University of Ghana http://ugspace.ug.edu.gh

ECONOMICS OF COCOA-AGROFOREST IN THE GWIRA BANSO JOINT FOREST MANAGEMENT PROJECT IN WESTERN REGION OF GHANA

UNIVERSITY OF GHANA LIBRARY

BY

KWESI BADU MENSAH

A THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ECONOMY AND FARM MANAGEMENT, UNIVERSITY OF GHANA. IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE MASTER OF PHILOSOPHY DEGREE IN AGRICULTURAL ECONOMY AND FARM MANAGEMENT

INTEGRI PROCEDAMUS

DEPARTMENT OF AGRICULTURAL ECONOMY AND FARM MANAGEMENT

FACULTY OF AGRICULTURE

UNIVERSITY OF GHANA, LEGON

June 2001

University of Ghana http://ugspace.ug.edu.gh

UNIVERSITY OF GHANA
★ LIBRARY ★

G 369109
SB 268.G3 M52

INTEGRI PROCEDAMUS

Theses Room

University of Ghana http://ugspace.ug.edu.gh

DECLARATION

I DO HEREBY DECLARE THAT EXCEPT FOR REFERENCES TO OTHER PEOPLE, WHICH HAVE BEEN DULY CITED, THE WORK PRESENTED IN THIS THESIS IS RESULT OF MY OWN RESEARCH. THIS WORK HAS NEVER BEEN PRESENTED EITHER IN WHOLE OR IN PART FOR ANY DEGREE OF THE UNIVERSITY OR ELSEWHERE

....
KWESI BADU MENSAH

....
DR. (MRS) RAMATU AL-HASSAN

(MAJOR SUPERVISOR)

....
KWAKU OWUSU BAAH

(CO-SUPERVISOR)

University of Ghana http://ugspace.ug.edu.gh

DEDICATION

TO MY SON, PAPA KOJO MENSAH

University of Ghana http://ugspace.ug.edu.gh

ACKNOWLEDGEMENT

Honor be to God for this work

I am most grateful to my supervisors, Dr. (Mrs.) Ramatu Al-Hassan and Kweku Owusu Baah, whose constructive criticisms, direction and invaluable suggestions have resulted in the completion of this work.

I thank Messers Edward Prah and Nicolas K. Ntiamoah, Project managers of Joint Forest Management (JFM) and Cooperative Agency for Relief Everywhere (CARE) International for providing me with transport during the survey. The staff of JFM and CARE, Mr. Owusu of Tabakrom, Chief of Jompere, DR. Anim Kwapong of Cocoa Research Institute of Ghana (CRIG), Mr. Ken Brew of Ghana Cocoa Board and Kweku Badu Mensah of Forest Products Inspection Division (FPID) need special mention for their assistance during the data collection.

I owe a lot to my mother Agnes Fynn, brothers and sisters especially Fiifi Mensah of Graphic Corporation for their encouragement, financial support and reassurance whenever all seemed lost.

I also wish to extend my profound gratitude to Maibel Azu (my wife) for her support, patience, love and understanding, which urged me on to get this far.

To my colleagues and lecturers of both the Economics and Agricultural Economics Departments and all who contributed morally and materially towards the realisation of this work, I SAY THANK YOU AND MAY GOD BLESS YOU.

University of Ghana http://ugspace.ug.edu.gh

ABSTRACT

Introduction of cocoa-agroforest in the Gwira Banso forest concession necessitates the following research questions: what evidence is there on the viability (profitability) of the proposed cocoa-agroforest practice? What are the short-term and long-term cash flow implications and how suitable are they to the farmers who are dependent on the forestland for their livelihood? How can farmers' knowledge on industrial use of timber trees, prices of timber trees, production and sale of timbers, be enhanced?

This study was carried out in the Gwira Banso Joint Forest Management Project (JFM) in Western Region of Ghana, with the objective of examining the prospect of developing cocoa agroforestry systems in the light of a growing problem of deforestation and efforts to curb it. Thus the study sought to identify industrial uses of timber trees planted by farmer and the market opportunities available and prepares financial cash flows for the cocoa monocropping, cocoa agroforest and a diversified system of productive activities. In the case of cocoa-agroforest and diversified system, the analysis was carried out for with and without incentives to farmer from the project. An optimal diversified mix of production activities that provide the highest returns to farmer is also determined.

Forty heads of household participating in the intervention introduced by JFM project were selected at random for obtaining information used to address the above objectives. Information obtained includes quantity of inputs used, unit prices of inputs, yields, as well as unit prices of output. This information was supplemented with field data on crop yield and trends of yield of cocoa and kola from Cocoa Research Institute of Ghana (CRIG) and black pepper from Plant Genetic and Resources Centre (PGRC). Information on prices of timber trees and their uses were obtained from Timber Export Development Division (TEDD) and Forest Products Inspection Division (FPID). Investment analysis and linear programming were the analytical tools used. Local market prices were used whiles constant 1999 prices were also used for the price projections. Given the uncertainty about the true discount rates, prices of inputs and outputs, and yields, sensitivity analysis was done to determine the effects of various rates of increases in cost of production and declining revenue on the farming systems.

University of Ghana http://ugspace.ug.edu.gh

The results of the study indicate that while major differences exist in the cash flows of diversified system and the other farming systems, the cash flow difference between cocoa monocropping and cocoa agroforest are negligible. Even though all the farming systems were profitable, the diversified system is superior to cocoa monocropping and cocoa-agroforests in terms of profitability and viability. Cocoa-agroforest is also more profitable and viable than cocoa monocropping.

In addition to being less sensitive to different rates of declining prices or outputs and revenue, the diversified system is more robust to the combined effect of increasing costs and declining revenue than cocoa-agroforest and cocoa monocropping. The optimal solution to the LP model, which is the maximum NPV attainable from combining kola, cocoa, black pepper and timber, taking into consideration farmers' constraints, is ¢56,498,960. The study recommends a more aggressive use of agroforestry as a tool for rural development and poverty alleviation as well as environmental conservation.

University of Ghana http://ugspace.ug.edu.gh

TABLE OF CONTENTS

University of Ghana http://ugspace.ug.edu.gh

University of Ghana http://ugspace.ug.edu.gh

LIST OF TABLES

University of Ghana http://ugspace.ug.edu.gh

University of Ghana http://ugspace.ug.edu.gh

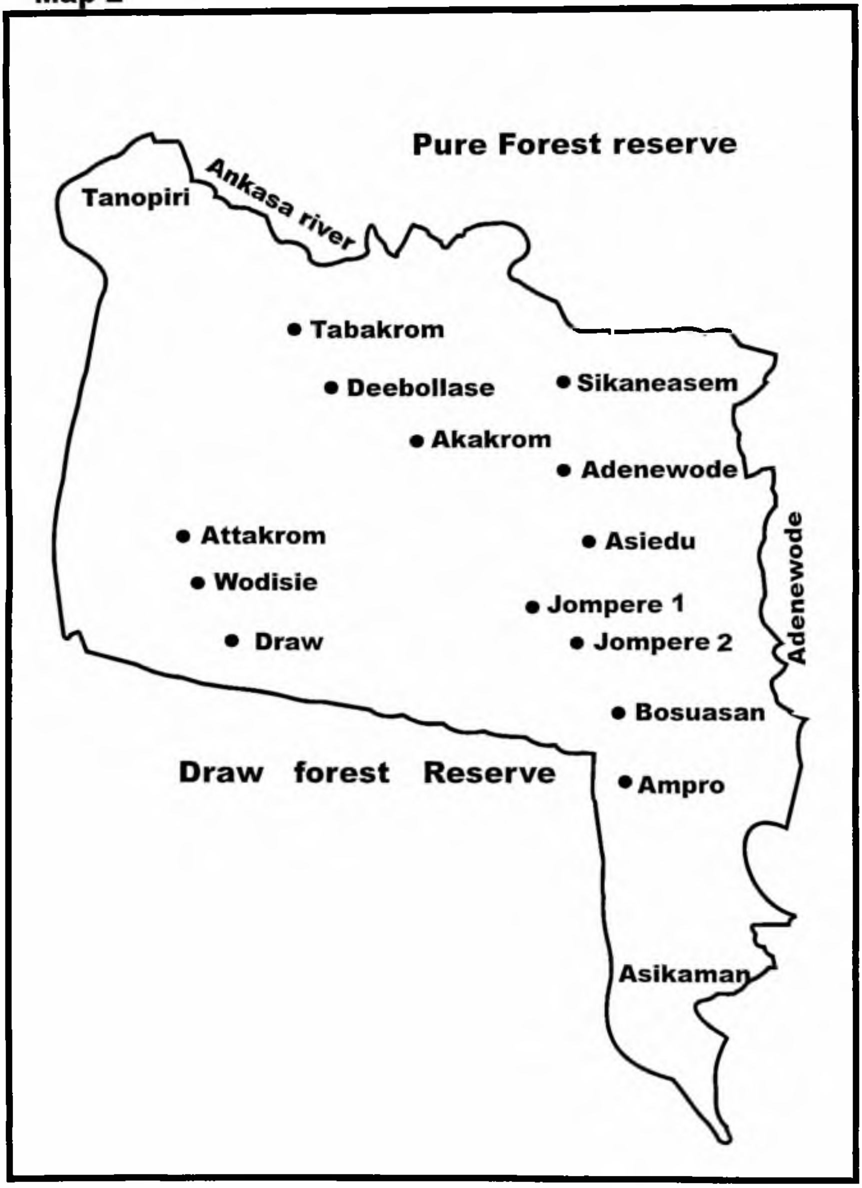
LIST OF ACRONYMS

NTFP:	Non-Timber Forest Product
GAP:	Ghana Primewood Limited
DLH:	Dalhoff Larsen & Hornemann
JFM:	Joint Forest Management
CARE:	Cooperative Agency for Relief Everywhere
NGO:	Non-Governmental Organisation
NPV:	Net Present Value
IRR:	Internal Rate of Return
B/C	Benefit-Cost Ratio
CRIG:	Cocoa Research Institute of Ghana
COCOBOD:	Ghana Cocoa Board
PGRC:	Plant Genetic and Resources Centre
FPIB:	Forest Products Inspection Bureau
TEDB:	Timber Export Development Board
MLF:	Ministry of Lands and Forestry
FAO:	Food and Agriculture Organisation
LP:	Linear Programming
ICRAF:	International Council for Research in Agroforestry
GEAP:	Ghana Environmental Action Plan
PAM:	Policy Analysis Matrices
TRM:	Timber Resources Management
LINDO:	Linear Interactive Optimzer

