greatly to the satisfaction of nation demand for timber; also the timber is either used for construction or sold by the owners. The money made from the cocoa plantations can also help to strengthen the farmers' financial status (Sonwa et al., 2001). According to Calvo and Platen (1996) timber producing shade trees have low management costs and are considered a "saving account" that can be realized at the time of low price or failure of the underlying crops. Bush mango, avocado and other fruit on cocoa farms play significant roles in the local diets of the farmers and also providing a source of revenues to farmer's households.

According to Juhrbandt, (2010) income from shade trees and other intercrops in cocoa agroforestry systems in Central Sulawesi (Indonesia) accounts for averagely about 7 percent of total cocoa plot revenue, but may reach up to 60 percent for mixed agroforestry plots. Trees can be also viewed as 'stored capital' providing a pulse of cash if families are in need. Tscharntke et al., (2011) states that 'tree bank' may greatly reduce vulnerability to environmental, economic or social shocks, example was the dramatic fallen prices as was the case in cocoa in the late 1980s ⁄ early 1990s and in coffee in the late 1990s ⁄ early 2000s. The researcher further indicated that the same is true for fruit trees like avocado *Persea americana and*mango *Mangifera indica* providing shade, fruits and income security. Cocoa agroforestry systems also promote self-sufficiency through a diversified food-and-cash crop livelihood strategy.

2.7.2 Shade Trees as Nutrient and Fertilizer Provider

Reports by Lehmann (2003) indicates that shaded crop tree species such as coffee and cocoa tend to have shallower root activity in the soil compared with fruit shade trees like citrus, guava, and mango that have particularly deep subsoil root activity. Decomposition of litter fall over time will increase the Soil organic matter content of soils under cocoa agroforestry system (Beer et al. 1998). In Ghana, cocoa tree nutrient uptake and cocoa biomass increased under shade tree canopy compared to a monoculture by 43–80 percent, 22–45 percent and 96–140 percent for N, P, K, respectively(Isaac et al., 2007). Appropriately selected shade trees will improve light regulation and nutrient status without any strong competition with cocoa where fertilizer is unavailable (Tscharntke et al., 2011).

2.7.3 Shade Trees as Nutrient Cycler and Nitrogen Fixer

Beer et al., (1998) reports that management practices would affect nitrogen fixation by leguminous shade tree in cocoa plantations. Practices such as pruning residues may be left around trees, chopped and spread on the ground or exported for fodder and firewood. All these practices will affect levels of nitrogen fixation and nitrogen availability in plantation. Shade management, especially pruning has a critical influence on nutrient cycling. In addition to its management, the microclimate of the underlying crops provides a tool to manipulate the timing and quantity of nutrient transfer from the tree to the soil (Beer et al., 1998). A study of gross soil nitrogen transformations and availability in Indonesian cocoa agroforest reports higher rates of nitrogen mineralization, ammonium uptake, and faster turnover of the ammonium pool than in an adjacent maize *Zea mays* monoculture indicating a higher nitrogen availability in agroforestry. This suggests that, in contrast to maize monoculture, the decomposer community in cocoa agroforest retains most of its nutrient cycling functions (Tscharntke et al. 2011). Studies carried out in Latin America on cocoa and coffee plantations with 120-560 leguminous shade trees per hectare showed that these inputs can vary from 3-14 Mg ha^{-1} Yr^{-1} of dry matter containing 60-340kg N $ha^{-1}Yr^{-1}$ (Beer, 1998).

2.7.4 Shade Trees as Erosion Controller

According to Ranieri et al., (2004) shade trees play an important role in erosion control because they protect the soil against raindrop impact; reduce runoff velocity by increasing surface roughness and water infiltration as well as providing a litter layer and tree roots that create channels in the soil. The level of runoff and soil loss is generally lower in shaded than unshaded plantations. Also soil erosion in mature cocoa agroforestry is negligible and losses of nutrients are insignificant unless plots are located on very steep slopes (Hartemink, 2005). The leaves from trees serves as mulch, which also improve the retention of soil moisture during the dry season and improve infiltration rates, bulk density and water storage capacity (Righi et al, 2008). A dense shade canopy provide better soil protection than an open canopy during high intensity rainfall as trees can adversely redistribute precipitation, hence, a low crown with small leaves is preferable to reduce drip damage (Beer et al., 1998).

2.7.5 Shade Trees as Home of Biodiversity

Agricultural activities diminish biodiversity by displacing or replacing natural environments. The major challenge for conservationists and agriculturists in biodiversity hotspots is how to balance the economically driven agricultural expansion with strategies necessary for conserving natural resources, and maintaining ecosystem integrity and species viability (Perfecto, 1997). Tscharntke et al., (2011) indicated that researches around the world suggest that tropical agroforestry systems can harbor high levels of biodiversity, often comparable to native forest, even though species composition often differs greatly. Biodiversity benefits of cocoa are most commonly linked to cocoa grown under shade, and more specifically in the shade of native forest species. Cocoa farms have positive benefits especially when grown under the shade of secondary forest or other species-rich tree canopies because they provide a wider array of ecological niches for wildlife than do many other cultivated land uses as well as stop over point for migratory birds (Leakey and Tchoundjeu, 2001). Shaded cocoa and coffee systems provide cool and thriving environment for biodiversity making the system being known to support much higher biodiversity than unshaded systems (Cassano et al. 2008; Clough et al. 2010). In many cocoa producing countries, cocoa is cultivated under thinned forest canopy but more often it is found beneath a diverse canopy of planted shade trees and these alternative systems probably support very different level of diversity of tropical forest organisms (Greenberg et al. 2000). Research by Schroth et al., (2007) demonstrated that the contribution of cocoa agroforestry systems to the conservation of biodiversity is dependent on their structure, composition and management, as well as on the quantity, quality and location of remnants of native forest habitat in the landscape. He further indicated that the correlation between biodiversity and land use intensification may not be linear and that management alternatives, such as agroforestry systems that have structural resemblance to natural forest ecosystems, may provide a combination of limited ecological losses and satisfying economic gains.

Greenberg et al., (2000) suggested the continuation in existing cocoa farms of the practice of using a diversity of shade trees rather than the change to monocultures or low-diversity shade systems and the promotion of cocoa establishment under a wide range of shade species in deforested areas are measure to enhance the impacts of cocoa on biodiversity.

2.7.6 Shade trees as Weeds, Diseases and Pests Controller

Schroth et al., (2000) indicated that in the case of cocoa plantations, agroforestry systems could modify pests and disease incidence compared with mono specific plantations, and the effect of shade trees on diseases could have several explanations. This indicates that the percentage of shade and the species of the shade tree has an incidence on the intensity of the epidemic of some diseases. Competitive weeds have been found to be on the increase in cocoa farms especially when cocoa is young under no shade system, with this weeds serving as pool for pests and diseases (Siebert 2002; Schroth et al. 2000). The planting of cocoa in association with various food crops, especially plantain and herbaceous plants, shrubs and tree according to Padi and Owusu (2003) provide temporal shade and also promote weed suppression and soil improvement. Mealy bug (*Homoptera*) infestation and Anthracnose fungal disease (*Collectotrichum gloesporiodes*) associated with unshaded cocoa according to Beer et al., (1998) have made the system not economically justified despite the initial production advantage. Rice and Greenberg (2000) suggested that the manipulation of the cocoa habitat in order to retain the co-evolved ecological relationships characteristic of natural forest should be the first approach to be taken to prevent disease or pest problems in cocoa agroforestry systems.

Excessive shade has been found to have negative effects on the disease and pest status of cocoa farms. Schroth et al. (2000) affirm that pathogens such as the black pod disease *Phytophtora sp* may profit from the higher humidity under planted shade trees although cocoa under no shade system is often more vulnerable to pest and diseases and therefore require higher inputs of pesticides. Also *Phytophthora palmivora* (black pod disease of cocoa) and other pests and diseases are reported to be favoured by increased humidity due to increased shading (Akrofi et al., 2003).

The impact of some pests can be reduced by managing the degree of shading through tree cover, this trees influence the sunny conditions. The “light” shading they provide can help reduce capsid attack, weed encroachment, and some parasitic plants that attack cocoa. It is recommended that 10 to15 trees per hectare be maintained within the cocoa plantation to avoid some of the danger of disease and pest incidence associated with heavy shade system (Padi and Owusu 2003). The equilibrium in natural undisturbed systems does not permit one or more species to cause major damage, as a large number of predators will be present. In a disturbed system such a balance may not exist because the reduced plant diversity and the absence of trees do not provide sufficient resources and niches for predators and antagonist (Anglaaere 2005).

2.8 Shade Trees and Tradeoffs in Cocoa Productivity

According to Anglaaere (2005), series of controversies arose in the late 1960s over cocoa shade and productivity with the emerging worldwide availability of agrochemical technologies and introduction of new cocoa varieties that required little or no shade. Ruf and Zadi (1998) states that, cocoa under agroforestry system may yield for 60-100 years whereas production may last for only 20 years without shade. This indicates that unshaded cocoa have a shorter life expectancy than shaded cocoa trees. Cocoa under shaded systems in Ghana can produce for over 70 years (Obiri et al. 2007).

Shade trees in cocoa have influenced fruit abortion, disease and pest severity and their spatial and temporal development of the cocoa. These shade trees are often assumed to affect cocoa growth and yield negatively through competitive water use, but empirical studies have shown positive effects of plant species-specific, complementary resource use in agroforestry systems (Ong et al. 2004). Report by Stephan-Dewenter et al., (2007) states that increased land use intensity in cocoa agroforestry, coupled with a reduction in shade tree cover from 80 percent to 40 percent, caused only minor quantitative changes in biodiversity and maintained high levels of ecosystem functioning while doubling farmers’ net income. However, unshaded systems further increased income by 40 percent, implying that current economic incentives and cultural preferences for new intensification practices put shaded systems at risk. Steffan-Dewenter et al., (2007) concluded that low-shade agroforestry provides the best available compromise between economic forces and ecological needs. According to Bos et al., (2007) planting leguminous shade trees in cocoa agroforestry systems may actually reduce fruit abortion of cocoa; also maintaining homogenous shade levels using large forest trees reduces the impact of mirids on cocoa productivity.

2.9 Shade Tree in Carbon Storage and Greenhouse Gases Emission

Zapfacket al., (2002) and Sonwa et al., (2007) stated that cocoa agroforestry systems make a significant contribution to carbon sequestration indicating that cocoa agroforests have considerable potential to sequester carbon in soils. If carbon credits are specifically targeted towards more sustainable agroforestry systems, increased environmental benefits in terms of higher carbon sequestration rates as well as higher income benefits for the poorer households can be obtained from shaded cocoa agroforests compared to non-shaded (Seeberg-Elverfeldt et al. 2009). The researcher further noted and concluded that payment for ecosystem services scheme is a win-win situation as both deforestation processes and poverty can be reduced with carbon payments. Plant biomass and associated carbon storage under cocoa agroforestry systems are higher than in an unshaded cocoa system (Bisseleua et al. 2009). Ofori-Frimpong et al., (2007) observed that shade trees litter fall contributed about 3 percent of the total litter fall under shaded cocoa farms. This percentage of liter fall contributes significantly to the amount of soil carbon under the cocoa agroforestry system. Findings from Indonesia by Steffan-Dewenter et al., (2007) on the amount of carbon under various cocoa agroforestry systems indicated that above-ground plant biomass was significantly lower in agroforestry with reduced canopy cover, mainly due to the removal of large trees. He further stated that this reduction corresponds to a loss in above ground carbon storage of roughly 100t C ha^{-1}via conversion of mainly undisturbed natural forest into low-shade agroforestry systems. Remarkably, the annual leaf litter carbon input to the soil is much lower in shaded agroforests than in natural forest, while the importance of root litter carbon flux to the soil is particularly high in shaded cocoa agroforests. This is due to a fine-root production and turnover in cocoa agroforests of a similar magnitude to natural forests (Hertel et al. 2009).

2.10 The Importance of Cocoa to the Economy of Ghana

Aryeetey and Kanbur (2008), asserted that Ghana’s first president, Kwame Nkrumah, used cocoa revenue as security for loans to establish different state-owned industries. Nkrumah’s dependence on cocoa, along with the fall in prices in the late sixties, caused a decline in the growth of the country and resulted in a coup to overthrow him. This assertion according to Amoah, (2008) showed that cocoa has been the backbone of Ghana’s economy for a century and plays a major role in employment, foreign exchange earnings, government revenue, education, and infrastructural development amongst others. It is estimated that over 14 million workers produce cocoa, of which 10.5 million are in Africa. Small-scale farmers grow 95 percent of the worlds cocoa. In Ghana, it is estimated that there are about 265,000 cocoa farm owners and roughly 800,000 people involved in cocoa growing and these figures exclude those working in other areas of the industry such as the processing firms, Licensed Buying Companies, chocolate vendors and others (Asamoah and Baah, 2003).

Table 2.1: Cocoa Farm Sizes in Ghana

Size range (Ha)	Total hectares in size range	Number of Farmers	Percentage of farmers in size range
Up to 1.0	187,155	120,750	34.5
1.1-2.0	218,481	87,500	25.0
2.1-4.0	336,633	85,750	24.5
4.1-8.0	287,363	40,250	11.5
8.1-20.0	191,863	14,000	4.0
20.1-40.0	38,270	1,400	0.4
>40	190,235	350	0.1
TOTAL	1,450,000	350,000	100

Source: COCOBOD, 2010

Cocoa contributes about 70-100 percent of smallholder cocoa farmer's annual household incomes in Ghana. Cocoa farm sizes are relatively small in Ghana ranging from 0.4 to 4.0 hectare with an estimated total cultivation area of about 1.45 million hectares (COCOBOD, 2010).

Table 2.2: Regional Cocoa Purchases in Ghana 2000-2010 (Metric Tons) by Region

Crop Year	Ashanti	Brong Ahafo	Eastern	Central	Western	Volta	Total
2000/01	72,993	33,110	46,226	32,136	203,626	1,681	389,772
2001/02	56,983	31,354	39,348	29,992	181,865	1,021	340,563
2002/03	82,445	45,308	51,604	39,989	276,587	913	496,846
2003/04	121,269	69,695	68,634	55,819	419,650	1,909	736,976
2004/05	90,535	55,025	48,868	59,308	344,246	1,336	599,318
2005/06	133,026	72,766	55,871	55,497	422,223	1,075	740,458
2006/07	95,427	65,629	51,132	43,757	357,827	761	614,532
2007/08	125,270	66,921	55,916	62,378	369,458	838	680,781
2008/09	110,643	61,562	63,405	60,686	413,395	951	710,642
2009/10	116,538	60,600	55,736	57,562	359,910	595	650,941

Source: ISSER, 2012

Throughout the years, sales of cocoa beans have been the major foreign exchange earners to Ghana. In 2009 cocoa made up for 32.0 percent amounting to $ 1,866 million of the total foreign exchange earnings. Among all the agriculture exportable commodities cocoa stood tall, of which it constituted 84.9 percent of the foreign export earnings from the agricultural sector, compared to 8.2 percent and 6.9 percent contribute by timber and the non-traditional export sectors respectively (ISSER, 2010).