University of Ghana http://ugspace.ug.edu.gh

Settlements in the Gwira Banso Concession

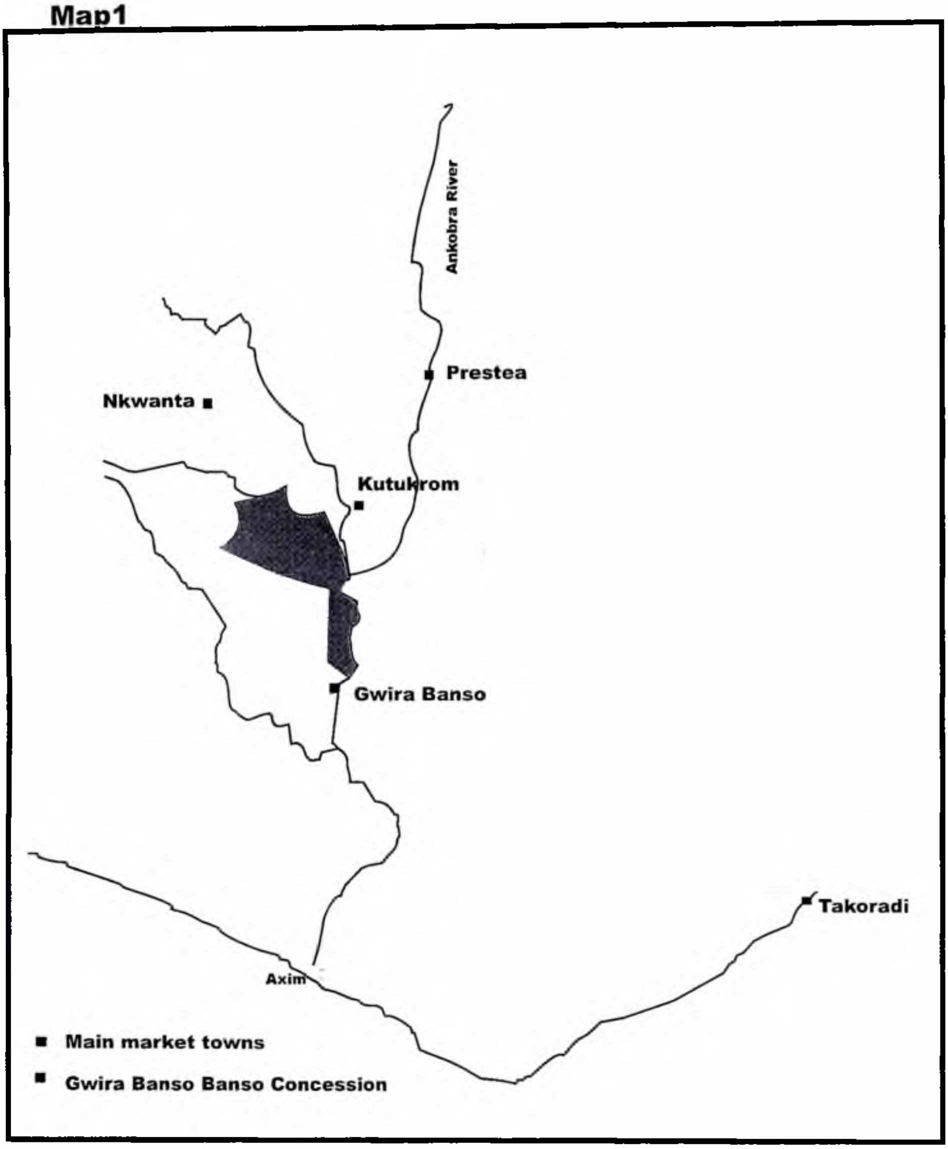
Map 2



University of Ghana http://ugspace.ug.edu.gh

The Gwira Banso Concession

Map1



University of Ghana http://ugspace.ug.edu.gh

UNIVERSITY OF GHANA LIBRARY

CHAPTER ONE

INTRODUCTION

1.1 Background

Gwira Banso forests concession (one of the last forests off- reserve) is located within the Tarkwa forest district, but falls under East Nzema District Assembly in Western Region of Ghana. It belongs to the Gwira Banso stool and covers about 16,600 hectares. The concession lies between the Draw river forest reserve (to the south) and the Fure river forest reserve (to the north), between the longitudes 2 ° 17′ and 2 ° 23′ and latitudes 5 ° 22′ north approximately. The external boundaries are marked by distinct natural features such as the Ankobrah River on the south-east and the Ankasa river on the east to the Northwest.

The area falls exclusively within the wet-evergreen forest zone. It is also characterised by high rainfall and a rainy season with peaks in May-June and September-October. Annual rainfall is in excess of 1750 mm and may exceed 2000 mm occasionally. The area also experiences very short dry season. Temperature variation is slight with a mean monthly maximum of 31-33 ° C and minimum of 19-21 ° C. The soils in the area are mainly forest oxisols, which are highly leached, yellowish, brown-loamy or black-brown clayey, very acidic and poor in nutrients. The pH values range between 3.8 to 4.3 (Hawthorne and Musah 1993)

The estimated population of about 600 household and 4000 people is scattered throughout the area (CARE 1998). The people in the area consist of different ethnic groups with different linguistic, cultural and economic characters (Amanor, 1997; Appiah and Pedersen, 1998).

Farmers practise shifting cultivation and this may explain the presence of pockets of farms throughout the area. Farmers, who have acquired customary rights within the area to use the lands for the cocoa cultivation, pay rent to the stool annually. Another land tenure arrangement is the

University of Ghana http://ugspace.ug.edu.gh

Abusa, which involves the payment of one-third of net proceeds from the harvested crop to the stool annually.

Cocoa production is the main source of income to the farmers. Other economic activities include weaving of cane baskets, collection of chewing sticks and collection of fruits and other non-timber forest products (NTFP). Some sources of off-farm income to the farmers are processing of cassava into gari, extraction of palm and palm kernel oil and hunting of bush meat. Other alternative income generating activities introduced to farmers, with help from the concessionaire include, the cultivation of shade-tolerant crops like kola and Black pepper (Prah 1998). There are also experimental fishponds, snail rearing, bee-keeping and mushroom growing (Prah 1998, 1999).

Settlement in the Gwira Banso forest concession has occurred over the last thirty years, but intensified in the 1990s, as new lands have become scarce in other areas and migration of cocoa farmers have increased in the Western Region. The area is one of the last forest frontier areas. The pattern of land use in the Gwira Banso forest shows a high percentage of 46 % of degraded forest (Table 1). Apart from the high rate of deforestation, the area is poorly served by infrastructure and farmers experience difficulty in marketing their produce. Road transport is scarce and the dominant forms of transportation are by foot and canoe along the Ankobra River.

University of Ghana http://ugspace.ug.edu.gh

Table 1.1 **Estimated Land Use Distribution In The Gwira Banso Joint Forest Management Project Area**

Land use	Area ha.	% of total
Farmland and villages	2000	12
Degraded forest	7600	46
Closed canopy forest	7000	42
Total	16,000	100

(Source: proposal for joint forest management, Ghana 1995)

It is estimated that, with the exception of forest species like ceiba (*ceiba pentandra*), ofram (*Terminlia superba*), kyenkyen (*Antiaris africana*), otie (*Pycnanthus angoiensis*), emire (*Terminlia ivprensi*) and perhaps dahoma (*Piptadeniastrum africanum*), all the major commercial species available at present will become economically extinct outside reserves within 20 years (JFM Gwira Banso, 1996). Continued deforestation will negatively affect, not only the climatic and environmental conditions for cocoa production, but also the economic life of the area as a whole. This has been the experience in the old cocoa growing areas of Eastern Region.

Many farmers in the concession are experiencing difficulty in cultivating cocoa and over the last thirty years many have abandoned their cocoa farms. Yields of cocoa farms are generally low and trees often die out after a few years. Fewer shade trees are being preserved than in the past. Seventeen percent of farmers do not preserve any trees in their cocoa plantations. Current farming practices and cocoa production are not sustainable in the face of increasing deforestation.

Meanwhile, with the exception of Western Region, which shows an increasing trend in annual cocoa production, the other five cocoa producing regions in Ghana are showing declining

University of Ghana http://ugspace.ug.edu.gh

levels of cocoa production (Amoah 1997). This has been attributed to the fact that the Western region has virgin forest that has initial response to cocoa production, whiles in the other regions, aging cocoa farms, diseases coupled with changes in environmental and climatic conditions contribute to declining cocoa production. With about 51% of cocoa production coming from Western Region, while traditional growing areas show a declining trend, it is not likely that the Western region alone can sustain the national production without enhancing the environmental sustainability of its production base. Increase in cocoa production will continue to come from the region through expansion in area under cultivation.

Evidence that cocoa monocroping has had a major impact on deforestation is being suppressed, since it undermines the interest of the state, cocoa commodity research institute and donor funding for the cocoa industry (Amanor 1994). While major research efforts focus on replanting of cocoa hybrids, the long term security of the cocoa sector remains uncertain, given the global over production and the replacement of cocoa by other natural and synthetic substitutes in the confectionery and beverage industry.

The state therefore runs the danger of sacrificing the forest sector that provides her with her third largest foreign exchange earner in favour of the cocoa sector whose future remains uncertain through its failure to develop a critical and radical appraisal of existing agricultural systems, and through its failure to draw upon and appraise the potentials of the diversity within environments and the farming systems of the people.

1.1.1 Intercropping Timber Trees in Cocoa Farms

Two possible strategies could be used to address the joint problem of declining cocoa production in the other regions of the country and the increasing deforestation in the western region,

University of Ghana http://ugspace.ug.edu.gh

particularly in Gwira Banso. These are rehabilitation of old cocoa farms and/or intercroping timber trees and fruit trees in cocoa so as to maintain the ecological conditions necessary for continued growing of cocoa

As a result of aging cocoa farms, rehabilitation of old cocoa plantations has emerged as a central policy objective for Ghana's cocoa industry (Amanor 1994). However, rehabilitation of cocoa farms is a complex problem because considerable outlays of capital are involved. Moreover, environmental conditions of the old cocoa growing areas have also changed. The wet moist forests in which cocoa thrives in its early years no longer exist. Declining soil fertility, moisture and the build-up of pests and weeds, are problems in the agro-ecosystem in the old cocoa areas (Amanor cip op). Also, the comparative advantage of Ghana as a cocoa producer used to lie in the relatively low cost of production in new 'frontier' areas.

The difficulty associated with the cocoa rehabilitation programs demands that researchers adopt strategies to arrest deforestation and increase agricultural production through the promotion of diversified farming systems which allow a healthy balance between cocoa and timber production, as well as production or harvest of other forest resources. Thus, it is to arrest the increasing trend of deforestation and ensure sustainable agriculture, that cocoa-agroforestry, a practice in which cocoa is intercropped with forest species, as opposed to shifting cultivation, is being proposed. Proponents of cocoa-agroforestry claim that it will ensure the creation of sustainable cocoa production that mimics the original forest system, lead to production diversification, mitigate global warming and minimise damage to fragile soils (Dumanski et al 1998; Ruf and Zadi 1998). Moreover, selective clearing by hand which retains indigenous fruit trees, medicinal plants and valuable timber species will contribute to increased and continuous cash flows and decrease risk of diseases and pests due to shading. Also, no-tillage ensures soil cover and reduced erosion.

University of Ghana http://ugspace.ug.edu.gh

One place that is earmarked for such intervention is the Gwira Banso forest concession. The area has been given to Ghana Primewood Limited (GAP), a Ghanaian timber firm and Dalhoff Larsen & Hornemann A/S (DLH), a Danish owned timber trade firm in Denmark to extract timber.