Table 2.3: Foreign Exchange Earned by Agriculture and Non-Agriculture Sector

Year	Agriculture						Non Agriculture		Total	
	Cocoa		Timber		Non-traditional					
	$	%	$	%	$	%	$	%	$	%
2005	908	32.4	227	8.1	151	5.4	1,516	54.1	2,802	100
2006	1,187	31.8	199	5.3	203	5.4	2,146	57.5	3,735	100
2007	1,103	26.3	249	6	197	4.7	2,646	63	4,195	100
2008	1,487	28.2	317	6	188	3.6	3,278	62	5,275	100
2009	1,866	31.1	180	3	151	2.6	3,794	63	5,991	100
2010	2,285	27.9	189	2.3	165	2	5,551	68	8,190	100
2011	2,871	22.5	166	1.3	297	2.3	9,749	75	13,083	100
2012	2,828	20.7	121	0.88	276	2	10,593	76.7	13,818	100

Source: Institute of Statistical, Social and Economic Research (ISSER). University of Ghana, 2012

In 2009 the percentage increase in production was 4.4 over the previous growing season, 2007/2008. According to ISSER (2012) the government target to increase output to 1,000,000 metric tonnes seems to be on course but at a slow pace and there is the need to further intervene to reach that target. In 2012 the government of Ghana met its unprecedented target of 1,000, 000 metric tonnes at beginning of the cocoa season of which it is expected to rise at the end of the season (GBC, 2012). This output has been the country's highest since joined the cocoa production nation.

Table 2.4: Annual Cocoa Production in Ghana

Year/ Period	Cocoa (000 tones)	Seasonal change (%)
2004/05	601.9	-18.3
2005/06	740.4	23.0
2006/07	614.5	-17.0
2007/08	680.8	10.8
2008/09	710.6	4.4
2009/10	800.0	12.5
2010/11	1,024.6	28.1
2011/12	879.3	-14.3

Source: Institute of Statistical, Social and Economic Research (ISSER). University of Ghana, 2012

In 2009 Ghana suffered a sharp decline in timber and timber products exports following a 24 percent increase in exports in 2008. Total exports receipts from timber and timber products fell by 43 percent in 2009, largely due to decreased export volumes attributed to the slump in trade (ISSER 2010).

CHAPTER THREE

METHODOLOGY OF THE STUDY

This chapter explores the research approach, sampling methods, methods of data collection and analysis as well as the present socio-economic and institutional situation of the study area.

3.1 Conceptual Framework

The basic concept underlying economic and financial analysis of a project is that for alternative project, the costs are compared with the return for our money (Gittinger, 1982). There are various analytical methods in determining project viability in the field of investment analysis but the most used of these methods is the cost-benefit analysis. Cost Benefit Analysis is a systematic approach to estimating the strengths and weakness of alternatives or functional requirements for best approach for a business. It is a technique that is used to determine options that provide the best approach for the adoption and practice in terms of benefits in labour, time and cost savings etc. (David et al. 2013). Cost-Benefit Analysis (CBA) according to Mensah–Bonsu (2000) is a quantitative technique that helps guide investment decision in a systematic approach. It is also an imperative instrument for estimating the relevant economic factors of a particular project, policy or a program. Cost-benefit analysis is a practical and rigorous means of identifying, targeting and checking the impacts of regulatory measures on the underlying causes of the ills, with which regulators need to deal with those causes being the market failures that in turn may justify regulatory intervention (Alfon, 1997).

In principle, all impacts are required to be assessed whether they are of a financial, economic, social or environmental nature. Costs and Benefits of investments are compared in order to determine whether on a balance, the investment is worthy; or altering some parameters such as technology and method of operation could ensure a successful implementation and operation. The main objective of Cost-Benefit Analysis is to attach a monetary value to all possible impacts of the project in order to determine its cost and benefits from a social perspective. Information from cost-benefit analysis attempts to establish the most effective allocation of resources, when determining whether a specific project or program should be undertaken or when selecting the most optimal alternative among a set of options. Results obtained from a Cost- benefit analysis are meant as a tool to improve decision-making.

The net benefit of project can easily be calculated when it is a one-year project by subtracting the total cost from the total benefit and the results compared with alternative projects. Projects with longer life, spanning more than one year has its cost and benefit occurring at different periods throughout the project life. In principle the cost and benefits cannot be compared with each other because the values are different and also occurs at different time periods.

In order to make all values compatible with respect to time, they need to be adjusted to present values (present worth). A discount rate will be used to adjust for the future values. To determine the net benefit of a whole project the cost and benefit will have to be discounted to bring all future values to the present.

3.1.1 Concept of Discounting

In comparing costs and benefits for a project such as cocoa agroforestry it will be realized that they occur at different points in time during the life of the project. Summation of the costs and the benefits accrued throughout the project would be inappropriate, since it universal preferences of an individual or society as a whole to gain benefits earlier rather than later will be more or less ignored (Piyaluk, 2001). What it means is that, a million Ghana cedis in five or ten years' time will have a different value from a million Ghana cedis today. This leads to the concept of time preference, which relate to the fact that the values received earlier are worth more than those received later. Having this in mind, it will be apprehended that comparing costs and benefits in project analysis is not straight forward matter, since the costs and benefits are to be realized at different points in time. In order to make all values compatible with respect to time, they need to be adjusted to present values. Future values will be adjusted by a certain rate called the 'discount rate' (Piyaluk, 2001).

The future sums accrued can be brought to the present terms through time discounting technique. Time discounting is the technique by which the values to be realized at different points in time are adjusted to their present values to make them comparable (Gittinger, 1982). The first step in discounting is to choose an appropriate discount rate. Discount rate is the rate by which benefits that accrues in some future time period must be adjusted so that they can be compared with values in the present. Deciding on the discount rate is one of the most important aspects in the field of cost benefit analysis.

When evaluating projects, the analyst must assign the most appropriate weight to the impact of project that can occur in the different years. These weights make net benefits that occur in the future comparable to the net benefits realized by society today and as a result analysts are able to aggregate them to obtain a single measure of the value of the project. The weights assigned to the impact are referred to as the discount factor. The general principle underlying discounting is that resources today are worth more than the same amount of resources at some future date. Given the amount of resources available today, it is better to invest now and turn those resources into greater amounts later in the future. Also, people favor consumption today over future consumption. Economists refer to an individual's preference for consumption today rather than later as time preferences. According to Boardman et al., (2006) the rate at which this trade-off occurs is referred to as the individual's marginal rate of time preference. To determine the correct discount rate is of great importance, it can be done by choosing a discount rate randomly or using any of the rates prescribed by several official institutions for use in project evaluations and obliges others to use them as well. That being said, the discount rate substantially influences the project's appraisal and should therefore be selected with care. Choosing a discount rate randomly may cause results that fail not to reflect the true appraisal of the project. In theory, a relatively low discount rate favors projects with the highest total benefits, regardless of the time of occurrence, since the social discount factors are all close to 1. With increasing discount rates, smaller weights are placed on the benefit or cost occurring further in the future, and as a result, back end loaded projects become unfavorable. Conversely, the case strengthens for front-end loaded projects (Boardman et al., 2006).

Boardman et al., (2006) suggest three different discount rates that can be derived from the market. In a perfect market, the discount rates would be unambiguous as there are no distortions and all rates observable in the market are equal. However, this kind of thinking is rather naïve. In a real economy, the discount rates are subject to taxes, risk and transaction cost and therefore they are unlikely to be equal. Thus, it becomes even harder to derive the correct discount rate in an imperfect market. According to Boardman et al., (2006) in suggesting a discount rate, the first choice would be to select a rate based on the marginal rate of return on private investment, *r*. The arguments for applying this rate is that before resources are drawn from the private sector, the government should be able to demonstrate that society will benefit more in the public sector than if these resources would have remained in the private sector. Thus, the return on the government project is expected to exceed the marginal return on the return on private investment, *r*. The second suggestion would be to apply a discount rate based on people's willingness to postpone current consumption for additional consumption in the future. In principle, this would be the marginal rate of time preference. A justification for using this rate would be appropriate if the project is financed purely by domestic taxation and thereby reducing consumption but not investment. The third and final suggestion is to use the government's borrowing rate or opportunity cost of capital to discount the project. Economists argue that this particular rate reflect the actual cost of financing and is possibly subjected to an actual pareto improvement for the society (Boardman et al. 2006). Even though Boardman et al., (2006) makes out these three suggestions of discount rates, they all have limitations in their application that make them unattractive. Thus, the most appropriate discount rate is the opportunity cost of capital. The opportunity cost of capital is a measure of the benefits forgone by applying resources to one use instead of the next best alternative use. This opportunity cost of capital is usually expressed as an annual interest rate. Gittinger, (1982) indicated that for developing countries, it is assumed that the opportunity cost of capital is somewhere between 8 and 15 percent in real terms whereas Boardman et al., (2006) suggest 3.5 percent if the project has no impact on future generation, say before 50 years. Once the discount rate has been determined, the next step is to multiply the cost or benefit streams occurring in each year (year t) by the appropriate discount factor.

3.2 Economic Verse Financial Analysis

Cost-Benefit Analysis involves trying to identify and value all the costs and benefits associated with a project. The costs and benefits associated with a particular project depend on whether they are viewed from the stand point of the individuals concerned or of the society as a whole. Thus, in project analysis, there is a distinction between economic analysis and financial analysis. Economic analysis deals with costs and benefits from the view point of the country as a whole while financial analysis deals with costs and benefits from the view point of the individual (or an agency or enterprise) (Gittinger, 1982). The distinction between economic and financial analysis can be summarized as;

a. In economic analysis, market prices are adjusted to reflect economic values e.g shadow, but in financial analysis, market prices, which might include taxes and subsidies are always used.

b. In economic analysis, taxes and subsidies are treated as transfer payments. Taxes are considered as part of the total project benefits, which is transferred to society as a whole, and not treated as a cost. On the other hand, a subsidy is considered as a cost to the society because it represents an expenditure of resources incurred by the economy for the purpose of operating the project. However in financial analysis such adjustments are not required. Taxes are treated as cost and subsidies as benefit.

c. In economic analysis, interest on capital is not separated out and deducted from gross returns, since it is a part of the total return to capital available to the society as a whole. In financial analysis, interest paid to outside suppliers of money is treated as cost and repayment of money borrowed from outside suppliers is deducted before arriving at the benefit stream.

3.3 Justification of Financial Analysis

The financial approach was used for the research as it includes marketable goods and services valued at current market prices. It also uses actual cash flows and is suitable from the point of view of the farmer. According to the USAID (2008), financial analysis is critical in showing the financial implications of a project under consideration. In this case, financial analysis is very important to the farmer because financial implications and profitability are of paramount importance to the farmer.

3.4 Identification of Benefits and Costs of cocoa agroforestry systems

To determine the financial viability of cocoa agroforestry systems, the relevant benefits and costs associated with the systems must be estimated. The implementation of a cocoa agroforestry project will divert resources from alternative production processes. These resources would be used in the cocoa agroforestry project to produce outputs, while at the same time the opportunity cost of these resources would result in a loss of output in the crop system. The aim should be to maximize net social benefits (public perspective), or profits (private perspective) of cocoa agroforestry systems. According to Nas (1996) the benefits to be accrued, as a result of increased output from cocoa agroforestry should be greater than losses to be accrued as a result of foregone output from other cropping systems.

3.4.1 Costs of Cocoa Agroforestry Systems

In project costing, first identify all costs and add cost by year. All the costs associated with cocoa agroforestry technology were identified at the first step in cost analysis. Costs comprise all of the expenses related to the investment and management of the project. Costs related to the commencement of the project are often referred to as investment costs. These include the cost of land, tool and equipments. Costs related to the operation of the project are also referred to as operation and management costs.

The private costs of cocoa agroforestry systems include the cost of the land, costs of planting and management of food crops, cocoa and shade trees. The costs of planting and management of food crops, cocoa and trees are direct costs of cocoa agroforestry systems. Prevailing market prices were used throughout the study since it was viewing its cost from the perspective of the individual farmers.

3.4.2 Benefits of Cocoa Agroforestry System

The private benefits of cocoa agroforestry system were the benefits accruing to the producer undertaking the cocoa agroforestry system, either directly or via the market place. The private benefits in the study includes food crops (yam, cocoyam, plantain, cassava and maize), cocoa beans and timber revenue.

Food crops revenue: These are the major benefit to be accrued from the early years of the cocoa agroforestry systems. Revenue from such crops was obtained by multiplying the prices per unit output of each crop by the number of units of ouputs realised each year.

Cocoa beans revenue: The major private benefit of cocoa agroforestry system is revenue from cocoa beans. Cocoa revenue was obtained by multiplying the bag price by the total number of bags per year.

Timber Revenue: Timber revenue was estimated by multiplying the timber price by the growth estimates. This would provide gross revenue for timber. Only four timber species which is dominant in the study areas were used for the analysis.

To the cocoa farmer, the financial analysis of cocoa agroforestry system would take opportunity cost of reducing scale of cocoa trees per hectare. For non-cocoa farmers, it means comparing investments in cocoa and other interest bearing assets such as bank time deposit. For the sake of this research the non-financial benefits of tree crop investments were not quantified.

3.5 Investment Appraisal Criteria

Cocoa like any other perennial crop generates a stream of costs and benefits over a given period of time. Due to the time value of money, discounted methods were used to enable the comparison of future cost and benefit with present values. This led to the concept of discounting. Discounting is a technique by which one can 'reduce' future benefit and cost to their 'present worth'. The discounting measure includes NPV, BCR and IRR are widely used to evaluate the viability of projects. These techniques were used in the cocoa agroforestry systems because it provides an easy to use and very popular analytical framework for which the project can be examined from the private perspective.

3.5.1 Benefit-Cost Ratio (BCR)

Benefit Cost Ratio is obtained when the present worth of the benefit stream is divided by the present worth of the cost stream; in other words, it gives a ratio between the benefits (revenues) derived from the project and the cost incurred in realizing those benefits. This ratio could be estimated with either discounted or undiscounted benefits or costs.

The mathematical expression is given by:

$$BCR = \sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t} \div \sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}$$

Where: B_t = benefit in each year, C_t = cost in each year, t = 1, 2, 3, 4 …n, n = number of years and i = discount rate

The decision rule is that, a BCR ratio of one (1) indicates a breakeven point, a ratio of greater than one (1) indicates a profitable venture with revenues accrued is high and can cover the costs incurred, and a ratio of less than one (1) indicates a non-profitable venture.

3.5.2 Net Present Value (NPV)

According to Gittenger, (1982) the net present value (NPV) is interpreted as the present worth of income stream generated by an investment. The net present value (NPV) is usually computed by finding the difference between present worth of benefit stream minus present worth of cost stream. Bert De Reyck et al., (2008) stated that traditional investment theory demonstrates the concept of net present value (NPV) by using a cost of capital based on the inherent project risk. It is also an economic standard method for evaluating long-term projects. NPV of an investment is the sum of its net discounted future cash flows. Net present value only tells us how much the expected present profit could be earned from the investment.

The decision rule of this technique is to accept those projects, which have a positive or zero NPV and the projects having negative NPV are rejected in evaluating a single project. In the case where evaluation of more than one project, selection should be made for the highest internal rate of return as well as net present value with high benefit cost ratio.

The mathematical expression for NPV is given as:

$$NPV = \sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t}$$

Where: C_t = cost in each year, B_t = benefit in each year, t = 1, 2, 3, 4 …n, n = number of years and i = discount rate.

3.5.3 Internal Rate of Return (IRR)

Internal rate of return is another analytical tool used to judge the viability of the projects apart from the net present value and benefit cost ratio analysis. It is the interest that a project could pay for the resources used if the project is to recover its investment and operating costs and still break even (Gittinger, 1982). The Internal Rate of Return (IRR) also corresponds to the rate for which the present value of the investment's money in-flows are equal to the present value of the money out-flows. Internal rate of return is measured when the discounted total benefits minus discounted total cost is equal to zero. IRR is known as rate of discount which, when applied to an investment's cash flow, produces zero NPV.

Simply, IRR is the value of "r" which satisfies the following expression:

$$\sum_{t=1}^{t=n} \frac{B_t - C_t}{(1+i)^t} = 0$$

Where: C_t = cost in each year, B_t = benefit in each year, t = 1, 2, 3, 4 …n, n = number of years and i = discount rate

The decision rule in this approach is to accept those investments having an IRR greater or equal to market rate of interest.

3.6 Sensitivity and Risk Analysis

The analysis of project is critically dependent on assumptions about future events through the estimation of costs and benefit of future cash flows. These estimates are error prone as the data on cost and benefit may be generally imperfect. One way to understand and quantify the possible errors in costs and benefits estimates and ultimately in financial analysis is through sensitivity analysis. Sensitivity analysis is a form of quantitative analysis that examines how net present values, total cost, or other outcomes vary as individual assumptions or variables are changed (Gittinger, 1982). It determines how sensitive the decision making criteria (BCR, NPV and IRR) is to vary in selected costs and benefits. Sensitivity analysis helps to test what happens to a parameter when altered. As the values of input parameters are often subject to great uncertainty it can be very beneficial to examine the project's outcome given a change in these parameters.

Again it highlights which parameters influence the results the most and should therefore be considered key parameters. Sensitivity analysis involves reworking an analysis to see what happens under these changes and also changing one key primary variable each time and keeps others the same and then observes the results of the decision making criteria. This approach gives a picture of the possible variation in when a given risky variable is wrongly estimated. There is a possibility that a variable itself maybe very risky, but it has small effect on the overall project decision making criteria. On the contrary, a non-risky variable may have a big impact on the whole project. It is easy to find the extent of forecast errors of a variable through this analysis before making a decision of investment. It is desirable that all projects are subjected to sensitivity analysis, because in reality the projections in project analysis are subject to a high degree of uncertainty about what would happen (Boardman et al. 2006). Cocoa agroforestry technology project can be variable in prices of cocoa beans, labour, fertilizer and variation in the yield.

3.7 Hypotheses of the Study

The following hypotheses were validated:

H_0: Cocoa agroforestry systems do not have positive Net Present Value.

H_1: Cocoa agroforestry systems have positive Net Present Value.

H_0: Cocoa agroforestry systems do not have Benefit Cost Ratio greater or equal to 1.

H_1: Cocoa agroforestry systems have Benefit Cost Ratio greater or equal to 1.

H_0: Cocoa agroforestry systems do not have Internal Rate of Return greater or equal to market rate of interest.

H_1: Cocoa agroforestry systems have Internal Rate of Return greater or equal to market rate of interest.

3.8 The Study Area

The study was carried out in the Sefwi Wiawso district in the Western Region of Ghana. The reason for selecting this cocoa growing region is that, it is among the highest cocoa producing districts in the country and also various agroforestry technologies have been introduced there. The district faces increasing deforestation due to its high population growth rate and the quest to increase cocoa output. This practice has degraded the virgin forest cover in several areas in the District and replaced by a mosaic of secondary forest, shrub covered land and agricultural holdings.

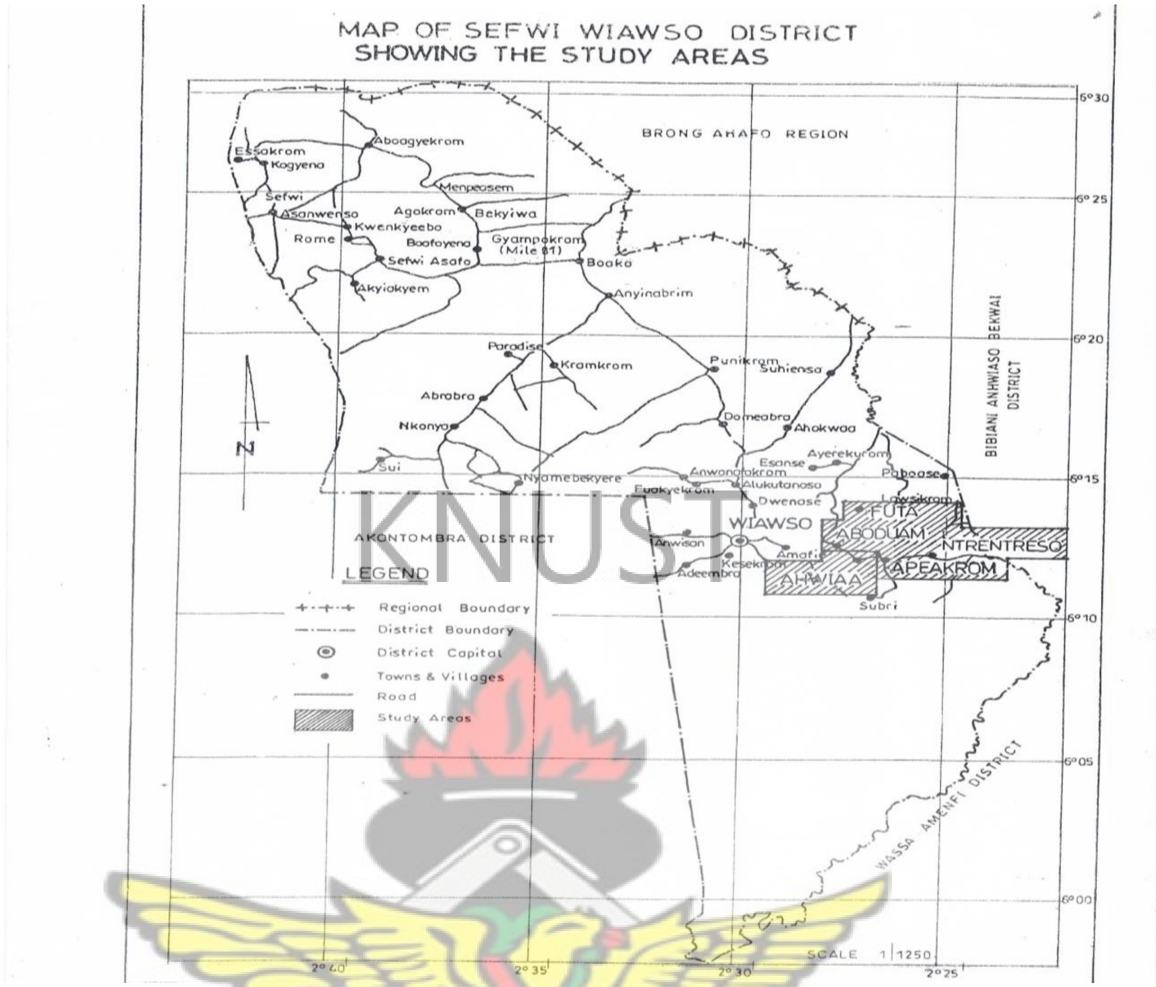

Figure 2: A Map indicating the various communities where survey was conducted in Sefwi Wiawso
Source: Sefwi Wiawso District Assembly

3.8.1 Location and Size

The Sefwi Wiawso District is located in the North-eastern part of the Western Region of Ghana. It shares boundaries with the Brong Ahafo in the north, Juabeso and Bia District in the west and by Aown/ Suaman in the south. It is also bordered by Bibiani-Ahwiaso-Bekwai to the coast and Wassa Amenfi West to the south-east. The Sewfi Wiawso District falls within latitudes 6º 00' and 6º 30 North and Longitudes 2º 15' and 2º 45 West (SWDA, 2012). The District covers an area of about 2,634 square kilometers. The entire District comprises about 21 towns with Wiawso as the District capital.

3.8.2 Relief and Drainage

The topography of the Sefwi Wiawso District is generally undulating with an elevation of about 206m above sea level (SWDA, 2012). The most prominent feature in the District is the range of hills ranges known as the Bibiani range. The District's drainage derives mainly from the Tano River and its tributaries, which cut through the district roughly in a north-south direction and enters the sea in Cote d'Ivoire. However, the usefulness of the rivers to the District is limited due to the higher level of pollution from various sources. The pollution of the water bodies in the District poses a great threat to the health of communities that use the rivers as source of drinking water and for other domestic purposes. Water related diseases are more likely to be prevalent within the District especially in areas where there is shortage of pipe borne water, this intern affect the productivity of cocoa farmers. The topography of the District makes it possible for the people to cultivate variety of crops. It thus presents an opportunity for farmers in the District to increase their income levels through commercial farming to reduce poverty among households in the District. However, overdependence on rainfall for farming, lack of credit facilities for farm implements and agrochemicals make it impossible for farmers in the District to embark on large-scale farming activities in their communities. This makes it impossible for farmers in the District to raise adequate income from their farming activities to satisfy their basic needs.

3.8.3 Vegetation and Climate

The District lies entirely in the rain forest belt and exhibits moist, semi-deciduous characteristics. It is much resourced with timber, herbs of medicinal values and fuel wood. Increased population, excessive and reckless logging for export and expansion of cocoa farms are responsible for the alarming rate of deforestation in the Sefwi

Wiawso District. This practice has degraded the virgin forest cover in several areas in the District and being replaced by a mosaic of secondary forest, shrub covered land and agricultural holdings. The hottest period of the year has recorded a mean monthly temperature range of about is 31^0C to 33^0C occurring within the month of February to March prior to the commencement of the rainy season. From July to August the weather is relatively cold with a mean monthly temperature of 19^0C to 21^0C (SWDA, 2012). The rainfall pattern of the District is not different from that of the Western Region except the hilly areas of the District. The District falls within the higher rainfall belt of Ghana, hence, has double maxima rainfall pattern. The rainfall period begins as early as March through June and July when it attains its peak and begins to subside. In October and November it rains again on a relatively minor scale, and this is followed by the dry season. The average annual rainfall range for the District is between 1500 mm and 1800 mm (SWDA, 2012). Rainfall is evenly distributed in the District and supports most of the rain forest crops grown in the District. Almost all the farming activities that take place in the District highly depend on the rain because there is no well-developed irrigation schemes to support agriculture in the District.

3.8.4 Soils and Agricultural Land Use

The soils found in the Sefwi Wiawso District can be grouped under the geological formation from which they were developed. They include soils developed over granite rocks, which comprise the Nyanako-Tinkong Association; soils developed over birimian rocks comprising of Bekwai-Oda Compound Association, Mim-Oda Compound Association, Kobeda-Esciem-Sobenso-Oda Complex (SWDA, 2010). The Bekwai- Oda Compound Association has relatively good agricultural properties. They are suitable for a number of crops. Such food crops as plantain, cocoyam, cassava, maize, legumes and vegetables thrive well on them. Cash crops such as oil palm, cocoa, coffee, citrus and pear are also cultivated on them. For the purpose of crop cultivation, Kobeda series of the Mim-Oda Compound Association are relatively limited because of their shallow depth and susceptibility to drought. The middle slopes are, however, very fertile due to the basic rocks from which they were developed. But their extent, location and inaccessibility make them agriculturally unimportant. Generally, however, the soil formation in the District supports most of the cash and food crops produced in the country.

3.8.5 Demographic Characteristics

According to the 2010 Population and Housing Census report, the Sefwi Wiawso District has a total population of 139,000 comprising 69,753 males and 69,417 females representing 50.2 percent and 49.8 percent respectively (Ghana Statistical Service, 2012). The dominance presence of male in the District is attributed to the intensive farming activities especially cocoa farming which is male dominated and labour intensive attracting males from other parts of the country into the District. In addition, the presence of timber processing firms also contributes to the high male population in the Sefwi Wiawso District. The annual growth rate is estimated to be 2.9 percent.

3.8.6 The Structure of the Local Economy

The local economy in the study areas is made up of agriculture, industrial/ manufacturing and services.

3.8.6.1 Agriculture

Agriculture is an important sector in the economy of the study area, due to the availability of fertile lands that support the cultivation of variety of crops for both the local market and for export. Major staple crops grown include cassava, cocoyam, plantain, yam and maize. Cocoa is the main cash crop cultivated in the district. While there are a few large cocoa farms and oil palm plantations, small scale agriculture is predominantly practiced in the district. Though wealthier households tend to have larger farms almost twice as big as those in lower income, the average farm size is 2 hectares (SWDA 2012). As a result of poor road network, most of the farmers are unable to transport their farm produce from the farms to the farm gates leading to high post-harvest losses in the study areas.

3.8.6.2 Manufacturing / Industry

There are industries in the district that are basically small scale in nature and could be grouped into the following broad areas. The agro-based industries referring to those industries that use agricultural produce as their raw materials. They include cassava processing (Gari making), oil and palm kernel extraction, etc. Wood based industries are those that process wood into other materials such as furniture, woodcarving, etc.; there are other timber processing companies as well in the districts.

The metals based industries include gold smiths, black smiths, metal fabricators etc. Though these industries contribute to the Districts economy they are all not well organized into industrial clusters.

3.8.6.3 Service Economies

The service economy is made up of both the informal and the formal economies. The informal economy comprises of hairdressers, barbers, drivers, painters, market women/ traders etc. these individuals dominate this sector activities in the districts. The formal sector is made up of the financial institutions, government firms, etc.

3.9 Sampling Technique and Limitation

Data used for the study were obtained from both primary and secondary sources. The primary source involved field survey whiles the secondary sources included a review of existing literature on the study area in relation to the districts, region, nation and the world as a whole. The study was conducted using three main approaches: exploratory/ familiarization visit, reconnaissance survey and socio-economic survey. A seven day familiarization visit was made to the communities to establish rapport with farmers in the villages where the actual survey is to be carried out, to identify possible households from which samples were to be taken for the actual survey, to pretest questionnaires to be used in the actual survey and to rapidly appraise some cocoa agroforestry management systems as well as the main biophysical and socio-economic features in the area. Secondary data were obtained from COCOBOD bulletins, Journals, Research Institutions, Statistical Research and Information Department of the Ministry of Food and Agriculture (SRID-MOFA), Forestry commission and internet.

In the case of the primary data, a multistage sampling technique was followed. The first stage involved purposively sampling the Western Region because cocoa farming is the main economic activity and also cocoa agroforestry technology has been introduced to various communities in the Region by the International Institute of Tropical Agriculture (ITTA) under the Sustainable Tree Crop Program (STCP). About 40 percent of the total volume of cocoa produced in Ghana is from the Western

Region of which Sefwi Wiawso Districts stands tall as one of the leading producing district in the Region. In the second stage, a simple random sampling was employed to select five communities out of the fifteen communities in which the cocoa agroforestry technology has been introduced. In each community respondent's households were selected using simple random sampling techniques. With available list of cocoa farmers in the five selected communities, 40 cocoa farmers from each community who are household heads and/or wives or household members responsible for cocoa production from the five communities namely Appiahkrom, Futa, Aboduam, Ahiwaa and Ntrentreso. Random sampling was used to avoid bias by giving all units in the target population equal chances of being selected. Through random sampling there is increased likelihood that the data collected was a representative of the whole population of interest. The random sampling technique is preferred over others to select the individual farm owners because with this method the probability of selection becomes the same for every case in the population. Random sampling is also an appropriate strategy to generalize from a sample studied to some large population.