1.1.2 The Joint Forest Management Project in Gwira Banso

Ghana Primewood Limited (GAP) and Dalhoff Larsen & Hornemann (DLH) A/S are private companies interested in the commercial utilisation of timbers within the project area. However, this interest is threatened by the fact that cocoa production is low and farming activities lead to deforestation. It is for these reasons that in 1996, the Joint Forest Management (JFM) project was initiated. The project seeks to adopt strategies which aim at changing the present farming system, with the goal of establishing sustainable natural resource use in an off-reserve concession to provide both long-term supply of raw materials to GAP, and a basis for improved living conditions for the communities. Some of the strategies to effect the change include, introduction of cash crops (which can grow under trees) as well as other income generating activities, reforestation program and the establishment of a development fund (Appiah et al, 1998, J F M 1996, CARE 1998). Some of the project strategies include:

- Defining and delimiting timber resources.
- Providing short-term benefits and adding value to agricultural production, which will supplement long-term investment in timber trees. For this reason, the farmers are growing shade-tolerant species like black pepper and kola in association with timber trees. The project is assisting farmers by providing some incentives in the form of seedlings and labour for planting them. Also, experimental fishponds, snail rearing and bee-keeping have been established on a small scale as alternative income generating activities for the farmers. There are also several

University of Ghana http://ugspace.ug.edu.gh

agroforestry interventions in farmed areas, one of which is the intercropping of selected timber species in cocoa farms, which is the subject matter of this study.

- Providing a system of incentives to farmers to plant timber trees and preserve standing timber .
- Restricting the further inflow of migrant farmers.(J F M 1996, CARE 1998).

In partnership with the JFM project team, Co-operative Agency For Relief Everywhere (CARE), an international NGO, also intends to implement a range of activities that will address the social or institutional constraints and the ecological constraints sustainable land-use. The overall objective of CARE is to increase the capacity of individual farmers and local institutions to implement land use practices that are economically, ecologically and socially acceptable in the Gwira Banso stool area. The purpose is to reduce pressure on forest land and promote sustainable community-based management of natural resources in the Gwira Banso stool area.

1.2 Problem Statement

The intervention of GAP/DLH, which encourages farmers to intercrop timber trees with cocoa, is the subject matter of this study. Traditionally, cocoa thrives well in the forest. Though the trees in the forest provide shade and other environmental benefits that enhance yield, they do not belong to the farmer because of the forest Act of 1962 (Act 124), which vests all timber rights in the President who acts as trustee of the chiefs and their people. For this reason, farmers make no deliberate attempt to plant trees as an investment for the future. Besides, the long gestation period required by the trees to reach their felling stage may also serve as a disincentive for farmers to consider the growing of timber trees a worthwhile investment. Also, with the introduction of tree planting, lands for agricultural purposes will be lost, farmers will have to wait until the harvest of

University of Ghana http://ugspace.ug.edu.gh

the trees to derive benefit. This means a delay of income flows to farmers by over forty years. Most farmers may also be uncertain about the possible returns to be derived from planting a diversified cocoa-agroforest. Furthermore, the poor smallholder farmer has very little interest in the global environment benefits of adopting agroforestry innovations unless they are expected to improve the livelihood of their families. Obstacles on production and sales of farm trees as timber that farmers may encounter include risk of damage to cocoa farms, perceived incompatibilities with current farming practices, non-standardised methods of classification and pricing of farm trees, and insufficient knowledge of the industrial uses of farm trees.

Research questions that arise from the introduction of cocoa-agroforest in the Gwira Banso forest concession are: what evidence is there on the financial viability (profitability) of the proposed cocoa-agroforest practice? What are the short-term and long-term cash flow implications and how suitable are they to the farmers who are dependent on the forest land for their livelihood? How can farmers' knowledge on industrial use of timber trees, prices of timber trees, production and sale of timbers, be enhanced?

1.3 Objectives of the Study

The primary objective of the study is to analyse the investment benefits of the cocoa-agroforest in the Gwira Banso JFM project. The study will also model the diversification of existing agricultural production system, through the deliberate planting of valued timber trees as an economic venture. Specifically, the task will be to:

1. Identify industrial uses of timber trees planted by farmers and their market opportunities.
2. Prepare financial cash flows for the cocoa monocropping, cocoa agroforest and a diversified system of production activities. In the case of cocoa-agroforest and diversified system, the

University of Ghana http://ugspace.ug.edu.gh

analysis will be carried out for 'with' and 'without' incentives to farmer from the project.

3. Compute and compare the Net Present Values (NPV) and the Internal Rate of Return (IRR) as alternative measures of profitability of the project, for the various farming systems.

4. Determine through a linear programming model, the optimal diversified system of economic activities that will provide the highest returns to farmers.

1.4 Hypotheses

The hypotheses to be tested concern the profitability and the cash flow streams of all the three farming systems.

1. H_0: There is no difference in profitability of cocoa-agroforest, cocoa monocropping and the diversified production system.

   H_1: Cocoa-agroforest is more profitable than cocoa monocropping and the diversified production system.

2. H_0: No difference exists in the level and variability of cash flow streams for cocoa-agroforest, cocoa monocropping and the diversified system.

   H_1 Difference exists in the level and variability of cash flow streams for cocoa-agroforest, cocoa monocropping and the diversified system.

3. H_0: If the value of timber trees is not considered, the cash flow streams for the three farming systems will be the same.

   H_1 If the value of timber trees is not considered, the cash flow streams for the three farming systems will not be the same.

University of Ghana http://ugspace.ug.edu.gh

1.5 Relevance of the Study

If found to be economically viable and profitable, the cocoa-agroforest could be adopted for sustainable land use in the new cocoa growing areas of the Western region. The study could also be used to assess the role of incentives in improving the farming system. The study can also be used to assess how rural development can be enhanced, rural poverty reduced and the natural resource base of the country maintained –"by not sacrificing one of the 'hens' (forest sector) that also lays the 'golden eggs' (foreign exchange) to pacify the 'gods' (nation) to atone for the 'sins' (problems) of a 'diseased hen' (cocoa sector) whose 'golden egg' is declining in value''. Besides, many of the arguments for, and studies on cocoa agroforest, are based on the biophysical effects and do not consider the economic value of the trees. This study will provide information on the economic aspects of the system to either support these claims or caution proponents about the economic or financial implications of the system.

1.6 Organisation of the Study

The study is organised into five parts. Chapter one introduces the study. It defines the study problem, its objectives, hypotheses and relevance as well as organisation of work.

Chapter two presents a review of relevant literature. In it, are a brief definition and description of agroforestry in general, and agroforestry in Ghana. Cocoa-agroforest is also discussed in detail. Literature on economics of agroforesty, economics of cocoa production including the use of linear programming in agroforestry is reviewed. Chapter three presents the methodology of the study. It includes theoretical and empirical frameworks, data requirements and sources, methods of data collection and the analytical methods used.

Chapter four presents the findings and discussion of such findings. Finally, Chapter five

UNIVERSITY OF GHANA LIBRARY

University of Ghana http://ugspace.ug.edu.gh

focuses on the conclusion and recommendations made, based on the findings of the study.

University of Ghana http://ugspace.ug.edu.gh

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is divided into two parts. The first part gives a brief account, definition and description of concepts of agroforestry in general and agroforestry practices in Ghana. The aim is to give a general overview of practices and concepts of agroforestry that have been identified. Literature on cocoa-agroforests is also reviewed to establish its importance in sustainable cocoa production. In the second part, literature on economics of agroforestry (including cocoa-agroforests) and the use of linear programming approach in agroforestry analysis is reviewed. This gives an understanding of the various criteria used in the measurement of profitability and viability and also helps in deciding on what methods of analysis to use to achieve the objectives of this study.

2.2 Definition and Concepts of Agroforestry

Agroforestry is a sustainable land management system that increases overall production, combines agriculture and tree crops, forest plants and/or animals simultaneously or sequentially, and is applied to management systems that are compatible with the local patterns (MacDicken and Vergara 1990). The International Centre for Research in Agroforestry (ICRAF) defines agroforestry as 'a collective name for land-use systems and technologies where woody perennials are deliberately used on the same land-management units as agricultural crops and or animals in some form of spatial arrangement or temporal sequence' (Nair 1990). In agroforestry systems, there are both ecological and economic interactions between the different components.

There are basically three types of agroforestry systems inferred from the three basic sets of elements or components managed by mankind. These include the tree (woody perennial); the herb

University of Ghana http://ugspace.ug.edu.gh

(agricultural crops including pasture species) and the animals. Agroforestry systems are thus classified as:

- Agrosilvicultural: crops and trees including shrubs and or vines,
- Silvopastoral: trees and pastures and or animals,
- Agrosilvopastoral: crops, trees and pastures and or animals.

Any other agroforestry systems that do not fall under these headings are categorised as others. These include apiculture with trees, aquaculture involving trees and shrubs and multipurpose tree lots (Nair op cit).

2.3 Agroforestry in Ghana

The hallmark of agroforestry in Ghana is the introduction of the cultivation of trees and shrubs into the farming systems of the Ghanaian farmer so as to enhance the agricultural environment. It is an important land use system in the country and has been practised, particularly by rural communities for a very long time (Ofori et al 1990).

Agroforestry actually started gaining prominence from 1986, with the establishment of the agroforestry unit at Ministry of Agriculture. The rationale for the introduction of agroforestry in the country stemmed from food crisis and environmental degradation, particularly, decline in soil fertility. Subsequently, a National Agroforestry Policy was formulated. The policy aims at introducing the cultivation of trees, throughout the country to sustain productivity. Adoption of agroforestry systems by farmers is expected to lead to:

- improvement of soil fertility and increased food production;
- control of soil erosion and improved soil management;
- provision of fodder for livestock on a sustainable basis;

University of Ghana http://ugspace.ug.edu.gh

- provision of fuelwood for both domestic and industrial use and wood/pole for construction and farm use (Stennett and Dampson 1990).

Thus, farmers in the country have been practising some sort of agroforestry by leaving such species as sheabutter (*balyrospermum paradoxum)* and baobob (a*dansonia digitata)* on their farms because they provide fruits and edible oil as well as serve as shade. *Gliricidia sepium* (Mother of cocoa) is also planted in cocoa farms for shade and soil enrichment. Other examples of agroforestry systems in the country include alley cropping, tree gardens, home gardens, taungya, improved fallows and wind breaks and shelter belts. The rest are farm tree planting, fodder banks, woodlots, live trees and tree cash crops.

2.4 Cocoa-agroforests

Cocoa-agroforest is an example of land use practice for sustainable agriculture in which cocoa is intercropped with tree crops, food crops as well as timber trees. It is an example of perennial tree-crop plantation. It aims at integrating socio-economic principles with environmental concerns so as to simultaneously maintain or enhance productivity, reduce the level of risk, protect the natural resources and prevent degradation of the land, and at the same time, be socially acceptable and economically viable (Dumanski et al 1998a,b).

The process of establishing a cocoa-agroforest is as follows. When land is cleared for farming, indigenous fruit trees, medicinal plants and timber tree species are deliberately retained for their economic value and to provide shade for the cocoa plants. Food crops such as cassava, maize, plantain and others are intercropped with cocoa during subsequent cropping seasons. Intercropping with food crops is done to exploit the fertile soil and to increase shade for the cocoa seedlings. The cocoa is left to develop as farmers harvest the season and annual crops. Depending on the density of

University of Ghana http://ugspace.ug.edu.gh

the retained species and the mortality rate of the cocoa seedlings, the system is further enriched by planting additional tree crops such as mango (*mangifra india*), avocado (*persea americanum*), cola (*cola nitida*), orange (*citrus senensis*), and where appropriate timber trees.