A total sample size of 200 was used for the study to improve the probability of capturing variation existing in the information gathered from the respondents. Data were collected with the use of structured questionnaires through interviews. The data collected covered some important socio-economic variables (age, sex, years of formal education and marital status) of farmers. Cost of inputs (fertilizer usage, insecticides and fungicides usage, labour and hectares of farm owned); and outputs (total cocoa produced by each respondent in kilograms); timber tree species grown and their uses, food crops grown on cocoa farms and management and marketing systems were also collected.

3.10 Data Analysis

A combination of descriptive tools, yield model and investment appraisal were used for the analysis. Descriptive tools including frequency distribution tables, graphs and measures of central location and dispersion were employed. Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) analysis were used to examine the viability of cocoa agroforestry systems in the study area. All the quantitative data were entered in the Statistical Package for Social Science (SPSS) software. Microsoft-word; Microsoft-Excel and SPSS Program were used for data processing, analysis and interpretation of the information collected.

For this project a discount rate of 20 percent was used to determine the viability of the cocoa agroforestry systems as the rate reflect the current base rate for agriculture loan in Agriculture Development Bank as at 2011.A sensitivity analysis was carried out using different discount rate to better understand the viability of the cocoa agroforestry systems. Cocoa price, fertilizer cost and cocoa yield were varied by increasing and decreasing them by 12.20 percent, 25 percent and 20 percent respectively.

Total land under cocoa cultivation was measured in hectares and crops output measured in kilogram per hectares. Labour used (hired plus household) were expressed as day/hectares for different farm operations. A cash flow tables were developed for each cocoa agroforestry system and profit estimated. All values were based on September 2012 prices, which were held constant throughout the analysis. Analysis was on GH₵/hectare bases.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Demographic Characteristics

The primary objective of this study is to determine the relative financial viability of cocoa agroforestry systems in Ghana. To facilitate the achievement of the main objective, in this chapter, the primary data collected from the field related to this thesis are presented, analyzed and discussed. The trends in the data are described and various comparisons are made in order to reach a succinct and prudent result.

Table 4.1 and 4.2 presents socio-economic characteristics of cocoa farmers in the Sefwi Wiawso District. The socio-economic characteristic of the respondent selected for the study were analyzed with respect to the gender, residential status, age, educational level, household size and farm size of cocoa farmers.

Both women and men play a role in the production cycle of cocoa although it is primarily viewed as men's crop. The gender composition of the cocoa farmers among all the agroforestry system revealed that 84.5 percent of the respondents are males with 15.5 percent being females. This indicates that cocoa production is a male dominated occupation in the study area. The males' dominance in cocoa farming in the study area is likely to be linked with the involvement of women in the cultivation and trading in food crops since the soils are favorable to most food crops. A study by Danso-Abbeam et al., (2012) on cocoa farmers in the Bibiani-Anhwiaso-Bekwai District revele similar results confirming the male dominance in cocoa production as an occupational business. The researcher finding showed that majority (91%) of the respondents were males whilst the proportion of female respondents was 9%. The age composition of the farmers reveals 45, 45, 46 and 49 years for the no shade, low shade, medium shade and heavy shade respectively. The age groups amongst all the cocoa farmers indicate that the farmers were in their prime ages and were actively involved in cocoa production. The age can influence the productivity and decision making. Finding from a study by Barrientos et al., (2008) was that young people are deserting the cocoa sector, which they view as an occupation with little prestige and a last resort for farmers. Young Ghanaian farmers were said to be looking for a better life in the urban sector, in occupations perceived as being more modern, and with a higher earning potential. This circumstance poses a threat to the prediction that cocoa demand will outstrip supply by 2020 according to Blas (2010).

Almost all farm lands are family lands which have been inherited from parents or grandparents. Finding by Clay (2004) indicated that roughly seventy percent of total global cocoa productions are smallholder farmers with land size ranging from in 0.5 to 7 ha. The results from the data revealed the cocoa famers in the Sefwi Wiawso have an average farm size of 2 hectares. This confirms a study by Obiri et al., (2007) which states that cocoa farming is mostly practice by small holder farmer with farm size ranging from 1-4 hectares. Gockowski (2000) indicted that in Cameroon the average cocoa farm sizes is 3 hectares with variations in region, wealth, cultural practices of the individual farmer, and farming intensity. This farm size of the study in Cameroon although is larger than that of the study in the Sefwi Wiawso district they all fall under the small holder cocoa farmers.

Most (69.5 percent) of cocoa farmer are indigenes for the Wiawso land, and the remaining 30.5 percent of the respondents are migrants from Northern and the Ashanti regions of the country and have spent over decades in the district farming cocoa. The average family size in the district per the data was seven and this implied large household size. This is consistent with the fact that 87.5 percent of the respondents are married and the remaining 12.5 percent are single. A study by Wiredu et al., (2011) indicated the cocoa farmers in the Ashanti region have an average household size of 10 which is more than that of the farmers in the Sefwi Wiawso District. The data collect revealed that more than 91.5 percent of the respondents were not educated beyond the primary school level, out of which 60.5 percent are not formally educated at all. A minority (7.5 percent) had secondary education. According to the Ministry and Food and Agriculture (2011) education of the respondents plays a significant role in the acquisition and use of information, hence technology adoption. This low level of formal educational background may likely affect their knowledge of innovations and attitudes to information which are necessary for farm work. The low level of formal education in the district is expected to affect farmers' attitude to innovations and improved technology.

Table 4.1: Demographic Characteristics I

Characteristic	No shade	Low shade	Medium shade	Heavy shade
Age of respondent	45	45	46	49
Household size	7	7	7	8
Plot size (Ha)	2.3	2.2	2	2.1
Age of farm	14	15	14	15
Years in cocoa farming	19	20	20	21

Source: Field Survey, 2012

Strong and pulsating farmers' organizations can provide opportunities to cocoa farmers to effectively play a role in the market economy and benefit from it. With farmer organizations they access affordable production inputs such as finance, technology among others. Table 4.2 shows that in the study 64.5 percent did not belong to any farmer group with 35.5 percent belonging to farmer groups. As a result, a large number of small-scale cocoa farmers in the community are not able to access loans and other support services from credit institutions.

Table 4.1 shows the average years of experience in cocoa farming was 21, although there were others who have about 35-40 years in cocoa farming. The farmers have been exposed to varying cocoa production techniques and other related information due to their relatively long years of farming experience. This experienced farmers are expected to have several innovations availed to them through chances, friends, neighbors and extension workers.

Table 4.2: Demographic Characteristics II

	No shade	Low shade	Medium shade	Heavy shade	All Systems
Gender					
Females	12 (24)	11 (14.7)	4 (8.9)	4 (13.3)	31 (15.5)
Males	38 (76)	64 (85.3)	41 (91.1)	26 (86.7)	169 (84.5)
Residential status					
Indigene	30 (60)	53 (70.7)	35 (77.8)	21 (70)	139 (69.5)
Settler	20 (40)	22 (29.3)	10 (22.2)	9 (30)	61 (30.5)
Level of formal education					
None	18 (36)	24 (32)	12 (26.7)	8 (26.7)	62 (31)
Basic	30 (60)	45 (60)	27 (60)	19 (63.3)	121 (60.5)
Secondary	1 (2)	6 (8)	5 (11.1)	3 (10)	15 (7.5)
Tertiary	1 (2)		1 (2.2)		2 (1)
Marital status					
Single	3 (6)	15 (20)	4 (8.9)	3 (10)	25 (12.5)
Married	47 (94)	60 (80)	41 (91.1)	27 (90)	175 (87.5)
Member of association					
No	41 (82)	51 (68)	19 (42.2)	18 (60)	129 (64.5)
Yes	9 (18)	24 (32)	26 (57.8)	12 (40)	71 (35.5)
Cocoa varieties planted					
Local variety	7 (14)	9 (12)	5 (11.1)	4 (13.3)	25 (12.5)
Hybrid	38 (76)	58 (77.3)	34 (75.6)	24 (80)	154 (77)
Both local and hybrid	5 (10)	8 (10.7)	6 (13.3)	2 (6.7)	21 (10.5)

Note: Figures are in frequencies and those in parentheses are percentages
Source: Field survey, 2012

In the Sefwi Wiawso district, lease management is not common. Data collected showed that 90.5 percent of the respondents manage their own farms. This is an advantage to the cocoa farmers as they will not spend additional cost in paying royalties and rent which tend to reduce their net income and affect their livelihood and welfare commitment of their families. Only 9.5 percent are share mangers. This confirms results from the study that most of the cocoa farmers in the districts are indigenes from the Wiawso land with just a few from Northern and Ashanti region managing other owners cocoa farms as share managers.

4.2 Cocoa Landscape in the Study Area

The current cocoa landscape shows that full-sun cocoa is replacing shade production in cocoa growing regions. A study by UNDP (2011), indicated that high proportion of Ghana's cocoa is grown in full sun at the expense of primary or secondary forest conversion causing a gradual shift on Ghana's cocoa landscapes which consist of 28 percent no shade; 42 percent low shade; 25 percent medium shade; and 5 percent dense shade cocoa systems.

Figure 3 shows the cocoa landscape in the Sefwi Wiawso district, consisting 25 percent no shade, 37.5 low shade, 22.5 medium shade and 15 percent heavy shade. Although the data from the study area is not the same as of that of the UNDP, the study confirms that there is a shift in the cocoa landscape in the cocoa growing regions. The 25 percent with no shade will have to replace their cocoa trees within a short period of less than 20 years, since the no shade cocoa has a shorter life span.

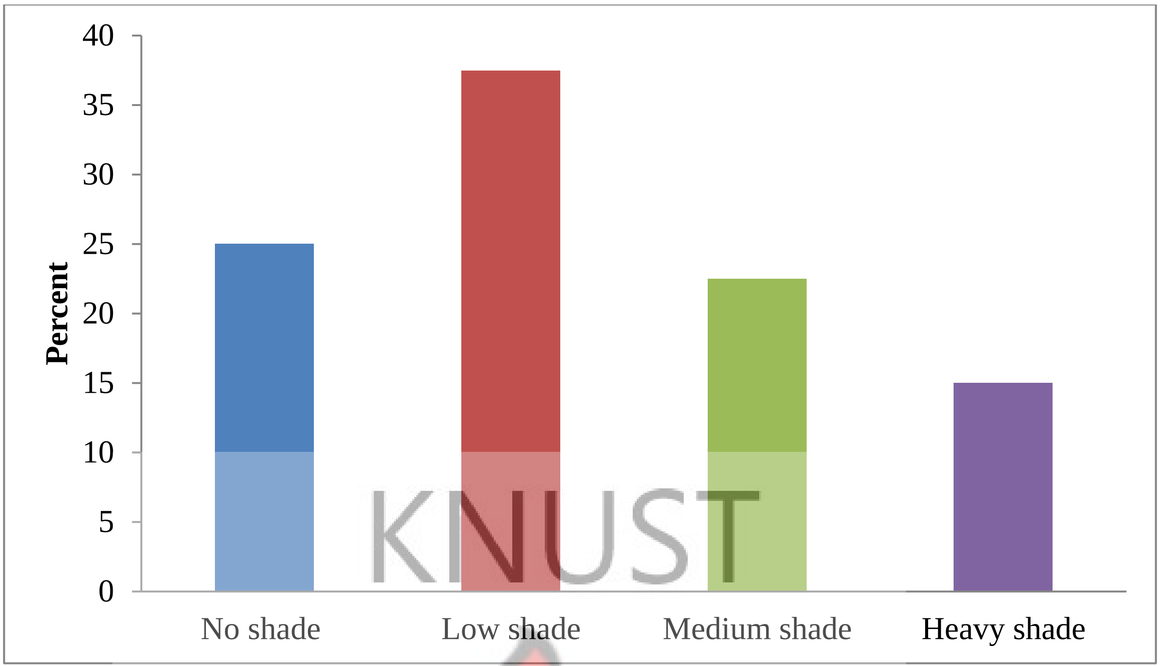

Figure 3: Cocoa Agroforestry Systems Adopted in the Study Area
Source: Field Survey, 2012

Shade tree densities, and average number of tree species per hectare was found by Sonwa et al., (2000) in a study to vary according to cultural tradition and ethnic group, age of farms, proximity to markets, and intensity of farming, this situation is similar to that of the study area after personal interaction with the cocoa farmers. Cocoa grown under no shade system tends to produce for a shorter amount of time than do shade cocoa. The yields under the low to no cocoa agroforestry system is high in the early years of the cocoa tree life but farmers have to incur more cost to manage the system as it in input demanding. Shaded cocoa may provide fewer economic benefits in the short-term but it will continue producing into the future without the need for much chemical inputs. Farmers cannot afford to apply fertilizer and other agro chemicals as recommended by CRIG. This confirms a study by Leiter and Harding (2004) indicating that in Ghana farmers cannot afford pesticides and rely on traditional insect control methods, such as weeding, pruning, and disposal of waste, which are associated with the production of higher quality cocoa.

The current trend of no shade is not only common in Ghana but other cocoa growing countries like Cote d'Ivoire, Malaysia, Indonesia and Ecuador. In Ecuador half of the new cocoa being planted is now of the full-sun and are from the high-yielding variety (Bentley et al. 2004). A study by Belsky and Siebert (2003) in Sulawesi revealed that cocoa farmers are switching from long-fallow shifting cultivation of food crops to intensive full-sun cocoa.

Table 4.2 shows that 77 percent of the cocoa farmers are planting hybrid/improved breed of cocoa. This seeks to address the low output per hectare which hybrid cocoa seeks to address. According to Asare (2005) hybrid cocoa varieties developed by the Cocoa Research Institute of Ghana (CRIG) have been adopted by approximately one-third of Ghanaian farmers who appreciate their high yielding nature. Also the hybrid cocoa varieties require less to no shade. It is of no surprise that there are high percentages of farmers practicing the no shade system of cocoa technology in the study area. It can be concluded that farmers have accepted the early and high yielding of the improved variety of cocoa that is why greater percentage has adopted it. Clay (2004) discussed that the use of high-yielding varieties in intensive production systems, and planting at high densities with or without intercrop species, may serve as a means of alleviating the pressure to clear primary forest in order to expand production.

4.3 Shade Trees on Cocoa Farms and Farmers Preferred Characteristics

About 12.5 percent still stick to the local breed while about 10.5 percent are combining the two breeds which is an indication of shift towards the adoption of improved variety.

Across all cocoa growing communities visited some patterns in the behaviour of the cocoa farmers were found. Although 62.5 percent of the farmers are in the low to no shade cocoa agroforestry system, farmers acknowledge the benefits of maintaining shade in production. Some benefits cocoa farmers attributed to shade on cocoa farms include maintaining soil moisture, improving soil fertility, and weed suppression. A study by Bentley et al., (2004) on cocoa farmers in Ecuador also indicated similar characteristics. However, the remaining 47.5 percent of cocoa farmers that keep shade trees intact were attributing ecological benefits to the trees and expressing concern over the risks associated with tree removal, such as dependency on chemical inputs. Farmers acknowledged that no shade cocoa agroforestry system is agriculturally unsustainable and is becoming common in the area. A study in Cote d'Ivoire by Ruf and Schroth (2004) indicated that migrant farmers tend to use less shade than indigenous farmers; in that study it was found out that the indigenous farmers uses an average of 37 shade trees per hectare, while migrants averaged 21 trees per hectare.