As the cocoa trees and the other components grow to maturity, the system evolves to a closed canopy of a multi strata system that resembles natural forest with most of the positive attributes with it. The hypothesis that cocoa-agroforest mimics original forest is confirmed by Imbach et al (1989). In their four year study of nutrient concentration using extrapolation to calculate leaching losses within the agroforestry systems of cocoa below the shade of poro (*erythrina poeppigiana*) and laural (*cordia alliodra*) in Turriiaba, Costa Rica, they concluded that agroforestry systems are equivalent to natural or artificial ecosystems and clearly better than annual crop systems.

Successful intercroping of cocoa with coconut (Leach et al 1974; Sheperd et al 1977; Ramadasan et al 1978), oil palm (Hartley 1966; Amoah et al 1995), kola (Ekenade 1987) and rubber (Egbe and Adenikinja 1990) is well documented. Major management requirements of cocoa-agroforests are shade control, weeding, pest and disease control, harvesting of pods and processing of beans (Wessel 1987). According to Wessel (op cit), the role of shade in the management of cocoa-agroforests is rather complex as it affects or is related to several other growth factors.

Though information and questions on the relative long term profitability of the unshaded crop is rare and open, the effect of inclusion of shade trees is less controversial in the case of small scale farmers, since they are frequently cultivating a sub-optimal site for the crop (Ahenkorah et al 1974, Beer 1984, Herzog 1994). Herzog (1994) has noted that, the use of unshaded crop comes with risk (because of price fluctuations) and ecological impacts. He observed that, while shade trees have an equalizing effect, intensified plantations are more difficult to manage and over the years

University of Ghana http://ugspace.ug.edu.gh

their yields show greater variations. Also, producing on a high level of intensity with monoculture type of plantation is risky for the farmer and especially for small farmers who hardly have any financial resources. This is because the value of the product could temporarily fall to a level where the farmer can no longer afford the necessary inputs and therefore, will temporarily abandon his farm. Cunningham (1963) also illustrated on the higher risk inherent in unshaded cocoa cultivation. He noted that the extra expenditure and work associated with clear-felling and growing unshaded cocoa with large amounts of fertilizer would probably be justified only when yields of 3000 lb dry cocoa bean/acre (3360 kg/ha) and over are obtained.

Shade trees may serve several purposes including being used as: a tool for the management of the environmental conditions in associated crop plantation, example *Erythrina poeppigiana* over coffee; a means of diversifying crop production (including timber) from a given area. In some cases the shade fulfils both management and production functions (Beer 1987). According to Purseglove (1976), shade also reduces photosynthesis, transpiration, metabolism and growth, and therefore, the demand on soil nutrients and so enables a crop to be obtained on soils with lower fertility.

It must however be noted that, the extent to which shade will be used depends on the individual circumstances. Bonaparte (1973) recognized that, the influence of light intensity on yield of cocoa is intimately associated with soil nutrient status. He pointed out that, where the supply of nutrients is non-limiting, the highest yields are achieved at full light intensity, but under poor nutrient conditions, the trees do not tolerate full sunlight and yields are reduced. However, under heavy shades yields are low irrespective of nutrient conditions.

In terms of biophysical and environmental implications, cocoa-agroforests remain productive and environmentally sustainable up to fifty years and at a level comparable to long term

University of Ghana http://ugspace.ug.edu.gh

fallows or primary forests (Duguma op cit). IRAD (1997) found that total biomass in cocoa-agroforests of 304 t/ha was by far greater than that in food crop fields of 85 t/ha and ranked third after the biomass in primary forest of 541 t/ha and long term fallow of 460 t/ha. Cocoa-agroforests also contained 62 % of the carbon stock found in primary forests (Kotto-Same et al, 1997). More so the apparent increase in soil organic material especially under poro (*Ethriana poeppigan)* gives an indication of the ecological sustainability of cocoa-agroforests over longer period (Beer et al, 1988).

While the literature gives strong indications that cocoa-agroforests may be sustainable, evidence available suggests that cocoa monocropping may not be sustainable. Soil changes under pure stands of cocoa are well documented. Ahenkorah and Akrofi (1968) found that the supply of exchangeable potassium was strongly depleted after seven years of continuous cropping with Amazon cocoa. The levels of exchangeable calcium, sodium and magnesium (Greenwood and Djokojo 1952), pH, organic phosphorus (Omotoso 1971), bulk density, total porosity, textural, chemical and nutrients properties (Wessel 1969, Ekanade 1985a,b) have also been observed to decline under cocoa monocrops over time (Ekanade 1987).

Cocoa is therefore well adapted to inclusion in multi-product and multi-strata agroforests in West Africa and Central America, and by diversifying production, smallholder farmers can safeguard their income should cocoa prices fall (Duguma op cit). According to Duguma (op cit), in West Africa, cocoa-agroforests are common in Southern Cameroon where they are known to remain in production for up to fifty years. In Ghana and Cote d'lvoire, livestock have been successfully integrated into tree crop systems on experimental research stations, such that with care taken to avoid degradation of the soil, small ruminants can provide additional benefits to cocoa-agroforests. In Costa Rica and Panama, leguminous plants or timber trees have been introduced into existing cocoa plantations as cheap alternatives to replace undesirable existing shade canopies (Duguma op

UNIVERSITY OF GHANA LIBRARY

University of Ghana http://ugspace.ug.edu.gh

cit; Beer et al 1988; Beer 1990; Fassbender et al 1991).

2.5 Degradation of Forest Resources in Ghana

Most of the original vegetation in the country has been removed or modified considerably through the various forms of land use. At the turn of the 20 th century, it was estimated that Ghana had 88,000 km^2 of forests. These forests support a wide diversity of plants and animals. World Bank (1988) indicates that within a single hectare in the forest zone, 125 plant families and a species diversity of about 300 plants can be found. Also, over 2,100 of the more than 3,000 plants and twenty-three of the 43 endemic plant species are also known to exist in the forest. More so, a total of 730 tree species have been recorded in the closed forest. However, by 1950, this had been reduced to 42,000 km^2 and by 1980 it was estimated at 19,000 km^2 (Frimpong-Mensah 1989). Currently the closed forest is about 15,000 km^2 (Nair 1990). Other estimates indicate that only 2.2 million hectares of the closed forest made up of 1.7 million hectares within forest reserves and 0.3-0.5 million hectares outside the legally reserved forests, actually remain (GEAP 1991).

Though different estimates exist, the rate of deforestation in Ghana is quite alarming. Whereas FAO (1988) shows annual rate of deforestation to be about 220 km^2, GEAP (1991) provides an estimate of about 22,000 hectares per annum for the period 1981-1985. These figures have since not been updated and are still being used for analysis and decision making. According to Tutu and Baah-Nuakoh (1994), these are conservative estimates, because in the Western Region alone, about 21,699 hectares of the forest is estimated to be deforested a year through logging and agriculture. Tutu (nd) therefore notes that, if this rate of deforestation continues in the Western Region without any serious reforestation, the forest area will be destroyed in only thirty-one years.

University of Ghana http://ugspace.ug.edu.gh

This is significant because the Western Region alone contains about 44% of the country's forest.

2.6 Forest Policies and Legislation

The need for sustainable forest management in the country stems from the fact that the forest sector contributes substantially to the Ghanaian economy, with the timber industry being the fourth largest foreign exchange earner after cocoa. The sector also employs about 70,000 people in the formal sector, while several thousands of self employed and artisans are engaged in the non-formal sector of the timber industry. However, in spite of the country's effort at sustainable forest management, there exists a deficit of 1,500,000 m^3/ annum in timber production and the fact that reforestation trails at 5% of deforestation, is an indication that all is not well (Antwi 1999).

Concern for the effects of deforestation and its impact on the environment of Ghana dates back to the beginning of the 20th century, with the passing of the Timber Protection Ordinance in 1907. Since then, a lot of ordinances, policies and legislation have been implemented or enacted as follows:

- Forest Ordinance in 1927, which provides the authority and methodology for the creation of forest reserves.
- First National Forest Policy in 1947, which seeks among other things to reserve sufficient forests and forest lands to supply the benefits needed by people, manage the reserved forest for sustained yield (of timber), conduct research to support utilization and forest management and educate the people to understand the value of the forest,
- Forest Concession Act in 1962, which prohibited the creation of forest reserves by local government/authority, removed the role of the courts in granting (timber) concessions and transferred the role to a minister of state, and vested all timber rights in the President acting as

University of Ghana http://ugspace.ug.edu.gh

trustees for the owners.

- The Timber Resources Management Act 1997,which prescribes a method for granting timber rights (to harvest and extract timber) in a manner that will secure the sustainable management and utilization of the timber resources.

Today, private and community forest management is being encouraged through public education, involvement of local people and NGOs in forest decision making and implementation of programs. Thus, there exist well-formulated forest and wildlife policies, forest management plans, forest protection strategies and timber harvesting regulations to enhance sustainable management of the forest estate.

2.7 Economic Analysis of Agroforestry Systems

2.7.1 Types of Economic Analyses

Economics deals with how people make decisions about the allocation of scarce resource, in order to meet designated targets or objectives. Decisions may have to be made at different points in time and by different parties (economic agents). Thus economic analysis may either be at different times (ex ante and ex post) or from different points of view (public and private).

The main aim of ex ante economic analysis of a potential agroforestry system is to give the various interested parties some idea on whether a system that is technically feasible is economically viable and if so, whether it has a chance of meeting specified objectives. It may also help to prioritize the various technology options available, and/or guide scientists to formulate or propose other technologies. On the other hand, the main aim of the ex post economic analysis of an agroforestry system that is already on the ground is to determine whether such a system should be re-adjusted so as to better meet objectives.

University of Ghana http://ugspace.ug.edu.gh

It is necessary to distinguish between private economic analysis and public economic analysis. Private economic analysis, sometimes referred to as financial analysis, is not necessarily limited to one farm, but could for example include all farms in a locality. In private economic analysis, the objectives of the individual (or group) are taken into account. This is reflected in the inputs and outputs to be considered as well as the values given to them. Common objectives for individuals are to obtain higher levels of income and leisure time, as well as the avoidance of risk that results from fluctuating income and consumption. Public economic analysis differs from private economic analysis in that it takes into consideration costs and benefits outside the farm or area where the system is present. The objectives include broader socioeconomic and ecological goals such as increasing employment, income distribution among regions and /or groups of individuals and maintaining the national resource base.

According to Hoekstra (1990), the most common analysis to which agroforestry systems are subjected at the private and public levels are:

- Labour input analysis, which shows the flow of labour inputs required for the introduction and maintenance of an agroforestry technology. In such an analysis, it is common to establish who does what to determine the effect that the system's introduction may have on different categories of workers (for example, male, female, children and the landless.)
- Material input analysis, which shows the flow of material inputs required for the introduction and maintenance of an agroforestry system.
- Cash flow analysis, which shows the flow of cash expenditure and receipts resulting from the introduction and maintenance of an agroforestry system.
- Discounted cost and benefit analysis, which determines the profitability of the agroforestry system.

University of Ghana http://ugspace.ug.edu.gh

- Sensitivity analysis, which demonstrates the effects of altered circumstances, or assumptions on the profitability of the system.

These approaches have been used by various authors in assessing the economics of agroforestry projects (Current et al 1995a,b; Dunnet al 1990; Jickling 1989; Anderson 1987; Sumberg et al 1984; Lowe and Twumasi-Ankrah 1992) What Hoekstra's overview lacked is the method for planning optimal economic strategies for agroforestry. Raintree et al (1980), Verinumbre et al (1984), and Betters (1988) have used linear programming to address this concern.

2.7.2 Profitability and Viability

Whilst profitability of a system is considered from the microeconomic standpoint involving decision making by the individual farmer, viability goes beyond the simple consideration of profitability. Viability concerns the widespread adoption of the practice, its ability to uplift the economic standards of the rural population (which include how rural development can be enhanced and rural poverty reduced), its relevance to large-scale applications, and its longer-term macroeconomic role in the development process. Viability of a system for a particular household or area will also be determined by the resources available to them and the constraints they face. Current et al (op cit) have noted that whilst home gardens and alley cropping for instance may be very labour intensive, timber trees or woodlots, on the contrary, require little labour but more land.

Literature on economics of cocoa-agoforests is scanty. Duguma et al (1997) evaluated the economic sustainability of cocoa agroforests by conducting profitability analysis for three production systems:

1. Low input intensity with commercial fruit trees production.
2. Low input system with no commercial fruit tree component.

UNIVERSITY OF GHANA LIBRARY

University of Ghana http://ugspace.ug.edu.gh

3. Medium input intensity with commercial fruit tree production.

Costs and returns from establishment to twenty-six years were estimated for all systems and profitability was assessed and compared through the use of the Policy Analysis Matrix (PAM). They used *fob/cif* border prices of exports/imports adjusted for internal transportation costs and misalignment of the real exchange rate as their economic prices. Only conventional fruit trees such as citrus and mango were used to estimate the value and profitability.

The result of their study showed that cocoa-agroforests are profitable under all the scenarios considered. This was despite the fact that the value of many indigenous timber, medicinal, fruit and food species that are often found providing shade were not captured in their budgets. They suggested genetic improvement research on almost all the components to improve profitability of the system and promote sustainable cocoa production. Amanor (1997) also raised similar sentiments.

Current and Scherr (1995) in their study on farmer cost and benefit from agroforestry and farm forestry projects evaluated the various types of agroforestry including woodlot, taungya, managed woody fallows, perennial intercrops, home gardens, alley cropping, windbreaks, trees on contour and trees in pastures. Although the results varied, depending upon local conditions of resource availability and markets, the study confirmed the ability of on-farm tree plant to provide rural communities with the tree products they need for household use and sale; protect and improve soil quality; improve environmental conditions; and create employment and income generating activities. They found that most of the 56-agroforestry systems studied were financially profitable from the farmer's point of view. It was also noted that, 75% of the systems analysed yielded positive Net Present Value (NPV) at a 20% real discount rate. In two-thirds of the cases, the NPV and the return to labour were superior to the alternative use of land, which was used for

University of Ghana http://ugspace.ug.edu.gh

comparison. Payback periods for woodlots were long (5-20years), but all of the other systems managed to fully pay back the initial investment within one to six years.

Comparing the financial returns from agroforestry with those from alternative farming practices, Current et al (1995) found that agroforestry systems produced significantly higher returns per hectare - at least 25% higher in approximately 40% of the cases and at least 10% greater returns in more than half of the cases. In more than 75% of the cases, the returns to labour were higher than the local agricultural wage for the systems including agroforestry. Furthermore, returns were sensitive to tree and agricultural product prices. That is, even higher input labour systems were profitable so long as output prices or productivity were high.

Current and Scherr (1995) conducted their studies using financial analysis. However, economic or societal benefits were identified, but no formal analysis was carried out. Alternative uses of land were not included as opportunity cost and market prices were used to value all inputs and products even though all inputs were subsidized. Family labour was also valued at the same cost as hired agricultural labour. However, no cost was assigned to land since alternatives compared were on the same land base. The absence of economic analysis in their study will not give a true reflection of the willingness to pay or buy on behalf of the whole society or countries concerned. Also, family labour is not normally paid. More so, family labour is not treated as an item of cost in farm accounting. Instead, the opportunity cost of family labour, which is the income from the next best alternative that is forgone by participating in the project, is used. Rourke (1973) also made no distinction between family and hired labour and all labour inputs.

Current et al (1995b) found that financial results were generally most sensitive to yields and product prices followed in importance by labour. The results were least sensitive to the prices of purchased inputs such as planting material and agrochemicals. When trees were included in

University of Ghana http://ugspace.ug.edu.gh

agricultural systems, it was found that tree crops and livestock systems were less sensitive to changes in yields and prices and improved overall profitability.

In an IITA alley cropping experiment in South Western Nigeria, Ehui et al (1990) used a capital budgeting approach to determine the profitability of alley cropping in comparison with traditional shifting cultivation, taking into account the short and long-term impact of soil erosion on agricultural productivity. They found that when access to new forest land is 'costless', traditional bush fallow systems are advantageous, but when there are heavy population pressures and land is scarce, then alley cropping system seems to be the most desirable option.

Dunn et al (1990) studied the profitability of four farm-level fuelwood management alternatives using benefit-cost analysis. The value of alderwood was based on the market price of a cubic meter of fuelwood sold. Sensitivity analysis of wage rate, fuelwood prices and project subsidies were conducted. The results indicate that managing alder for fuelwood on 2 ha. of land on a 20-year rotation can yield a real rate of return greater than 15% and that thinning at 10 years will result in a higher NPV and B/C ratio than thinning at 5 and 10 years, and 6 and 12 years or no thinning at all. They concluded that, the rates of return on managing alder for fuelwood are extremely favorable even without including monetary value for other benefits accruing to the farmers. Thus, even with a heavy subsidized bill, the social benefits of increased fuelwood supplies, decreased soil erosion, and increased agricultural and livestock production, make alder management a viable investment alternative for government or institutions.

Jickling (1989) in a review` of economic studies in agroforestry found that some of the best studies relate to small on-farm tree plants or woodlots, which are only peripherally relevant to agroforestry. He pointed out, however, that although studies tend to isolate tree-planting investment from other on-farm agricultural activities, they are nonetheless valuable in assessing the positive

University of Ghana http://ugspace.ug.edu.gh

returns from tree production.

Anderson (1987) carried out a cost-benefit analysis of afforestation (shelter belts and farm forestry) in Northern Nigeria. Assuming a rate of decline of 1% per annum in soil fertility, he estimated the IRR's to be about 15-17 % for shelter belts and 15-22% for farm forestry.

Sumberg et al (1984) developed an economic model to compare maize production in monocropping situations with production when maize is alley cropped with *leucaena leucoceplata*, in Southern Nigeria. They concluded that alley cropping is more profitable, but that the advantage decreased as the price of maize increased relative to the cost of labour, and profitability was found to be more sensitive to maize prices than to labour cost.

Lowe and Twumasi-Ankrah (1992) evaluated the profitability to the individual rural farmer for adopting agroforestry cropping systems in Ghana. All economic inputs, both cash and non-cash, as well as the direct benefits of trees and food production were valued. A 7% social discount rate to reflect the long-term social view point and a private discount test rate of 20% to reflect the medium term view was used. Special attention was also given to issues of labour and land as scarce factors of production. According to them, the use of hired labour wage rate can be a crude simplification ignoring which family members supply the labour, the type of work undertaken, the season and value-status. They attempted to meet this criticism by categorising central operations by type of labour required and indexing the relevant wage rate to a general figure: male-weight 1, female-weight 0.75, male (over 60 years)-weight 0.50, children (10-15 years)-weight 0.50 and children below 10 years no weight. However, this indexing failed to account for seasonality.

The use of hired agricultural labour wage rate as opportunity cost of family labour has been adopted by many writers including Rourke (1973) and Current et al (1995a,b). For the sake of simplicity, and to prevent the problem of seasonality, most analysts use hired labour wage as an

University of Ghana http://ugspace.ug.edu.gh

approximation of the opportunity cost for labour, increasing the price by 25% during the peak seasons and decreasing it by 25% during the off season (Hoekstra 1990). However, Hoekstra (op cit) suggested that returns to family labour divided by days in peak season should be used as opportunity cost for peak seasons and off season as opportunity cost for the off seasons.

Araya and Asafu-Adjaye (1999) argued that although it is reasonable to assume that daily wage of unskilled labour reflects the marginal value product (MVP) of labour, this assumption is not realistic for the whole year because of seasonality in agricultural production. As a result, they derived a social discount factor for unskilled labour by calculating the ratio of the mean number of days farmers spend in on-farm employment to the total number of days in the off-peak season. This factor is applied to the going rural wage to arrive at a shadow wage rate. The opportunity cost of labour was also estimated by the cash value of food earned from the project.

Lowe and Twumasi-Ankrah (1992) used cost-benefit analysis to determine the profitability of each of the agroforestry systems that were then being promoted in the country. Table 2.2 gives a summary of their results ranked by their profitability and objectives of the agroforestry interventions.

University of Ghana http://ugspace.ug.edu.gh

LIBRARY

Table2.1 **Objectives Of Agroforestry Intervention, Ranked By Their Profitability**.

Farming systems	Objectives	Rank	Agroforestry system
Cereal cropping	Soil improvement	1	Alley cropping (mulch)
		2	Planted wood fallow
		3	Planted farm trees
	Erosion protection	1	Alley cropping (mulch)
Orchard crops	Cash benefits	1	Temporary taungya
		2	Permanent intercrop
Livestock	Fodder supply	1	Fodder bank
		2	Planted farm trees
		3	Planted wood fallow
		4	Alley cropping (fodder)
Yam	Cost saving	1	Live staking
		2	Harvested stakes

Source Lowe and Twumasi-Ankrah 1992

2.8 Economics of Cocoa Production

A great deal of work has been carried out on cocoa production in Ghana because of its significance to the economy. This ranges from preparing land, through cultivation, maintenance and harvesting to marketing of cocoa. It also involves costs and returns to the farmer, the society and the nation as a whole.

Rourke (1973) studied profitability of cocoa in the Eastern region by considering six alternative enterprises, among which are cocoa pure stand and cocoa intercropped with plantain and

University of Ghana http://ugspace.ug.edu.gh

cocoyam. Pure stand of cocoa was used as a hypothetical case to help assess the advantages of intercropping because, in practice, cultivation of pure cocoa monocrop from establishment to maturity is rare. He valued all produce at their point of sale. In the case of plantain, cocoyam, maize and cassava, the average wholesale prices in Koforidua were reduced by 20% to cater for cost of transport and handling of middlemen, were used. Rourke (op cit) valued the selling time and transport cost of cocoa in his work. His findings suggest that the returns on investments in the establishment of cocoa, particularly when returns from intercrops are included, are high.

Olayemi (1973) used similar approach to evaluate cost and returns to cocoa and alternative crops in Western Nigeria. He found that a remarkable rate of return on investment could be obtained from the planting of cocoa when organised on small scale. However, these studies did not take into account the cost of acquiring land, and omitted such items as the cost of building facilities on new farms or in new communities when migration occurs. They recognised this weakness but were unable to obtain an appropriate estimate because of the many different ways in which land may be acquired. Sensitivity analysis should have been considered to take into account the opportunity cost of the land and the other omitted items.