The use of shade trees on cocoa is an ancient practice, apparently dating back to the domestication of the crop according to the farmers interviewed. Most cocoa farmers (90 percent) interviewed sees the inter planting of shade tree on the cocoa farms as mimicking the natural sub canopy cover of traditional cocoa tree in the forest. Table 4.3 shows some of the shade trees that the farmers in the study area inter plant on their cocoa farms. Some of the trees identified on the farms are the same as those found by Asare (2005) on other cocoa farmers' field in the Ashanti and Western regions. Farmers selected those tree species based on their characteristics and importance. Some of the characteristics identified by the farmers are shade trees that have minimal competition with cocoa trees for nutrient, water, and light and also easy to establish, and have leaves that decay easily. A tree that does not favor alternative host for pest and disease is another quality that is looked out for by the cocoa farmers. With the high wind storms in the study area as asserted by the cocoa farmers' interviewed the trees they selected to be on their farms must have strong rooting system and minimal branch shedding so as to withstand the high wind storms.

The shade trees selected by the farmers need to provide products and additional income when sold. *Terminalia superb, Milicia excels, Terminalia ivorensis, Cedrella odorata, Ceiba pentandra* and *Ceiba pentandra* are the most dominant shade tree on their farms, with economic importance being the main intention for retaining those trees on the farm.

Table 4.3: Shade Tree on Cocoa Farms

Local Name	Scientific Name	Heavy shade	Medium shade	Low shade
Emeri	*Terminalia ivorensis*	13 (30.23)	16 (37.21)	14 (32.56)
Ofram	*Terminalia superba*	24 (22.22)	39 (36.11)	45 (41.67)
Odum	*Milicia excels*	10 (19.61)	15 (29.41)	26 (50.98)
Wawa	*Ricinodendron heudelotii*	1 (9.09)	2 (18.18)	8 (72.73)
Cedrella	*Cedrella odorata*	1 (7.14)	1 (7.14)	12 (85.71)
Pear	*Persea americana*	2 (28.57)	1 (14.29)	4 (57.14)
Onyina	*Ceiba pentandra*	4 (13.79)	14 (48.28)	11 (37.93)
Otie	*Pycnanthus angolense*	1 (25.00)	1 (25.00)	2 (50.00)
Edinam	*Entandrophragma angolenses*	2 (100.00)		
Danta	*Nesogordonian papaverifera*	1 (25.00)	2 (50.00)	1 (25.00)
Akonkodie	*Bombax buonopozense*		1 (25.00)	3 (75.00)
Nyame dua	*Alstonia boonei*		1 (33.33)	2 (66.67)
Kokonusua	*Spathodea campanulata*			1 (100.00)
Orange	*Citrus sinensis*			2 (100.00)

Note: Figures are in frequencies and those in parenthesis are percentages
Source: Field Survey, 2012

The cocoa farmers interviewed in the study areas know and use a wider range of tree species on their cocoa farms. These varying species are also used for wider range of purposes. Knowledge of the rich and diverse flora found on cocoa farms inherited from their elders appears to be fading among the young farmers who use fewer of the species found on their farms. It is important to note, however, that on the average knowledge of useful species in this communities is fading. For example, some of the younger farmers interviewed retain shade trees on an interest in the knowledge of their parents and grandparents. Although many farmers value the benefits of shade, native species are often gradually lost from cocoa agroforestry systems over time due to the regular clearing of undergrowth to access the cocoa trees. Shade trees species retained or planted on cocoa farms plays a positive role in biodiversity conservation as part of a mélange of managed landscapes. Also as being useful, species retained on cocoa farms are often of conservation importance in the study area. Food crops are also planted on young cocoa farms, and around the boarders of older farms. These food crops include cocoyam (*Colocasia esculenta*), plantains (*Musa paradisiaca*), cassava (*Manihot esculenta*), maize (Zea mays). Orange (*Citrus sinensis*), mango (*Mangifera indica*), pawpaw (*Carica papaya*), and avocado (*Persea americana*) are also some exotic fruit trees planted on cocoa farms.

4.4 Perception of Farmers on Cocoa Agroforestry Systems

Table 4.4 shows farmers' perception on cocoa agroforestry systems. Farmers have various levels of perception on certain characteristics of cocoa agroforestry systems. The results indicates that 47 percent of farmers strongly agree that cocoa with shade trees gives sustainable yield than no shade system whiles 36.5 percent agree on this perception although 10 percent of the farmers disagree with the perception that cocoa agroforestry system gives sustainable yield. Eighty eight percent of cocoa farmers interviewed perceive that shade trees on cocoa farms increases the level of humidity in and around the farm, therefore being a major contributing factor on the incidence of pest and disease outbreak on the cocoa farms

Table 4.4: Farmers Perception on Cocoa Agroforestry System

	No shade	Low shade	Medium shade	Heavy shade	Total
Cocoa agroforestry technologies give sustainable yield than no shade technology					
Disagree	8 (16)	6 (8)	3 (6.7)	3 (10)	20 (10)
Undecided	1 (2)	6 (8)	5 (11.1)	1 (3.3)	13 (6.5)
Agree	13 (26)	30 (40)	15 (33.3)	15 (50)	73 (36.5)
Strongly agree	28 (56)	33 (44)	22 (48.9)	11 (36.7)	94 (47)
Shade trees enhance soil fertility					
Disagree	5 (10)	3 (4)	2 (4.4)	1 (3.3)	11 (5.5)
Undecided	9 (18)	2 (2.7)	2 (4.4)	24 (80)	37 (18.5)
Agree	26 (52)	52 (69.7)	28 (62.2)		106 (53)
Strongly agree	10 (20)	18 (24)	13 (28.9)	5 (16.7)	4 (23)
Shade trees increases the humidity of the farm					
Disagree	2 (4)	4 (5.3)	2 (4.4)	2 (6.7)	10 (5)
Undecided	6 (12)	4 (5.3)	3 (6.7)	1 (3.3)	14 (7)
Agree	26 (52)	48 (64)	26 (57.8)	22 (73.3)	122 (61)
Strongly agree	16 (32)	19 (25.3)	14 (31.1)	5 (16.7)	54 (27)
Cocoa agroforestry reduces risk of farmers with respect to income stability					
Disagree	7 (14)	4 (5.3)	1 (2.2)	3 (10)	15 (7.5)
Undecided	20 (40)	31 (41.3)	14 (31.1)	17 (56.7)	82 (41)
Agree	20 (40)	35 (46.7)	26 (57.8)	9 (30)	90 (45)
Strongly agree	3 (6)	5 (6.7)	4 (8.9)	1 (3.3)	13 (6.5)
Shade trees provides sufficient fuel wood					
Strongly disagree	1 (2.1)	1 (1.3)	1 (2.2)		3 (1.5)
Disagree	1 (2.1)	2 (2.7)	1 (2.2)	1 (3.3)	5 (2.5)
Undecided	3 (6.2)	3 (4)	1 (2.2)	2 (6.7)	9 (4.5)
Agree	31 (64.6)	46 (61.3)	25 (55.6)	21 (70)	123(61.5)
Strongly agree	14 (29.2)	23 (30.7)	17 (37.8)	6 (20)	60 (30)
Cocoa agroforestry conserve natural resources and maintains ecosystem					
Disagree	3 (6)	4 (5.3)	2 (4.4)	2 (6.7)	11 (5.5)
Undecided	4 (8)	2 (2.7)	2 (4.4)		8 (4)
Agree	25 (50)	44 (58.7)	23 (51.1)	21 (70)	113(56.5)
Strongly agree	18 (36)	25 (33.3)	18 (40)	7 (23.3)	68 (34)
Cocoa under agroforestry technology has longer life span					
Disagree	3 (6)	3 (4)	1 (2.2)	2 (6.7)	9 (4.5)
Undecided	8 (16)	5 (6.7)	3 (6.7)	2 (6.7)	18 (9)
Agree	20 (40)	42 (56)	23 (51.1)	19 (63.3)	104 (52)
Strongly agree	19 (38)	25 (33.3)	18 (40)	7 (23.3)	69 (34.5)

Note: Figures are in frequency and those in parentheses are percentages

Source: Field Survey, 2012

The presence of shade tree on cocoa farms have been found to improve the fertility of the soil, and 53 percent of farmers interviewed agree that cocoa agroforestry systems improve the fertility of the soil as the litter falls decompose to enrich the soil On the other hand 5.5 percent of the respondent disagree with that perception. Since litter fall from shade trees decay to enrich the nutrient level of the soil there will be the need for less fertilizer requirement. This confirm the result of the study done by Leiter and Harding (2004) that farmers practising cocoa agroforestry systems use little to no chemical inputs, while intensive production systems of the no shade require these inputs.

Forty five percent of the cocoa farmers interviewed perceived that cocoa agroforestry reduces the risk on farms through income stability as the farmers' use the shade trees as insurance cover for unfavorable climatic condition and outbreak of disease and pest that may cause a reduction in yield. However 7.5 percent of the farmers did have different perception by not agreeing to the income stability created as a result of cocoa agroforestry systems. Fuel woods for household uses are accessed in the forest by most farmers interviewed. Most farmers (91.5 percent) perceived obtaining large percentage of their fuel wood for their household use from the shade trees on their cocoa farms. Cocoa famers in the study area are aware of the benefit cocoa agroforestry has in harboring higher level of biodiversity for both flora and fauna. The results indicate that 90.5 percent of the farmers perceived the system harbor high diversity of flora and fauna. Results indicated that 86.5 percent of the cocoa farmers consider cocoa agroforestry system as having longer lifespan and gradual yielding process as compared to the no shade system that has early yield with shorter lifespan.

Table 4.5: Challenges for not Adopting Cocoa Agroforestry Systems

	No shade	Low shade	Medium shade	Heavy shade	Total
Tree ownership right problems					
Very high	7 (14)	14 (18.7)	10 (22.2)	4 (13.3)	35 (17.5)
High	12 (24)	14 (18.7)	9 (20)	5 (16.7)	40 (20)
Very low	5 (10)	6 (8)	2 (4.4)	4 (13.3)	17 (8.5)
Low	14 (28)	4 (5.3)	2 (4.4)	2 (6.7)	22 (11)
None	12 (24)	37 (49.3)	22 (48.9)	15 (50)	86 (43)
Benefits of the technology not well communicated to farmers					
Very high	6 (12)	9 (12)	5 (11.1)	4 (13.3)	24 (12)
High	21 (42)	24 (32)	15 (33.3)	9 (30)	69 (34.5)
Very low	13 (26)	14 (18.7)	8 (17.8)	6 (20)	41 (20.5)
Low	8 (16)	25 (33.3)	16 (35.6)	9 (30)	58 (29)
None	2 (4)	3 (4)	1 (2.2)	2 (6.7)	8 (4)
Benefits of the technology not well communicated the community					
Very high	9 (18)	7 (9.3)	5 (11.1)	3 (10)	24 (12)
High	22 (44)	25 (33.3)	15 (33.3)	8 (26.7)	70 (35)
Very low	11 (22)	10 (13.3)	8 (17.8)	3 (10)	32 (16)
Low	5 (10)	28 (37.3)	16 (35.6)	14 (46.7)	63 (31)
None	3 (6)	5 (6.7)	1 (2.2)	2 (6.7)	11 (5.5)

Source: Field Survey, 2012

Note: Figures are in frequencies and those in parentheses are percentages

This affirm a finding by Ruf and Zadi (1998) that cocoa with less than optimum shade has a shorter life cycle and also under certain soil conditions and rainfall regimes shade cocoa may yield for 60-100 years whereas production may last for only 20 years without shade. Clay (2004) also discussed that high-yield varieties grown intensively without shade tend to produce for a much shorter time period, often only 6–8 years with yields declining after 15 to 20 years of planting.

4.5 Challenges for Not Adopting Cocoa Agroforestry Systems

Shade trees on cocoa farms have both economic and environmental benefit. Aside these benefits the trends from the study area show a decline in inter planting cocoa with shade trees. Respondents noted that benefits of shade tree had not been communicated to the farmers and the whole community, and this is a major constraint to planting shade trees on their cocoa farms. Table 4.5 showed that 43 percent of the respondents indicated that tree ownership right is not a challenge on the other hand 17.5 percent and 20 percent identified tree ownership problem to be very high and high respectively. Almost 47 percent of the farmers' interviewed stated that they agree to the benefits of shade tree on cocoa farm not well communicated to farmers and indigenes in the community. 5 percent of the farmers also did not acknowledge communication of shade tree benefit to the community as a challenge.

4.6 Cocoa Yield Curves under Cocoa Agroforestry Systems

The yield curve model for the study was adopted from a work carried out by Ryan et al., (2007). Ryan et al. (2007) and Makonda (2003) used this model for cocoa and gum arabic respectively. Under the various agroforestry systems, cocoa yield curve was fitted from a regression of the age of the cocoa farm on cocoa yield using yield data obtained from the fields' survey.

Table 4.6 shows the result from the regression in which the natural logarithm of cocoa yield per hectare was the dependent variable whiles the age of the cocoa being the independent variable. The R^2 value obtained under the no shade, low shade, medium shade and heavy shade were 77, 61, 53, 56 percent respectively. All the R squares under the various cocoa agroforestry systems were greater than 50 percent. The results indicate a significant relationship between the natural log of cocoa yield and age of cocoa farm. Among all the four agroforestry systems the no shade system had the highest R^2 value of 77 percent.

Table 4.6 Output from Regression of Age of Cocoa Farm on Cocoa Yield

	Coefficients	Standard Error	Z Statistics	P-value
No shade				
Intercept	-2.6720	1.0479	-2.5498	0.0191
Age of farm	-0.3198	0.0690	-4.6373	0.0002
LN Age	5.2176	0.7754	6.7289	0.0000
	R^2= 0.77	F= 34.34		
Low shade				
Intercept	1.8722	0.6877	2.7224	0.0116
Age of farm	-0.1022	0.0223	-4.5861	0.0001
LN Age	2.2411	0.3850	5.8211	0.0000
	R^2 = 0.61	F=19.36		
Medium Shade				
Intercept	3.8458	0.5655	6.8005	0.0000
Age of farm	-0.0784	0.0259	-3.0203	0.0074
LN Age	1.4428	0.3715	3.8839	0.0011
	R^2= 0.53	F = 10.19		
Heavy shade				
Intercept	-0.0002	1.8960	-0.0001	0.9999
Age of farm	-0.2600	0.0689	-3.7720	0.0027
LN Age	3.7676	1.1225	3.3565	0.0057
	R^2 = 0.56	F= 7.49		

Source: Field Survey, 2012

Figure 4 shows a combination of the yield patterns in the cocoa agroforestry systems in Ghana. The highest yield per hectare and age of highest yield of the no shade, low shade, medium shade and heavy shade were 794kg/Ha in year 16, 696kg/Ha in year 22, 735kg/Ha in year 19 and 546kg/Ha in year 15 respectively. The no shade cocoa agroforestry system had the highest yield level among all the cocoa agroforestry systems.

According to PAN (2001) hybrid cocoa will tend to peak earlier and at a higher level than traditional varieties and a cocoa plantation tends to be less productive over its lifetime with insufficient shade trees. The yield pattern under the no shade system shows a sharp rise in the yield and followed by a sharp fall in the yield till the end of the rotation period. This situation is not so in the other cocoa agroforestry systems as the medium shade has a gradual yield till it peaks followed by a gradual fall in yield. This confirms a study by Ruf and Zadi (1998) and Clay (2004) that cocoa with less than optimum shade has a shorter life cycle and with yields declining by 15 to 20 years after planting. Cocoa under agroforestry system has been reported to continue producing for 80–100 years (Bentley et al. 2004). A study by Obiri et al., (2007) adapting the model for the traditional Ghanaian system with insufficient shade gave a peak yield of 800 kg ha^{-1} in year 24 whiles that of the hybrid cocoa without planted shade gave a yield peak of 1,200 kg ha^{-1} in year.