Elliott (1973) presented a paper on benefit-cost analysis of cocoa development program in Ivory Coast for three production strategies: traditional cocoa cultivation, regeneration of cocoa and replanting and new planting of selected cocoa materials. His work focused on calculation of per hectare benefit-costs for the farmer, for the production strategies using different producer prices, at different discount rates for various wage rates, to derive the NPV, B/C ratio, payback period, daily return to family labour, daily return to total labour, net cash return/cost, IRR and break-even price. The same producer price and discount rate combined with different world prices were used to calculate net government benefits, Stabilization fund revenues, Government revenues/ Government

University of Ghana http://ugspace.ug.edu.gh

outlays, and Payback period, in the case of the government. For the economy, the new producer prices were used along side the previous discount and wage rates.

Elliott (1973) used an alternative approach of imputing the cost of clearing of land to the food crop for which land would have been cleared even in the absence of cocoa; and presenting as labour time only the extra labour which can be directly imputed to the cocoa project. His explanation is that, this avoids the problem of imputing a value to the food crop where yield figures are unreliable, where only a part of the output may be sold or consumed and where local market prices are an unreliable guide to the value of the food crop.

Oni and Adubi (1973), in their work on the economics of fertilizer use in cocoa production, found that it is profitable to use fertilizer at the on going producer prices and that even when subsidies on fertilizer were set aside, fertilizer application was still profitable. However, a two-thirds decline in the producer price would make fertilizer application irrational even if the subsidy were still operative. This indicates the significance of cocoa producer price in determining whether it is economically profitable or not to fertilizer.

COCOBOD (1997) observed that as farmers usually have more than one farm, some of which may be very far apart, it becomes necessary to engage caretakers. Therefore in view of their distributive effects on farm income, it is essential that these farm production arrangements be taken into account when estimating the profitability of investment into cocoa farming.

2.9 Linear Programming

The objective of linear programming (LP) is to determine the optimal allocation of scarce resources among competing products or activities. Linear programming is one possible method of economic evaluation that deals with multi-dimensional agroforestry systems, though its application

University of Ghana http://ugspace.ug.edu.gh

to agroforestry has been limited (Betters 1988, Wojtkowski et al 1988).

Lileholm et al (1991) used knowledge of past market price fluctuations to reduce the risk of future financial returns through linear and quadratic programming, to explore the context of planning an agroforestry system with a cash crop component. The study demonstrated that if past and current price behaviours are indicative of future price behaviour, planting crops with stable and/or negatively correlated net revenues can reduce the variance of future net revenues and hence decrease the financial risks of agroforestry systems.

Verinumbre et al (1984) using a linear programming model reported that leucaena-maize alley cropping is economically attractive. More labour was required to prune trees, but lower amounts of fertilizer and herbicide were needed. They concluded that under severe cash constraints and where hired labour is available at a relatively low cost, leucaena-maize alley cropping systems are the most promising package.

In profitability analyses based on NPV, IRR and B/C, resource constraints and requirements are ignored. These are taken care of in the use of LP. Betters (1988) using LP determined what is ‘best’, given the objective of maximizing net present value by allowing for a mix of the two ‘best of the best’ agroforestry practices while considering constraints and requirements such as land, family labour, budget, fuelwood and nutritional protein.

Ashraf (1990) using linear programming model for farming systems under different types of management in South Western Nigeria, for various land sizes, found that alley cropping could increase the length of cropping cycle in a bush fallow with cocoa when the farm size is less than 5 ha. Thus, alley cropping could contribute to transforming a shifting cultivation system into a semi-permanent cultivation system, especially in the case of small holdings. The study showed that a higher degree of land-use intensity could also be obtained by using chemical fertilizer.

University of Ghana http://ugspace.ug.edu.gh

Though LP is a powerful technique, it optimizes a single objective at a time. Wojtkowski et al (1988) used Multiple Objective Linear Programming (MOLP) to evaluate multi-participant (farmer and forester) agroforestry systems and to optimize the species mix and density of these systems, with regard to more than one objective. Their study revealed that a farmer could expect substantial reduction in output, if the taungya approach is used to start a teak plantation.

Wojtkowski et al (1991), bi-economically modelled a rubber-cocoa agroforest combination for a forty-year cycle. A number of scenarios were simulated to find the optimal planting densities for each situation.

2.10 Conclusion

This chapter reviewed literature to support the claim that agroforestry and, for that matter, cocoa-agroforest creates a sustainable cocoa production system that mimics original forest systems, enhances biodiversity, mitigates global warming, decreases risk of disease and pests due to shading and could diversify production. Literature on economics of agroforestry, economics of cocoa production and the use of linear programming in agroforestry were also reviewed.

Empirical literature point to the fact that not much work has been done on economics of agroforestry. Most research and analysis on agroforestry has dealt with the physical and biological aspects, neglecting systematic analysis of agroforestry's economic contributions at the farm level. Information available indicates that no effort has been made to evaluate the economics of intercropping cocoa with commercial timber trees in Ghana. This study seeks to fill this gap. Hoekstra (op cit) provides detailed examination of the issues or obstacles that economists encounter, as well as the options that are available to them in the appraisal of agroforestry projects. This work used the approach suggested and used by Hoekstra and others like Gittinger (1987), Betters (1988),

University of Ghana http://ugspace.ug.edu.gh

Arnold (1984), Dunn et al (1990), and Current et al (op cit).

The study identified how trees can be used to generate cash income or saving, or as insurance. It computed the cost of inputs including labour, land and related capital or household resources, and outputs using prices paid and received by farmers.

UNIVERSITY OF GHANA LIBRARY

University of Ghana http://ugspace.ug.edu.gh

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This section is divided in two parts. The first part examines the estimation of financial costs and returns of cocoa-agroforests to farmers in the Gwira Banso JFM project area. Net Present Value and Internal Rate of Return criteria are used to measure the profitability between cocoa-agroforests, cocoa monocropping and diversified farming systems using data obtained from farmers in the area and other field data. Contribution of cocoa-agroforest is examined by analyzing the different industrial uses of the timber trees being planted by farmers. Optimal mix of economic activities that provides farmers with highest returns is determined through the use of linear programming in the second part of the section.

3.2 Investment Analysis

The focus of this study is the investment analysis of cocoa-agroforest in comparison with cocoa monocropping and diversified system of farming for farmers and their supporting agencies. Investment analysis is a means for comparing benefits and costs of a project in monetary terms either by using market prices or shadow accounting prices that are considered to reflect true social or economic values. Investment analysis assesses the benefits and costs of a project in monetary terms and reduces them to a common denominator at a point in time; if benefits exceed costs, the project is accepted, otherwise, the project is rejected.

Underlying all investment analysis is an assumption that prices reflect value or can be adjusted to do so (Gittinger 1982). There are problems with the use of investment analysis in a

University of Ghana http://ugspace.ug.edu.gh

developing country like Ghana. In developed countries, market prices are reasonable measures of value of goods and costs since they are more often than not determined by the market mechanism. This is not the case in developing countries where market prices cannot be said to be good indicators of social costs and benefits, because of market imperfections reflected in factors like inflation, currency over-valuation, wage rates and under-employment, protection of infant industry, export disincentives and many others. These problems are however overcome in economic analysis by using shadow or accounting prices, which are considered to reflect the real cost of inputs and real benefit of outputs to the society.

Some of the methods used to evaluate investment analysis are:

1. Payback period;
2. Net Present Value (NPV);
3. Benefit-Cost ratio (B/C) and;
4. Internal Rate of Return (IRR).

The NPV and IRR methods are applied in this study. Despite its simplicity, the Payback Period criterion fails to consider the time value of money and is seriously biased in favour of short-lived projects. The results of the B/C ratios on the other hand are implicitly captured by the NPV method. Besides, the B/C ratio tends to favour smaller projects.

3.2.1 Net Present Value (NPV)

The NPV is the present worth of the net benefit or net cash flow streams. It is the difference between the discounted benefits and costs (Dunn et al 1990).

Mathematically, the NPV is specified as:

$$NPV = \sum_{t=0}^{n}(B_t - C_t)/(1+i)^t \quad \text{.................................(1)}$$

University of Ghana http://ugspace.ug.edu.gh

Where B_t is the benefit in each year, C_t is cost in each year, i is discount rate, t is time and n is the project period.

The NPV method is suitable for analysing the relative viability of a project by indicating whether one project is more economic than another (or others). It is preferable for comparison of viability of different options as it easily copes with changes of costs and revenues over time. This step answers the question as to whether the return on investment for a project is sufficiently high to cover its average costs. A positive NPV means the project will be able to sufficiently recover the cost of investment and make profit. A negative NPV means the project will not be able to sufficiently recover the cost of investment and make profit.

In financial analysis, the NPV is the present worth of the income stream accruing to the individual farmer, while in economic analysis, the NPV is the present worth of the incremental national or societal income generated by the project.

3.2.2 Internal Rate of Return (IRR)

A further criterion which is applied for the purpose of viability calculation is the internal rate of return (IRR). The IRR is used to measure economic performance of time-related investment. Internal rate of return is the maximum 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. More formally, the IRR is the rate of return which equalises the present value of cost and benefit (that is the rate of return at which NPV=0).

Mathematically, the IRR is determined by the formula:

$$0 = \sum_{t=0}^{n} (B_t - C_t)/(1+r)^t \text{...}(2)$$

Where r is the IRR and definitions of other variables are the same as those used in equation (1).

University of Ghana http://ugspace.ug.edu.gh

The interpolation method will be used to determine the value of IRR, because of the problems of multiple-roots, sensitivity to economic life and time phasing of costs and benefits, That is the IRR can be re-specified as follows:

$$r = \mathbf{L_D} + \mathbf{D_{LH}(NPV_{LD}/(NPV_{LD}+NPV_{HD}))} \qquad \textbf{(3)}$$

Where r is the IRR, L_D is the discount rate just before NPV turned negative, D_{LH} is the difference between the discount rate (lower) just before NPV turned negative and the discount rate (higher) at which NPV turned negative, NPV_{LD} is NPV at the lowest discount rate and NPV_{HD} is the NPV at the highest discount rate.

The IRR is a measure of profitability and a useful indicator of the desirability of a project. The higher the rate of return that reduces the NPV to zero, the more attractive the project is. The key advantage of using IRR to compare agroforestry investments is that no specific time preference must be determined (Better 1988). The IRR method is closely linked with the NPV method and is recommended for viability calculation for a single project as the project's IRR is compared with the IRR of the market. However, using IRR only will mean ignoring the timing and relative magnitude of the costs and benefits, so it is combined with the NPV to be able to assess the viability and profitability of the project.

3.3 Estimation of Costs, Returns, and Cash Flows

Investment analysis requires estimates of costs and returns of alternative investments. Whereas, cost is defined as anything that reduces net returns, returns contribute to net returns. For a farmer, a major objective of participating in farming is to maximise the amount or income his family has to live on. Alternative investments considered in this study are cocoa monocropping, cocoa agroforest and diversified system of production. Costs and returns are derived by identifying

University of Ghana http://ugspace.ug.edu.gh

and valuing annual inputs used and outputs. Annual budgets for the investment alternatives provide information on the cash inflows and outflows as indicated in Tables 3.1 and 3.2. Budget structure for cocoa monocrop differs from that of cocoa agroforests with the addition of tree seedlings and labour for planting the trees, while sale of trees add up to the returns.