The equation for estimating the yield of cocoa during the fifty-years production cycle under the no shade, low shade, medium shade and heavy shade cocoa agroforestry systems are as follows:

$$Y = \exp(-2.6720 - 0.166A + 5.2176\ln(A))$$

$$Y = \exp(1.8722 - 0.1022A + 2.2411\ln(A))$$

$$Y = \exp(3.8458 - 0.0784A + 1.4428\ln(A))$$

$$Y = \exp(-0.0002 - 0.2600A + 3.7676\ln(A))$$

Where Y is cocoa yield per hectare and A is age of the cocoa farm in years

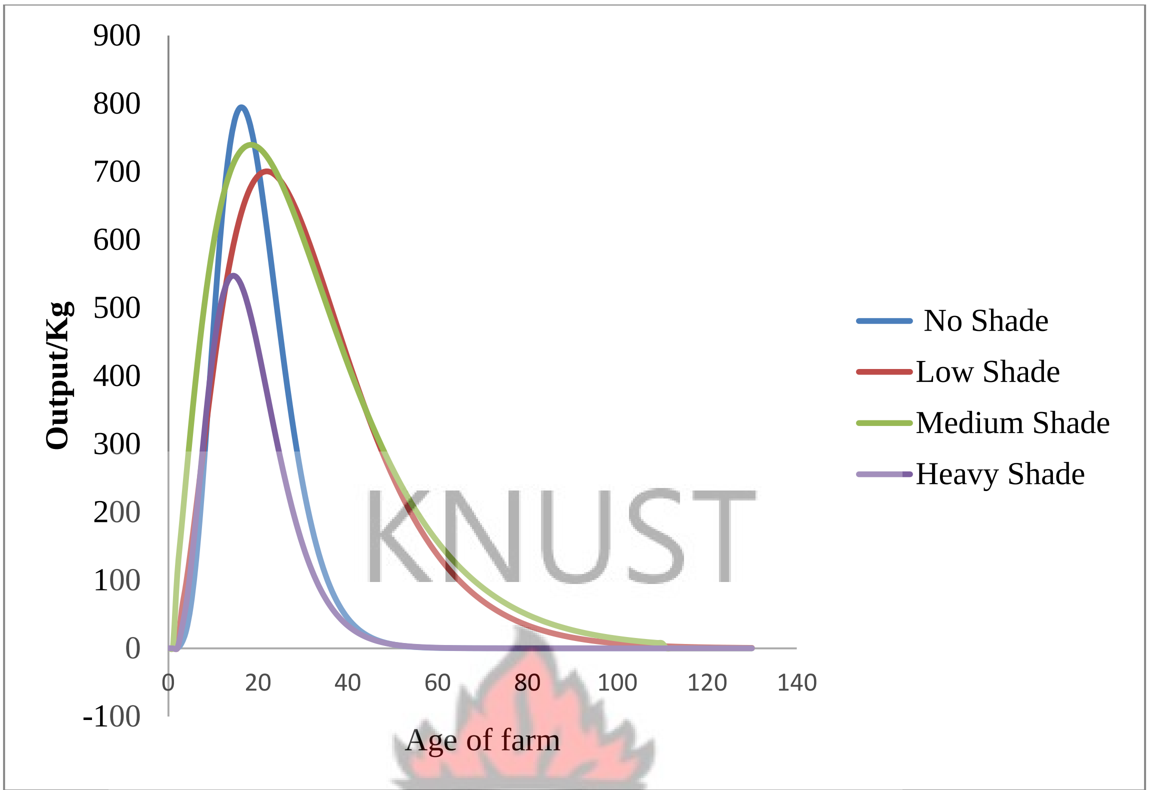

Figure 4: Cocoa Yield Pattern in Different Cocoa Agroforesty Systems in Ghana

4.7 Cash Flow Analysis

Table 4.7 shows a summary of the cash flow analysis for the no shade, low shade, medium shade and heavy shade cocoa agroforestry systems. There is high investment cost at the early stages of production. Although there are varying cocoa agroforestry systems in the study area the investment cost are the same since the land is cleared and tree felled under all the system followed by the planting of food crops. A study by Nkang et al., (2007) indicated that there are high establishment costs associated with cocoa production which are then followed by annual benefits that are non-linear over the life of the cocoa trees. The highest cost factor at the early years of production is from the land clearing and management cost as well as the cost of the planting materials for the food crops. The benefit components included income from food crops (maize, cassava, plantain, yam and cocoyam), cocoa beans and timber species.

The no shade cocoa agroforestry system had GH₵10836.67 from the food crops and it is the highest among all the cocoa agroforestry systems. This is explained by to the long period during which the food crops remain on the cocoa farm (over four years) whiles that of the medium shade, low shade and heavy shade allows food crops for only four years. For the low shade, medium shade and heavy shade, shade tree after the canopy is formed, after four years outgrowing the cocoa as was indicated by the farmers interviewed. The cocoa generate a stream of costs and benefits over a given time period after the fourth year of planting.

The low shade cocoa agroforestry system had the highest cost GH₵16723.98 for processing cocoa; this is followed by the medium shade, no shade and heavy shade with cost of GH₵15055.96, GH₵12183.03 and GH₵9404 respectively. Although the low shade had the highest cost of cocoa production, the cost was directly proportional to the revenue from the cocoa. For the cost of purchasing agrochemicals the medium shade farmers spends GH₵ 6960. 97 which makes them the highest for the agrochemicals, followed by the low shade, no shade and heavy shade.

The cost component from the low shade system on the use of agrochemical is consistent with the results of the study by Leiter and Harding (2004) who indicated that cocoa farmers using such production techniques will be dependent on chemical inputs but not always able to afford them.This poses a threat to the livelihood of the farmers adopting this system of cocoa production.

Table 4.7 Summary Cash Flow for Cocoa Agroforestry Systems/Ha over 50 years

	No Shade	Low shade	Medium shade	Heavy shade
Gross Returns (GH₵)				
Food crops(Plantain, Yam, Cocoyam, Maize, Cassava)	10836.67	10046.67	10046.67	10046.67
Cocoa	46170.00	73191.06	70091.01	33394.83
Timber	0.00	1525.02	3294.44	7184.56
Total returns	57006.67	84762.74	83432.11	50626.06
Cost				
Planting materials				
Food crops (Plantain, Yam, Cocoyam, Cassava, Maize)	947.08	907.08	972.08	897.08
Cocoa seedlings	275.00	225.00	200.00	220.00
Tree seedlings	0.00	50.83	50.83	90.83
Labour				
Land preparation and maintenance	740.00	780.00	740.00	790.00
Food crops (Planting, harvesting & haulage	3040.00	3010.00	2990.00	3055.00
Cocoa production(planting, pest and disease control, weeding, harvesting, processing)	12183.03	16723.98	15055.96	9404.42
Tree planting	0.00	40.00	40.00	40.00
Other cost				
Land sale	812.50	812.50	812.50	812.50
Farm tools	489.93	616.14	537.26	310.75
Agro chemicals (Fertilizer, fungicide, pesticide & weedicide)	3417.51	6001.10	6960.73	3357.45
Total expenses	21905.05	29246.63	28459.37	18978.04
Net Cash Flow	35101.62	55516.11	54972.74	31648.02

Source: Field Survey, 2012

1$= GH₵2

Table 4.8: Monetary Value of Shade Trees

Tree species	Average size at 50 years (m^3) (A)	Government stumpage rate/m^3 (B)	Total stumpage price (GHC) (A x B)
Emire- *Terminalia ivorensis*	$12m^3$	10.68	128.16
Ofram- *Terminalia superb*	$12m^3$	5.95	71
Odum-*Milicia excelsa*	$20m^3$	25.16	503.2
Onyina-*Ceiba pentandra*	$5m^3$	4.78	119.5

Source: FSD (2004)

4.8 Discounted Cash Flow

The viability indicators estimated were BCR, NPV and IRR. The discounted cash flow results presented in Table 4.9 shows that cocoa production is in general, viable at a 20 percent discount rate. However, the medium shade cocoa agroforestry system is the most viable among the other cocoa agroforestry systems with BCR of 1.36, NPV of GHC 3264.08 and IRR of 47.23 percent. The no shade is the least with profitable BCR of 1.17, NPV of 1540.58 and IRR of 33.18 percent, although it has higher yield in the early years of production.

The sharp fall in the yield of the no shade system gives it lower revenue over the long production period. Although the revenue from the no and low shade cocoa agroforestry system is higher than that of the heavy shade, the revenue from timber in the heavy shade cocoa agroforestry system makes it more profitable than the no and low shade cocoa agroforestry systems.

Table 4.9: Discounted Cash Flow for the Different Cocoa Agroforestry Systems

Viability Indicators	No shade	Low shade	Medium shade	Heavy shade
BCR	1.17	1.21	1.36	1.25
NPV(GH₵)	1540.58	1868.2	3259.71	2083.90
IRR (%)	33.18	38.72	47.90	41.77

The IRR results from Table 4.9 showed that cocoa agroforestry will not be viable for the no shade, low shade, medium shade and heavy shade only if the rate of borrowing money for such project exceeds 33.18 percent, 38.72 percent, 47.90 percent and 40.97 percent respectively. A study by Obiri et al., (2007) showed that the introduction of hybrid cocoa greatly enhances profitability. The researcher further stated that shaded hybrid cocoa is also much more profitable than the traditional unshaded system due to the earlier and higher yield peak. Duguma et al. (2001) also reported that, even with no value assigned to the tree species, cocoa production in smallholder systems in Cameroon are profitable, with production being more profitable with planted shade trees.

4.9 Sensitivity Analysis

Table 4.10 shows the cost and output parameters that were varied to observe the sensitive nature of the viability indicators. First, the farm gate price of GH₵ 3.20 per kilogram of cocoa is increased by 12.5 percent to GH₵ 4 per kilogram and is also reduced by 12.5 percent from GH₵ 3.20 to GH₵ 2.80 to determine how the viability indicators will vary as a result of change in the cocoa prices. Under this condition all the cocoa agroforestry systems were still profitable although it was quite sensitive to this variation in cocoa prices. For the rise in the cocoa price by 12.5 percent, the IRR values raised proportionately across all the cocoa agroforestry systems by between 1 and 2 percent.

The medium shade cocoa agroforestry system had the highest NPV of GH₵3843.63 and BCR of 1.42 followed by the heavy shade, low shade and the no shade in that order. A fall in the cocoa price by 12.5 percent saw a fall in the IRR by 1 to 2 percent. The government through it support to boost cocoa production subsidises the cost of fertilizer to the cocoa farmers.

The viability of the various cocoa agroforestry systems were determined by varying the cost of fertilizer. A 25 percent increase and reduction in the cost of fertilizer did have little change in the viability parameters. This is as a result of the low use of fertilizer by the cocoa farmers. From the data gathered it was found that 74.5 percent of the respondents did not use fertilizer and for the 25.5 percent of cocoa farmers who used fertilizer on their cocoa farms applied 2 bags /Ha.

Again sensitivity to changes in timber prices for the timber tree under the low shade, medium shade and heavy shade cocoa agroforestry systems was determined by increasing timber tree value by 50 percent as it is assumed cocoa farmer managing the shade trees will prefer higher value for resources spent in managing the trees.

Table 4.10: Sensitivity on the Viability of Cocoa Agroforestry Systems

Economic indicators	No Shade	Low Shade	Medium Shade	Heavy Shade
Increase in cocoa price by 12.2%				
BCR	1.2	1.25	1.42	1.27
NPV	1787.06	2236.25	3843.63	2291.2
IRR	34.22	40.46	49.57	42.4
Fall in cocoa prices by 12.2%				
BCR	1.14	1.17	1.29	1.2
NPV	1258.39	1506	2693.72	1646
IRR	31.85	36.77	44.65	39.39
Increase in fertilizer price by 25%				
BCR	1.17	1.2	1.35	1.23
NPV	1504.12	1812.23	3197.06	1936.4
IRR	32.94	38.41	46.83	40.83
Fall in fertilizer price by 25%				
BCR	1.18	1.22	1.37	1.24
NPV	1574.28	1919.03	3331.09	1996.24
IRR	33.42	39.02	47.62	41.11
Increase in tree stumpage value by 50%				
BCR		1.21	1.36	1.23
NPV		1867.3	3259.71	1966.73
IRR		38.71	47.9	40.97
Fall in cocoa yield by 20%				
BCR	1.12	1.14	1.25	1.18
NPV	1074.51	1269.98	2317.71	1555.56
IRR	30.86	35.3	43.51	39.22
Increase in cocoa yield by 20%				
BCR	1.23	1.28	1.45	1.32
NPV	2006.65	2466.43	4201.72	2611.94
IRR	35.1	41.5	51.54	43.93

Source: Field Survey, 2012

The rise in the shade tree value did not result in any change in the IRR; this is due the long period required to in realise the timber revenue in the cash flow.

The yield of cocoa is influenced by external factors like the rains, sunlight as well as soil nutrients. It is assumed that the yield of the cocoa can increase when conditions are favourable. On the other hand yield could also fall due to unfavourable conditions like disease and pest out breaks as well as natural disasters. Yield of the cocoa is assumed to increase by 20 percent and also fall by 20 percent. From Table 4.10 cocoa yields under all the different cocoa agroforestry system were viable since it gave positive Net Present Values and Internal Rate of Return greater than the rate of borrowing money.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study analyzed the viability of cocoa agroforestry systems in the Sefwi Wiawso District, Ghana. The study was motivated by the gradual shift of cocoa farmers from shaded cocoa system to the no shade system which is not environmentally sustainable and putting the long term livelihood of cocoa farmers in doubt. There was therefore the need to provide empirical analysis on the various cocoa agroforestry systems in Ghana so as to promote the one that is environmentally sustainable and most profitable. The findings of this study looked at the demographic characteristics of the farmers, perception of cocoa agroforestry systems, yield trends under the different cocoa agroforestry systems, compare the viability indicators like the NPV, BCR and IRR of the No shade, Low shade, Medium shade and Heavy shade cocoa agroforestry systems in Ghana. Results indicated that both women and men play a role in the production cycle of cocoa although it is primarily viewed as men's crop. About 85 percent of the respondents were males indicated that cocoa production is a male dominated occupation. More than 91.5 percent of the respondents were not educated beyond the primary school level, out of which 60.5 percent are not formally educated at all. Cocoa landscape in the study area, consisted 25 percent no shade, 37.5 low shade, 22.5 medium shade and 15 percent heavy shade. The yield pattern under the no shade system shows a sharp rise in the yield and followed by a sharp fall in the yield till the end of the rotation period. The highest yield per hectare and age of highest yield of the no shade, low shade, medium shade and heavy shade were 794kg/Ha in year 16, 696kg/Ha in year 22, 735kg/Ha in year 19 and 546kg/Ha in year 15 respectively. Results from the analysis showed that all the cocoa agroforestry systems were viable at 20 percent interest rate since it all gave positive NPV, BCR greater than one and IRR greater than the interest rate of borrowing money. Results across the various cocoa agroforestry systems show that medium shade had the highest IRR of 47.90 percent followed by Heavy shade, Low shade and No shade with IRR of 41.77 percent, 38.72 percent and 33.28 percent respectively. Variation in some parameters such as the cost of fertilizer, price of cocoa as well as the cocoa yield to determine how sensitive these variables are to the viability indicators of the cocoa agroforestry showed that the systems were still viable. Among all the cocoa agroforestry systems the medium shade is the most viable and therefore has to be promoted for adoption since production under such system provide sustainable yield over a long period.

5.2 Recommendations

First, outreach programs focusing on medium shade cocoa agroforestry system would be the most effective way of optimizing ecological, economic, and social outcomes as it maintains at least 10-15 trees/Ha. Medium shade cocoa agroforestry systems need to be encouraged and farmers need to be educated on the ecosystem services provided by this shade cocoa system. Shaded cocoa inter-cropped with timber and food crops is likely to provide greater net income and less risky than cocoa produced as a monocrop.

Secondly, the government or other agencies should create economic incentives in order to prevent further loss of shade cover on cocoa farms so as to improve the income and livelihoods of small cocoa farmers. Example is that premium prices for ‘‘high quality’’ cocoa grown under shade could help to promote shade production.

Finally, policies aims at promoting tree ownership rights among cocoa farmers should be formulated and enforced.

5.3 Limitations of the Study

A number of difficulties were encountered during this study. Most of the cocoa farmers did not keep records and therefore relied heavily on their memories and so could not give specific answers to specific questions. This led in some cases to cocoa farmers giving inconsistent responses. Void answers to questions asked could have had adverse effect on the analysis thus a lot of time was taken to explain questions before answers were recorded to minimize inaccuracies.

Secondly, some of the farmers were reluctant to respond to the questions or disclose all their cocoa and other food crop yields and income as they were suspicious of the researcher's motives for fear of taxation.

The limitations to the study where reduced as much possible, as the researcher exercised the greatest amount of care in conducting the study. For example, the researcher recruited and trained three assistants to administer the structured questionnaires so that problems such as ambiguity, misinterpretation or misunderstanding of questions associated with conduction of interview surveys could be reasonably ironed out.

The researcher and his team administered the interview schedules during the off-farming period and in the evenings during which period most of the respondents were at home.

5.4. Suggestions for Future Research

Although the cocoa agroforestry systems are profitable, a number of issues still require further investigation in order to gain a fuller understanding and benefits of cocoa agroforestry systems in Ghana. Itemized below are some areas requiring research attention:

1. Investigate the land and tree rights and its impact on trees retention on cocoa farms.

2. Assess and quantify non-financial benefit such as carbon pricing under the different cocoa agroforestry systems.

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Appendix I

Farm Household Questionnaire

1. General Information

Information	Responses
1.1 Name of enumerator	
1.2 Questionnaire Number	
1.3 Date (dd/mm/yy)	
1.4 Name of Region	
1.5 Name of District	
1.6 Name of Village	
1.7 Name of Farmer	
1.8 Mobile phone number	

2. Personal and Household Characteristics

A) Personal characteristics

	Questions	Response
2.1	Gender 1-Male 2-Female	
2.2	Age (Years)	
2.3	Residential status 1-Indigene(Native) 2-Settler (Permanent) 3-Migrant (Temporal)	
2.4	Ethnic background (Tribe) 1= Akan 2= Ga- Adangbe 3= Ewe 4= Dagomba5= Gonja 6=Frafra 7= Grushie 8= Other(specify)	
2.5	Religion: 1. Christian 2. Muslim 3.Traditional 4. Others (specify)	
2.6	Highest level of formal education 1=None 2=Basic(Primary/JHS/Middle) 3=Secondary/Vocational 4= Tertiary(Training collage/Polytechnic/University)	
2.7	Marital status 1= Single 2=Married	
2.8	Is the respondent the head of the household? 1=Yes 2=No	
2.9	Counting yourself what is the size of your household?	
2.10	Number of children below15 years	
2.11	Is cocoa your main economic activity? 1= Yes 2=No	
2.12	What is your secondary economic activity? 1= None 2= Labourer 3= Food processing 4= Livestock rearing 5= Bee keeping 6= Trading 7= Artisan 8=Salaried worker 9= Remittances 10= other (specify)	
2.13	How much do you earn from your secondary economic activity?	
2.14	For how many years have you been in cocoa farming	
2.15	How many visits did you receive from extension services within the 2011 season?	

2.16	How many visits did you make on your own, searching for information from extension services within the 2011 production season?	
2.17	Apart from Extension Agents where do you get your technical advice from? 1. Researchers 2. From media (TV, radio, newspapers) 3. other farmers /friends 4. other (specify)	
2.18	Are you a member of cocoa farmers' association? 1=Yes 2=No	
2.19	Have you received assistance from any farmer-based organization in the 2011 production season? 1-Yes, 2-No	
(i)	If yes, what form of assistance? 1. Cash 2. Fertilizer 3. Knapsack sprayers 4. Cutlass 5. Agro chemicals 6. Other (specify)	
2.20	Have you received any credit during the 2011 production season? 1.Yes 2.No	
(i)	If yes, what form of credit? 1. Cash 2. Input 3. Both Cash and Input 4. Other (specify)	
(ii)	If yes, Total credit in cash?	
(iii)	If no, why? 0= N/A 1=No facility 3=Did not look for credit 4=No collateral 5=High interest rate 6= Fear of not being able to pay back 7=Other (specify)	

B) Household characteristics

(i) Domestic Assets

Type of Assets	Does the HH have this asset? (1= Yes; 2= No)	Number of asset owned by HH
Drying mat		
Fermentation container		
machetes		
Sickle		
Axe		
Cutlass		
Hoe		
Basket		
knapsack		
Wellington boot		
Protective clothes		

(ii) Livestock Assets

	Chicken	Goat	Cattle	Sheep	Guinea fowl	Pig	Rabbits
Do you have the following animals? 1. Yes 2. No							
How many did you have at the beginning of 2011?							
How many did you have at the end of 2011?							
Unit cost of livestock (Gh₵)							
Did any veterinary officer attend to your animals in 2011? 1-Yes,2-No							

3. Plot-level characteristics

	Questions	Response
3.1	What is the size of your plot (acres)?	
3.2	What is the distance of your plot from home (miles)?	
3.3	What is the means of transportation to your plot? 1-On foot, 2-bicycle, 3-motor bike, 4-car	
3.4	Are you an owner-cultivator? 1-Yes 2-No	
(i)	If no, what tenancy contract exist between you and your landowner? 1-share cropping, 2-fixed-rent, 3-others (specify)	
(ii)	If sharecropping, what is the arrangement?1-Abunu 2-Abusa 3- Others (specify)	
(iii)	If sharecropping, what is the duration of tenancy?	
(iv)	If share-cropping, how are input costs shared? (tenants-owner) 1. 50%-50% 2. 70%-30% 3. 30%-70% 4.100%-0% 5. 0%-100%	
(v)	If fixed-rent, what is the amount of money paid per acre (Gh₵)?	
(vi)	If fixed-rent, what is the duration of the tenancy?	
3.5	What was the previous use of land? 1. Fallow 2. Cropped	
(i)	If fallow land, what form of fallow? 1. Primary forest 2. Secondary forest	
(ii)	If fallow, how many years has the land been under fallow?	
(iii)	If cropped, how many years has the land been cropped?	
(iv)	If cropped, what main crop was being grown on the land?	
3.6	How did you prepare your land for cultivation? 1- Slash and burn 2-Set fire in the bush 3-Zero burning 4-others (specify)	

3.7	What is the type of soil on your plot? 1. Sandy 2. Clayey 3. Loam 4. Sandy loam 5. Clay loam 6. other (specify)	
3.8	What is the nature of slope on your farm? 1. Steep slop 2. Gentle slope 3. Flat 4. Other (specify)	

4. Cocoa Agroforestry

A) Adoption of Agroforestry Technology

1. Have you adopted any cocoa agroforestry technology? 1. Yes 2. No

(i) If yes, which of these cocoa agroforestry technologies have you adopted?

	Type of cocoa agroforestry technology	No. of years of adoption	No. of shade trees per acre	Reason for adoption
1	Low shade			
2	Medium shade			
3	Heavy shade			
4	Other (specify)			

(ii) If no, complete the table

		No. of years of practice	Reasons for non-adoption
1	No shade		

B) Tree species planted

(i) Did you plant the shade trees yourself? 1. Yes 2. No

(ii) If yes, what is the source of the tree species? 1. COCOBOD 2. Forestry Commission

3. NGO 4.Timber company 5. Other (specify)

(iii) If No, specify how it came about? 1. Natural growth 2. Planted by another person

(iv) Have you attended any course in tree planting and management? 1= Yes 2= No

(v) Tree species planted

Local name	Scientific name	Uses (to the farmer)

C) What qualities would you look out for from agroforestry shade trees?

Shade trees qualities for cocoa agroforestry	Yes	No
Minimal competition with crops for nutrients ,water and light		
Ease of establishment and rapid regeneration of leaves		
Provision of open shade		
Does not favour alternative host for pest and crop diseases		
Provision of alternative tree products and additional income		
Minimal branch shedding		
High litter production		
Other(specify)		

D) Perceptions of farmers on cocoa agroforestry technologies

1. What is your perception about the following below relating to cocoa agroforestry?

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
(a)Cocoa agroforestry technologies give sustainable yield than no shade cocoa technology	[ ]	[ ]	[ ]	[ ]	[ ]
(b)Cocoa agroforestry help farmers to grow more crops on the same land	[ ]	[ ]	[ ]	[ ]	[ ]
(c)Shade trees in cocoa increase the nutrient content of the soil	[ ]	[ ]	[ ]	[ ]	[ ]
(d)Shade trees enhance soil fertility	[ ]	[ ]	[ ]	[ ]	[ ]
(e)Cocoa under agroforestry technology requires less Fertilizer	[ ]	[ ]	[ ]	[ ]	[ ]
(f)Shade trees increases the humidity of the farm	[ ]	[ ]	[ ]	[ ]	[ ]
(g)Cocoa agroforestry reduces risk of farmers with respect to income stability	[ ]	[ ]	[ ]	[ ]	[ ]
(h)Cocoa agroforestry technologies will help increase income of farmers	[ ]	[ ]	[ ]	[ ]	[ ]
(i)Cocoa agroforestry technologies reduce the cost of farm management	[ ]	[ ]	[ ]	[ ]	[ ]
(j)Shade tree increases nutritional quality of farmers through the consumption of wild meat and fruit	[ ]	[ ]	[ ]	[ ]	[ ]

(k)Shade tree provides sufficient wood for cooking	[ ]	[ ]	[ ]	[ ]	[ ]
(l)Cocoa agroforestry harbours higher levels of biodiversity (Animals)	[ ]	[ ]	[ ]	[ ]	[ ]
(m)Agroforestry system conserves natural resources and maintains ecosystem	[ ]	[ ]	[ ]	[ ]	[ ]
(n)Shade tree on cocoa promote traditional knowledge on use of medicinal plants	[ ]	[ ]	[ ]	[ ]	[ ]
(o)Shade trees in cocoa agroforestry are reduced to increase cocoa yield	[ ]	[ ]	[ ]	[ ]	[ ]
(p)Cocoa under agroforestry technology has longer life span	[ ]	[ ]	[ ]	[ ]	[ ]
(q)Cocoa under agroforestry technology have lower incidence of pest than no shade cocoa technology	[ ]	[ ]	[ ]	[ ]	[ ]
(r)Pests and diseases are biologically controlled under the cocoa agroforestry system	[ ]	[ ]	[ ]	[ ]	[ ]

SECTION E: Constraints to adoption of cocoa agroforestry technologies

1. Please tick the constraints to adoption of cocoa agroforestry technologies

	Constraint	Very high	high	Very low	low	None
	Local customary practices					
(i)	Incidence of bushfires					
(ii)	Grazing by livestock during the dry season					
	National Policy					
(iii)	Absence of perennial private right over land					
(iv)	Tree ownership right problems					
	Training					
(v)	Lack of training on management of agroforestry trees					
(vi)	Difficult in managing the shade tree by cocoa farmers					
	Seed and Germplasm					
(vii)	Inadequate access to quality seeds and seedlings					
(viii)	Quality seeds and seedlings can only be purchased at few vantage points.					
(ix)	Seedling sellers are not closed to farmers' vicinity.					
(x)	Seedlings are not affordable.					
	Poor information dissemination about the technology					

(xi)	Benefits of the technology to farmers are not well communicated.					
(xii)	Benefits of the technology to community are not well Communicated.					
	Human Resource capacity					
(xiii)	High labour demand for tree pruning					
(xiv)	Lack of agricultural extension agent(AEA)					
(xv)	High labour requirement in establishment of shade tree nursery					
(xvi)	High labour requirement in the maintenance of the shade tree nursery					

2. List the challenges you have encountered in the adoption of cocoa agroforestry

   Technology.
   ………………………………………………………………………………………………
   …………

…………………………………………………………………………………………………

3. What Suggestions can you make to help solve the challenge(s) you have identified above?

5. Cocoa Production in 2011 season

A) Cultivation

(i) What cocoa varieties have you cultivated on your plot? 1. Local variety 2. Hybrid 3. Both local and hybrid 4. Other (specify)

(ii) What percentage-cultivated cocoa is of hybrid variety in relation to local variety? 1. fifty percent 2. seventy percent 3. thirty percent 4. Other (specify)

(iii) Where did you obtain your cocoa seedlings from? 1. Own farm 2. COCOBOD 3. Open market 4. Other (specify)

(iv) What arrangement has your cocoa seedlings been planted on your farm? 1. Row 2. Scattered 3. Other (specify)

(v) Average productive life of the cocoa : ……………………………………………

B) Labour Input for 2011 production

(i) Family labour input per acre

	Males		Females	
	No. used	No. of days	No. used	No. of days
1st weeding/pruning				
2nd weeding/pruning				

Fertilizer Application				
Insecticides Application				
Fungicides Application				
Plucking of cocoa beans from the trees				
Husk removal				
Transportation of cocoa beans from the farm				
Others (Specify)				

(ii) Hired labour input per acre

	Males			Females		
	No. of persons	No. of days	Cost (Gh₵)	No. of persons	No. of days	Cost (Gh₵)
1st weeding/pruning						
2nd weeding/pruning						
Fertilizer Application						
Insecticides Application						
Fungicides Application						
Plucking of cocoa beans from the trees						
Husk removal						
Transportation of cocoa beans from the farm						
Others (Specify)						

C) Inputs for 2011 production

(ii) Input cost per acre

Inputs	Frequency (year)	Quantity	Units	Unit cost
Weedicide				
Fertilizer				
Fungicide				
Insecticide				
Cutlass				
Hoe				
Chisel				
Other (specify)				

D) Output from cocoa production

(i)How many bags of cocoa did you harvest in the 2011 season?

Cocoa season(s)	Total output from farm (65kg bag)	Output per acre (65kg bag)	Price per bag (GH₵)

Major			
Minor			

(ii) Which producer buying company do you normally sell your cocoa to? ....