Table 3.1 Hypothetical Budget Profile for Cocoa Monocropping and Cocoa Agroforests

Cash flows	Activity		
	Establishment period (year 0)	Maintenance period (1-3)	Maintenance, harvesting and selling (year3-40)
Returns: (cash inflows)	-	-	
Costs : (Cash outflows) **Fixed costs**: **Variable cost:** Tools & equipment Labour: **Total**	 Land: Land clearing Tree felling Burning forest Seeds & seedlings Sharpening stone Cutlass, baskets, protective clothing, Wellington boot, rent, Planting, weeding	 - - - - -do-, insecticides -do- -do-, weeding maintenance	 - - - - -do-, drying mats, -do-, harvesting hooks -do-, insecticides weeding, maintenance, harvesting, selling
Cash flows Returns less Costs			

University of Ghana http://ugspace.ug.edu.gh

Table 3.2 Hypothetical Budget Profile for Diversified System

Cash flows	Activity		
	Establishment period (year 0)	Maintenance period (year 1-3)	Maintenance, harvesting and selling (year 3-40)
Returns: (cash inflows)	-	-	
Costs : (Cash outflows)			
Fixed costs:	Land: bee-hive, bee smoker, bee-suit with veil, hive tool, gloves hive stand, fingerlings pick axe, shovel, wood, mesh, snails, sharpening stone	- - -	- - -
Labour	Land clearing, tree felling, burning forest, seeds & seedlings, construction of ponds and padlock	-	-
Variable cost:			
Tools & equipment	Cutlass, baskets, protective clothing, wellington boot, rent, feed	-do- -do-	-do- -do-
Labour:	Planting, weeding, feeding of snail and fish, maintenance, inspection of bee-hive	-do-, processing of honey ,collecting catching and selling of fish and snail	-do-,maintenance, harvesting and selling of cocoa, black pepper and kola nuts
Cash flows Returns less Costs			

University of Ghana http://ugspace.ug.edu.gh

3.3.1 Identification and Valuation of Inputs

Inputs for the establishment of cocoa monocropping include planting materials such as seed and seedling of cocoa, labour, land, cutlasses, hoes, and sharpening stone. Other inputs for maintenance, harvesting and selling are agricultural chemicals including insecticides and pesticides, knapsack sprayer, drying mats, standard prunner and mistblower. Inputs for cocoa agroforest differs from cocoa monocrop only with the addition of timbers tree seedlings and labour for planting the timber seedlings. In the diversified system, inputs include those used in the construction, maintenance, harvesting and selling for snail and fish farming, and bee-keeping as well as inputs for the production of black pepper and kola, which are similar to those used for cocoa production.

All inputs are valued at their market prices. Where a farmer pays separate rent for the use of the land, the rent is shown as the cost of land, but if the land is purchased, the price is used in the analysis. Labour is measured in workdays or hours by type- (adult male or female), likely source- (family, hired, community or project), activity- (establishment, maintenance, harvesting, production, and marketing,) and timing during and over the years. Hired labour is valued at its market price and it is assumed here that family labour is valued at their opportunity cost and hence paid the same wage as hired workers.

3.3.2 Identification and Valuation of Outputs

Output for cocoa monocrop is dried cocoa beans measured in kilograms. Producer price as paid to the farmers is used in the financial analysis. With regard to cocoa agroforest output includes dried cocoa beans and standing timber trees. Various types of trees planted by farmers were identified, and the price of timber quoted by TEDB used in the analysis. Average price of the different timber trees are used in the study. Dried cocoa beans, dried black pepper, kola nuts, snail,

University of Ghana http://ugspace.ug.edu.gh

fish and honey make up the output for the diversified system. Prices farmers received for these products are used in the analysis.

3.4 Data Requirements

Basically primary data, supported with some secondary data, were used in the study. Primary data required for the study include information on the costs and returns from the production of cocoa, timber (logs), snails, fish, kola and black pepper production and bee keeping. This includes data on yields (kg/ ha) of crops per season, quantity of input used per unit area of land and unit prices of inputs used as well as unit prices of outputs.

Inputs include seeds and seedlings (of cocoa, trees/timbers, kola, black pepper), fingerlings, bee hive, smoker, and other planting and maintenance materials such as cutlass, hoes, knapsack sprayer, pesticides, fungicides, insecticides, labour, land, drying mats, sharpening stone, standard pruner, mistblowers and others. The labour data covers different categories of labourers, their activities on the farm and their wage rate. The number of times that certain farm activities are undertaken in a year over the project period was also determined. Furthermore, information on the flow of material input and on tenure systems for tree and land under which farmers operate was also required. Expected useful life of tools used by farmers was also recorded.

Information on the types of trees planted by farmers, sources of acquisition, reasons for choices of trees, expected benefits to be derived as well as tree planting and forest management practices and tree production constraints were determined. Information on cocoa production includes those on establishment, maintenance of mature farms, harvesting, fermentation and drying and sale of dried beans. Data on the construction cost, cost of input and output from snail rearing, bee-keeping and fish farming is also needed. Information on crop yields, trend in crop yield from

University of Ghana http://ugspace.ug.edu.gh

one season to another was also required.

3.5 Sampling and Data Collection Procedures

Farmers who are participating in the interventions introduced by JFM formed the core of the population but household heads were targeted for sampling. Amanor (1997) divided the concession into four blocks as follows:

Block 1-Asiedu, Jompere, and Ampro area (Eastern sector of the concession area);

Block 2- Sikaneasem(North-east of the project area);

Block 3-Draw, Wodisie Attakrom area (South west of the project area);

Block 4- Tabakrom area (North west of the project area).

The rationale for this classification is that it places the settlement in well defined blocks which gives a representative picture of the different geographical and environmental conditions within the project area. For this reason, farmers were selected and interviewed based on this classification. Ten household heads were selected randomly with the help of the JFM/CARE project team from each block to give a total sample of forty. Ten farmers who are purely cocoa farmers were also interviewed informally. Structured and informal questionnaires were used to obtain the primary data required. The purpose of the study was explained to farmers after which they were interviewed and, where possible, their farms visited. A copy of the questionnaire that was used in the interviews is presented in Appendix 1

The JFM/CARE project team was also interviewed to verify some of the data collected from the farmers. Field data on crop yields, trend of yields, and trends of inputs and outputs prices were obtained from other sources as indicated in Table 3. 3.

University of Ghana http://ugspace.ug.edu.gh

Table 3.3 **Data Type and Source**

Enterprise	**Data Type**	Source
Cocoa	Crop yields, trend of yields Inputs and output prices	Cocoa Research Institute, COCOBOD
Black Pepper	Maintenance and harvesting cost, output prices	Plant Genetic and Resources Centre
Kola	Maintenance and harvesting cost	Cocoa Research Institute
Timber	Price of logs, Forest management practices	Forest Products Inspection Bureau (FPIB), Timber Export Development Board (TEDB),

3.6 Data Analysis

To achieve the first specific objective, information from the structured interview on intended use of the timber trees by farmers was combined with field data on uses of the trees, their price and market availability to assess the market opportunities for the trees farmers are planting.

To achieve the specific objective of estimating the financial cash flows to the three systems, local market prices for the physical inputs and outputs are applied to estimate the cash outflows and inflows. Constant 1999 prices are used in the study for price projections. Using a real discount rate of 10%, the present values of the net benefits for each year were computed and summed to derive the NPV and IRR using Microsoft Excel software. This also serves to achieve objectives three and four.

The choice of discount rate is a controversial topic in the literature. High discount rates are believed to be associated with environmental degradation and deforestation (Goodin, 1982; Jepma, 1995). According to Araya et al (1999), high discount rates are associated with degradation because

University of Ghana http://ugspace.ug.edu.gh

individuals prefer short-term measures to satisfy immediate needs at the expense of environmental conservation. Gittinger (1982) notes that in developing countries, the discount rate is assumed to be somewhere between 8% and 12% and a choice of 12% is commonly used. FAO (1979) suggested a value of 10% for forestry projects. The objective of the study and the information above provide the rationale for the 10% discount rate used in the study . The low discount rate reflects the medium and long-term social viewpoint of agroforests.

In this study sensitivity analysis is used to determine the effect of future increase in cost of production, decline in revenue and increase in the discount rate on the economic viability and profitability of the project. Effects of possible reduction of revenue by 10, 20, 30, 40 and 50%, resulting from a fall in yield or price, is analysed. Similar analysis was done for a 10, 20, 30, 40 and 50% increase in production cost resulting from an increase in input prices particularly land and labour. Combined effects of some percentage (10, 20, 30, 40, 50) increases in production costs and declines in revenues on profitability were assessed. This was done to give the analysis greater flexibility given the uncertainty about the true discount rate, prices of inputs and outputs and yield values.

A period of 40 years, representing the economic life of cocoa and timber, is used for the analysis. A review of literature indicates that, economic analysis beyond twenty-five years makes little difference and doubling the life of the project by adding twenty-five years to the analysis only increases the total present worth of the project by about one-fourth of the year's annual benefits (Gittinger 1982). Gittinger points out that the net benefit from the twenty-sixth to the fiftieth year is worth today only about three months' worth of the same net benefit of the first year. However, the economic life of cocoa and the felling cycle of the forest for the timber extraction are both forty years, therefore the economic life of the project is specified at forty years.

University of Ghana http://ugspace.ug.edu.gh

3.7 Determination of Optimal Diversified Mix of Enterprises.

In the analysis of the NPV, IRR, and B/C, certain other constraints and requirements which may exist are ignored. For example, there may be limits on land, labour and capital as well as requirement for certain production levels associated with off-farming activities mentioned earlier, which the regular investment criteria do not take account of.

Linear Programming (LP) is a technique based on the processes of matrix algebra which, given suitably formulated data, is capable of producing optimal, mathematical solutions in terms of either maximising or minimising some stated objective. It thus lends itself readily in farm planning for determining the combination of enterprises and techniques that maximise the returns to a particular set of fixed resources.

This study applies LP to determine the optimal mix of economic activities for diversification. The approach is to combine LP with the investment analysis methods, by maximising the NPV generated from different investment alternatives subject to farmers' production constraints and preferences.

3.8 Linear Programming Formulation

The problem is how many hectares of land to devote to each crop/activity so as to get the desired mix of economic activities that maximise total net present value. The decision variables are hectarage of cocoa (C), kola (K_o), black pepper (B) Timber (T), snail (S), Fish farming (F), bee-keeping (BK).

University of Ghana http://ugspace.ug.edu.gh

The L P formulation of the problem is:

Maximize **RT** = $R_cC + R_{ko} K_o + R_bB + R_t T + R_s S + R_f F + R_{bk}BK$ ....(4)

Subject to::

$h_cC + h_{ko} K_o + h_b B + h_t T + h_s S + h_f F + h_{bk} BK <= H$ ...(5)

$l_c C + l_{ko}K_o + l_b B + l_t T + l_s S + l_f F + l_{bk} BK <= L$ ...(6)

$k_c C + k_{ko}K_o + k_b B + k_t T + k_s S + k_f F + k_{bk} BK <= K$ ...(7)

$C, K_o, B, T, S, F, BK, >= 0$ ....(8)

Where,

RT is the total NPV from the mix of economic activities. R's are net present values from the various enterprises. The h's, l's, and k's are requirements of land, labour and capital respectively for each unit enterprise. H, L, K, are total units of land, labour and capital available respectively.