6.2 REVENUE:

	Year 1			Year 2			Year 3		
	Output	**Unit cost**	**Total**	**Output**	**Unit cost**	**Total**	**Output**	**Unit cost**	**Total**
Maize									
Plantain									
Cassava									
Cocoyam									
Yam									

Appendix II

Cost and Benefits for No Shade Cocoa Agroforestry System

Year	1st-4th		5th- 15th		16th-35th		35-40th	
Expenses/Ha/Yr	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**
Land	816.25	5.30						
cutlass	9.47	8.88	6.70	1.34	9.33	3.00	10.43	2.56
Chisel (digging planting holes)	17.25	0.35						
Hoe	6.83	7.71	5.60	0.55	10.50	0.71	18.54	3.80
Sickle (Soso)	4.00	1.41	6.57	1.27	9.14	3.39	23.43	8.44
Maize seeds	23.17	0.24						
Plantain suckers	308.33	11.79						
Cassava sticks	21.88	10.31						
Cocoyam cormlets	221.25	182.0						
Yam suckers	110.42	14.73						
Cocoa seedlings	222.50	3.54						
Cost of weedicide	16.85	6.33	15.47	18.9	4.26	6.82	54.43	3.55
Cost of fertilizer	33.00	1.00	100.0	3.50	180.40	9.87	35.82	12.74
Cost of fungicide	31.80	38.78	23.61	34.5	88.33	65.3	23.56	7.45
Cost of Insecticide	28.49	31.61	16.33	18.5	91.58	146	67.75	3.98
Labour for land preparation(clearing)	186.67	9.43						
Labour for land preparation(burning)	116.67	4.71						
Labour for land preparation(stumping)	183.17	0.24						
Labour for land preparation(tree felling)	247.50	3.54						
Labour plant maize	156.67	9.43						
Labour plant cassava	95.00	11.79						
Labour plant cocoyam	125.83	53.03						
Labour dig holes & plant plantain	150.83	88.39						
Labour dig holes & plant cocoa	238.33	4.71						
Labour peg, dig holes	42.50	3.54						

& plant indigenous trees								
Labour for weeding 1	138.67	49.78	55.03	30.8	45.98	33.3	44.18	25.5
Labour for weeding 2	153.33	57.17	62.80	39.6	57.19	38.6	54.13	32.5
Labour for weeding 3	115.00	66.79	18.93	16.3	14.02	23.9	20.79	36.1
Labour for removing epiphytes (nkranpan)	15.50	0.71	18.25	1.39	19.00	0.00	23.5	12.6
Labour harvesting maize	155.00	7.07						
Labour hauling maize	123.33	4.71						
Labour harvesting plantain	204.44	46.32						
Labour harvesting cassava	160.56	75.39						
Labour harvesting cocoyam	180.56	81.81						
Labour harvesting yam	130.00	18.86						
Labour for fertilizer application	26.59	19.10	24.07	15.6	16.26	15.2	8.76	4.54
Labour for insecticide application	40.16	16.15	37.83	64.3	18.79	10.5	19.64	14.1
Labour for fungicide application	43.49	16.61	19.09	8.99	21.85	22.5	17.38	11.9
Labour harvesting cocoa	43.25	24.75	24.21	11.2	42.64	52.6	20.16	15.6
Labour for processing (cracking, fermenting & drying cocoa beans)	52.70	38.32	37.80	23.1	35.76	23.2	19.92	18.0
Labour for cocoa transportation (from farm to home and cocoa shed)	29.92	14.68	25.23	11.9	24.10	16.7	13.49	4.81

Cost and Benefits of Low Shade Cocoa Agroforestry System

	1st-4th Year		5th-15th Year		16th-35th Year		35-40th Year	
Return(GHC)/ Ha	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**
Maize	747.51	872.36						
Cocoyam	1345.8	943.79						
Cassava	389.16	338.43						
Plantain	2247.2	1018.4						
Yam	858.33	601.04						
Cocoa	232.77	85.16	1251.0	439.0	1240.8	634.	644.87	86.2
Expenses (GHC)/ Ha								
Land	856.25	61.87						
Machete/Cutlass	12.12	9.73	9.62	3.33	18.72	8.28	15.70	2.09
Chisel (digging planting holes)	9.37	10.87	12.33	2.56				
Hoe	11.76	9.47	8.55	4.47	14.06	9.19	17.92	10.5
Sickle(Soso)	1.52	2.12	9.22	3.34	17.44	7.71	18.78	4.30
Maize seeds	23.67	0.47						
Plantain suckers	308.33	11.78						
Cassava sticks	21.87	10.31						
Cocoyam cormlets	221.25	182.08						
Yam suckers	110.41	14.73						
Cocoa seedlings	227.57	3.53						
Cost of weedicide	76.45	3.45	93.72	26.98	73.21	19.9	64.70	2.98
Cost of fertilizer	124.56	32.74	129.22	3.34	210.53	8.02	31.43	1.41
Cost of fungicide	85,15	2.12	92.22	3.34	80.84	2.22	86.32	2.44
Cost of Insecticide	59.2	1.32	9.22	3.34	20.53	8.02	73.54	5.65
Tree seedlings	55.41	6.48						
Labour for land preparation(clearing)	196.66	4.71						
Labour for land preparation(burning)	116.67	7.41						
Labour for land preparation(stumping	176.66	9.42						

Labour for land preparation(tree felling)	245.60	7.07						
Labour plant maize	144.16	27.10						
Labour plant cassava	95.76	11.78						
Labour plant cocoyam	125.83	53.03						
Labour dig holes & plant plantain	150.83	88.38						
Labour dig holes & plant cocoa	235.73	8.25						
Labour peg, dig holes & plant indigenous trees	50.33	14.14						
Labour for weeding 1	134.89	57.51	60.70	37.74	67.72	31.3	41.25	5.30
Labour for weeding 2	146.67	71.26	61.08	26.95	87.90	47.3	65.98	21.2
Labour for weeding 3	114.27	68.23	18.46	13.83	12.37	21.9		
Labour for removing epiphytes (nkranpan)	10	7.07	38.25	1.38	49.65	0.34	54.43	7.07
Labour harvesting maize	155.65	9.73						
Labour hauling maize	123.33	4.71						
Labour harvesting plantain	204.44	46.31						
Labour harvesting cassava	160.56	75.39						
Labour harvesting cocoyam	180.56	81.80						
Labour harvesting yam	130.26	18.85						
Labour for fertilizer application	47.22	4.91	163.72	11.92	106.14	9.74	85.33	6.78
Labour for insecticide application	79.58	13.55	76.61	10.35	12.52	44.6	54.17	19.0

Labour for fungicide application	67.80	5.65	62.14	10.50	65.69	14.7	71.87	1.23
Labour harvesting cocoa	61.38	16.10	87.46	13.71	36.84	27.3	68.33	2.35
Labour for processing (cracking, fermenting & drying cocoa beans)	27.54	10.65	56.84	21.67	20.56	31.1	63.33	4.7
Labour for cocoa transportation (from farm to home and cocoa shed)	26.875	9.72	35.48	21.13	28.14	27.1	8.33	11.7

Cost and Benefits of Medium Shade Cocoa Agroforestry System

	1st-4th Year		5th-15th Year		16th-35th Year		35-40th Year	
Return(GHC)/ Ha	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**
Maize	1130	183.8						
Cocoyam	1345.83	43.79						
Cassava	389.167	38.44						
Plantain	2247.22	18.43						
Yam	858.33	61.04						
Cocoa	159.04	15.19	1367.27	51.1	1045.4	75.1	538.93	68.5
Expenses (GHC)/ Ha								
Land	806.25	8.83						
Machete/Cutlass	15.125	8.08	16.89	3.68	22.44	5.38	16.34	2.63
Chisel (digging planting holes)	17.25	0.35						
Hoe	10.67	10.84	5.33	6.11	17.21	2.64		
Sickle(Soso)	7.43	1.41	7.12	4.16	17.25	2.22	16	22.6
Maize seeds	26.62	4.71						
Plantain suckers	308.33	11.78						
Cassava sticks	21.87	10.31						
Cocoyam cormlets	221.25	82.08						
Yam suckers	115.42	7.66						
Cocoa seedlings	212.50	17.67						
Cost of weedicide	18.98	1.44	58.02	37.8	26.90	5.02	34.56	7.67
Cost of fertilizer	35.34	0.70	68.89	3.68	22.44	5.38	38.50	9.19
Cost of fungicide	42.13	1.41	88.90	3.68	23.37	4.92	46.32	19.7
Cost of Insecticide	55.32	0.70	6.88	3.68	22.44	5.38	16.34	22.6

Tree seedlings	50.44	0.58						
Labour for land preparation(clearing)	196.66	4.71						
Labour for land preparation(burning)	116.67	4.71						
Labour for land preparation(stumping	181.67	2.36						
Labour for land preparation(tree felling)	235.00	21.21						
Labour plant maize	156.67	9.42						
Labour plant cassava	95	11.78						
Labour plant cocoyam	125.83	53.03						
Labour dig holes & plant plantain	150.83	88.38						
Labour dig holes & plant cocoa	190.83	71.88						
Labour peg, dig holes & plant indigenous trees	45.00	7.07						
Labour for weeding 1	150.19	28.76	76.99	43.7	42.37	24.8	45.62	6.18
Labour for weeding 2	159.02	45.58	50.76	26.3	44.72	26.0	43.9	5.59
Labour for weeding 3	51.42	6.79	12.5	25				
Labour for removing epiphytes (nkranpan)	26.5	2.12	18.56	1.54	29.33	1.08	23.45	5.34
Labour harvesting maize	155.00	7.07						
Labour hauling maize	123.33	4.71						
Labour harvesting plantain	204.44	46.31						
Labour harvesting cassava	160.56	75.39						
Labour harvesting cocoyam	180.56	81.80						
Labour harvesting yam	130	18.85						
Labour for fertilizer application	78.23	1.65	73.30	22.1	78.14	12.6	25.73	8.85
Labour for insecticide application	14.07	2.72	30.16	20.7	51.99	5.30	49.05	0.17
Labour for fungicide application	42.18	3.97	26.97	2.48	72.28	21.7	40.16	17.7
Labour harvesting cocoa	26.90	4.37	39.00	22.8	38.06	22.0	26.99	8.68
Labour for processing (cracking, fermenting	17.90	5.78	67.85	86.1	7.58	20.5	30.94	5.32

& drying cocoa beans)								
Labour for cocoa transportation (from farm to home and cocoa shed)	19.41	7.90	32.64	19.8	8.82	19.7	23.68	1.34

Cost and Benefits of Heavy Shade Cocoa Agroforestry System

Year	1st-4th		5th-15th		16th-35th		35-40th	
Return(GHC)/ Ha	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**
Maize	820	61.2						
Cocoyam	1345.83	93.7						
Cassava	389.17	38.4						
Plantain	2247.22	118.4						
Yam	858.33	601.0						
Cocoa	118.39	65.31	118.8	337.3	561.2	48.3	279.90	80.2
Expenses (GHC)/ Ha								
Land	781.25	44.19						
Machete/Cutlass	19.16	1.67	8.75	2.21	16.66	1.52	12.56	3.45
Chisel (digging planting holes)	18.75	1.76						
Hoe	19.17	1.17	9.45	1.82	17.50	0.70		
Sickle(Soso)			8.6	2.07	17.5	0.70		
Maize seeds	24.16	1.17						
Plantain suckers	308.33	11.78						
Cassava sticks	21.87	10.31						
Cocoyam cormlets	221.25	182.08						
Yam suckers	125.41	6.48						
Cocoa seedlings	212.5	17.67						
Cost of weedicide	27.75	29.88	55.41	25.3	38.43	12.5	44.32	2.64
Cost of fertilizer	55.70	1.87	68.75	4.34	53.45	2.34	53.23	6.43
Cost of fungicide	36.28	3.63	69.67	3.80	35.34	7.07	32.22	2.35
Cost of Insecticide	47.32	3.46	19.09	3.87	32.5	3.53	25.35	6.87
Tree seedlings	55.42	6.48						
Labour for land preparation(clearing)	196.67	4.71						
Labour for land preparation(burning)	116.66	4.40						
Labour for land preparation(stumping	191.66	11.78						
Labour for land preparation(tree felling)	225.00	35.35						
Labour plant maize	156.68	9.42						

Labour plant cassava	95.23	11.78						
Labour plant cocoyam	125.83	53.03						
Labour dig holes & plant plantain	150.84	88.38						
Labour dig holes & plant cocoa	235.83	8.24						
Labour peg, dig holes & plant indigenous trees	45.00	7.07						
Labour for weeding 1	158.75	24.80	43.57	26.54	40.73	36.2	16.25	5.30
Labour for weeding 2	177.08	24.43	27.44	43.51	24.37	5.72	34.54	3.54
Labour for weeding 3	141.64	34.74						
Labour for removing epiphytes (nkranpan)	11.5	9.19	28.09	1.54	39.76	3.98	23.54	3.54
Labour harvesting maize	170.00	14.14						
Labour hauling maize	123.33	4.71						
Labour harvesting plantain	204.44	46.31						
Labour harvesting cassava	160.56	75.39						
Labour harvesting cocoyam	180.56	81.80						
Labour harvesting yam	86.67	76.23						
Labour for fertilizer application	27.52	3.53	42.82	17.9	34.22	4.33	33.67	4.88
Labour for insecticide application	19.68	13.64	60.71	7.38	64.34	2.54	21.64	6.89
Labour for fungicide application	50.69	45.41	29.24	3.79	24.43	9.54	33.24	2.87
Labour harvesting cocoa	24.55	18.01	39.98	31.3	54.33	3.43	23.54	3.52
Labour for processing (cracking, fermenting & drying cocoa beans)	27.68	25.83	45.41	23.8	33.12	2.65	18.43	7.84
Labour for cocoa transportation (from farm to home and cocoa shed)	32.32	16.78	26.95	23.0	19.43	3.43	23.64	9.87

Appendix III

Planting material cost and quantity of food crops for 1st -4th Year

Components	Maize seeds/Ha	Plantain suckers/Ha	Cocoyam Corm/Ha)	Cassava stick/Ha	Yam (tuber)/Ha
No shade Year 1	27	126	140	33	104
Low shade Year 1	30	120	85	30	165
Medium shade Year 1	12	124	123	42	145
Heavy shade Year 1	10	130	180	45	150

Appendix IV

Output for the 1st -4th year under the different cocoa agroforestry system

No shade					
Year 1	10	143	18	13	333
Year 2		373	25	7	226
Year 3		134	8	3	86
Year 4		76	5	2	45
Low shade					
Year 1	9	210	15	8	347
Year 2		300	18	12	240
Year 3		120	11	6	80
Year 4		90	3	5	65
Medium					
shade	12	267	23	12	230
Year 1		154	18	8	190
Year 2		80	10	6	86
Year 3		50	4	6	45
Year 4					
Heavy					
shade	10	330	18	13	210
Year 1		243	24	10	347
Year 2		120	12	8	86
Year 3		80	9	8	60
Year 4					

Appendix V

Revenue from tree component

Timber values of shade trees			
Tree species	**Average size at 50 years (m^3)**	**Government stumpage rate/m^3**	**Total stumpage price**
Emire- ***Terminalia ivorensis***	$12m^3$	10.68	128.16
Ofram- ***Terminalia superb***	$12m^3$	5.95	71
Odum-*Milicia excelsa*	$20m^3$	25.16	503.2
Onyinah-*Ceiba pentandra*	$5m^3$	4.78	119.5

Agroforestry system	**Tree species**	**Average No. of trees/HA**	**Total tree value**
Low shade	Ofram	2	142.8
	Odum	2	1006.4
	Emire	2	256.32
	Onyinah	1	119.5
Medium shade	Ofram	3	357
	Odum	4	3012.8
	Emire	3	357
	Onyinah	4	512
Heavy shade	Ofram	12	856.8
	Odum	9	4528.8
	Emire	7	856.8
	Onyinah	6	768.96