Equation 4 is the objective function while equations 5, 6 and 7 represent land, labour and capital constraints. Equation 8 is the set of non-negativity constraints.

3.9 Data Requirements and Estimation of the LP Model

Information for the analysis is obtained by synthesizing the budget data requirements earlier discussed . Data required for the study is grouped into objective function and constraints. Total NPVs from various enterprises is used in the formulation of the objective function. Data required for the constraints include actual levels of inputs farmers used on those farms for the various enterprises.

Total capital available was calculated by deducting production cost from the revenues from produce to arrive at cash on hand at the end of each season. Fifty percent of the cash on hand was set aside for home consumption to arrive at total capital available the next year. This capital

University of Ghana http://ugspace.ug.edu.gh

available is also meant to cater for labour cost. However, because labour is set as a separate constraint, the cost of labour is further deducted from the capital available to arrive at the capital limitation value for the analysis. Average land available to the farmers is used as land available. For this reason one 'square mile' equivalent to 18-19 acres or 7.6 hectares is assumed as available land to each farmer. For labour availability, the study considered the fact that farmers use four days in a week at eight hours a day, after deducting taboo, market and Sabbath days. This was changed to mandays of five hours a day to conform to the five hours that hired labourers work.

Table 3.2. **Hypothetical Matrix of Input requirements per activity**.

Crop/others	BP*	Cocoa	Timber	Snail	Fish	BK**	Kola	Total amount required
Land used	h_b	h_c	h_t	h_s	h_f	h_b	h_{ko}	H
Labour used	l_b	l_c	l_t	l_s	l_f	l_b	l_{ko}	L
Capital used	k_b	k_c	k_t	k_s	k_f	k_b	k_{ko}	K
NPVs	R_b	R_c	R_t	R_s	R_f	R_b	R_{ko}	RT

*- Black Pepper **- Bee-keeping

University of Ghana http://ugspace.ug.edu.gh

CHAPTER FOUR

Results and Discussions

4.1 Introduction

The purpose of this study is to examine the prospect of developing cocoa agroforestry system in the light of deforestation and efforts to curb it. The study therefore performs investment analysis of intercropping timber trees in cocoa farms. However, the long gestation period of the timber trees necessitate consideration of a diversified system of farming that could give short-term benefits while waiting for the trees to mature. Optimal mix of economic activities that give the highest returns is evaluated. Industrial use of timber trees, their prices and the market opportunities available to the farmer are also discussed.

4.2 Farming Systems

The study considered three farming systems, on a two hectare land each. These are pure cocoa stand (cocoa monocropping), intercropping timber trees in cocoa farms (cocoa agroforests) and intercropping timber trees in a hectare of cocoa, half a hectare of kola and a quarter of a hectare of black pepper farms, with fish and snail farming as well as bee keeping (diversified system).

The Gwira Banso forest concession area is dominated by migrant farmers with traditions of cocoa farming in other localities. It is a young cocoa growing area and most cocoa farms are young. The characteristic in cocoa growing areas, in which most land is a monocrop of cocoa leaving little available land for food crops, is not yet predominant. In practice, cocoa monocropping from time of establishment to maturity is rarely encountered. Within the cocoa cropping system, farmers

University of Ghana http://ugspace.ug.edu.gh

intercrop food crops in their farms. These crops play three important functions in the cropping system. They provide:

a) shade for young cocoa seedlings, such as in the case of plantain, cocoyam, cassava and banana;

b) food for home consumption in an area where markets are not well developed and provisions are not easy to purchase; and

c) cash income before the cocoa bears fruits.

Since the practice of interplanting food crops is common to farmers who plant timber on their farms and those who do not, the study does not include these intercrops, though it recognizes their importance in the farm development cost and net farm earnings in the early years of the investment.

Farmers in Gwira Banso forest concession plant a variety of timber trees in their cocoa farms. At their request, the trees are planted on their farms by the JFM project staff. The farm may either be an old cocoa farm, newly cultivated cocoa land or abandoned cocoa farm. The trees are planted at a spacing of 15 meters, making about 40 trees per hectare. Most of the trees are intercropped in young cocoa farms of ages up to ten years. Timber trees which farmers in the concession are intercropping in their farms include Edinam (*ent.angolense)*, Mahogany *(khaya spp)*, Makore (*tieghemella heckelii)*, Asanfina *(anigeria)*, Emire (*terminlia ivprensi)*, Ofram (*terminalia superba)*, Sepele (*ent.cylindricum)*, Akasa (*chrysophyllrm albidum)*, Niangon (*heritiera utilis)* and Dahoma (*piptadeniastrum africanum)*.

To relieve pressure to clear more forest land and develop a more sustainable forest-based agriculture, timber trees are also intercropped in more shade-tolerant crops like black pepper and kola. In addition, other income-generating activities are fish culture, snail farming and bee-keeping. Table 4.1 presents the percentage of farmers engaged in the farming activities that diversify cocoa production. Farmers on the average cultivate less than half a hectare of Kola and about a quarter of

University of Ghana http://ugspace.ug.edu.gh

black pepper. The seedlings are provided by JFM. JFM also provides the fingerlings to interested farmers for their fish ponds. Farmers interested in beekeeping were also supplied with bee-hives and other bee-keeping equipments. Snail farmers make their own padlocks. In addition to supplying seedlings of timber trees, kola and black pepper, JFM also provides labour to plant the seedlings for the farmers.

Table 4.1 **Number of Farmers Engaged in Each Farming Activity**

Farming enterprise	Total number of farmers	Percentage of total (%)
Cocoa	40	100
Timber	40	100
Kola	15	38
Black pepper	15	38
Bee-keeping	I1	28
Snail farming	10	25
Fish culture	9	23

Source: Response from structured interviews

4.3 Industrial Use of Timber Trees, Their Prices and Market Opportunities

4.3.1 Industrial Use of Timber Trees

Information on the industrial uses of timber trees from FPIB and TEDB indicates that they vary in their end uses, depending on their strength, weight, durability, and working properties. In general, the trees are used as machined wood to produce a wide variety of mouldings and profiled boards including skirting, architrave, cornices, slices rails, glazing bars, sashes, windows and door

University of Ghana http://ugspace.ug.edu.gh

frames, door trim, panel and edge mouldings. They are also used for furniture parts, doors and windows and their frames, flooring and decking, heavy-duty works, towel and tool handles, veneer and plywood. Tree species planted by farmers are highly priced for their grain and attractive appearance and are therefore valued for high quality door production.

4.3.2 Market Opportunities

Farmers were prejudiced on the markets for their trees as they were assured by the JFM project, that GAP and SAMATEX, both timber firms, would purchase their trees. This is reflected in their response on how they intend to use their trees when they mature as indicated in Table 4.2. Seventy percent of those interviewed prefer to sell their trees to JFM. This is because they see it as unfair to sell their trees to anybody apart from JFM because of the agreement though verbal, to buy the trees and the assistance given to them by JFM. They contended that it is when the JFM decides not to buy the trees that they may consider alternative buyers. About 22% of the farmers however had different opinion and are prepared to sell their trees to the highest bidder irrespective of the assistance from the JFM. They see the trees as solely theirs and can do what ever pleases them. However, about 8% consider the possibility of operating a sawmill as a means to create employment, train the increasing unemployed youth and to add value to their product.

University of Ghana http://ugspace.ug.edu.gh

Table 4.2 **Farmers' Intended Use of the Timber Trees**

Intended use of timber trees	Number of farmers	Percentage (%)
Sell to JFM	28	70
Open saw mill	3	8
Sell to highest bidder	9	22
Total	40	100

Source: response from structured interviews

Markets for the trees do not seem to be a problem because Ghana has about 452 timber firms with about 250 engaged in logging, 124 in saw milling, ply milling and veneer milling, whilst 28 are in furniture manufacturing, flooring, doors and windows, chips and particle board, toys, boards/moulding (TRM (Act527) 1997). Timber trees processed into lumber and other finished products are exported to other African countries and more distant markets including Denmark, Belgium, France, Germany, Greece, Ireland, Italy, Netherlands and others. Exports of such products are kiln dried, well finished and carefully packaged. About 700000 m^3 of the annual allowable cuts of the timber trees support the export market.

4.3.3 Timber Prices

Prices of timber trees are determined on the basis of either bidding or a formula option. The Forestry Commission uses the formula option to determine prices that those in the timber industry pay to the government for extracting timber from the forest. This is based on the fact that trees, as natural resources, are owned by the stool land, but the government acts as the custodian and charges the fee to develop the local communities who own the land. The value of timber tree termed the

University of Ghana http://ugspace.ug.edu.gh

stumpage fee is the standing value of the tree. The stumpage fee is determined by the formula:

SF= TV x TP x SR

Where,

SF =Stumpage fee, TV = Tree volume, TP = timber price and SR= stumpage rate

The tree volume is computed in cubic metres according to the measurement taken of each tree felled, using Smalian's formula (TRM (Act527) 1997). The timber price is 35% of the fob value of the air-dried lumber of the species (i.e. estimated round wood equivalent), based on previous quarter's average of such exports as published from time to time by Forest Product Inspection Bureau (FPIB) and Timber Export Development Board (TEDB). FPIB and TEDB have thus estimated the mean cubic metres for each species as in column 2 of Table 4.3. The stumpage rate for each specie is determined by assigning weights to the price of the log, based on demand and their availability in the forest. Thus species that are abundant in the forest are assigned lower weight and those that are scarce are assigned higher weights.

The price of a specie is thus obtained by multiplying the mean cubic metre by the stumpage fee. Table 4.3 gives the stumpage fee per cubic metre of the various timber trees being planted by the farmers, their mean volumes, their stumpage rate and the price of log. The price per standing tree ranges from ¢283,000 for Ofram to ¢2,304,960 for Makore.

The Forestry Commission is yet to determine the mechanism for computing the price of on farm trees. In Gwira Banso, it is expected to depend on agreement that will be reached between the stakeholders, after taking into consideration assistance farmers received from the JFM.

University of Ghana http://ugspace.ug.edu.gh

Table 4.3 **Prices of Timber**

Local name	Mean/m^3	Stumpage rate %	Stumpage fee /m3 ¢	Timber price/log ¢	FOB price Dm/m3	Timber price 35%of fob/m3 ¢	Fob of log ¢
Asanfina	17.5	20	75,500	1,286,250	750	367,500	6431250
Mahogany	18.0	20	68,600	1,234,800	700	343,000	6174000
Makore	29.4	20	78,400	2,304,960	800	392,000	11524800
Sepele	22.5	20	72,912	1,640,520	744	364,560	8202600
Ofram	11.1	10	25,500	283,050	500	245,000	2719500
Edinam	22.7	10	26,950	611,765	550	269,500	6117650
Emire	10.6	10	33,320	353,192	680	333,200	3531920
Akasa	11.6	10	37,750	426,300	750	367,500	4263000
Niangon	7.6	10	41,160	312,816	840	411,600	3126160
Dahoma	15.7	5	11,025	173,092.5	450	220,500	3461850

Source: FPIB, TEDB 1 DM = ¢1400

University of Ghana http://ugspace.ug.edu.gh

4.4.1 Calculation of Costs and Returns

Estimating the rates of returns from the various activities under consideration is a difficult task. This is so because of the shortage of reliable data on inputs, yields and prices. The estimates of costs and returns are based on the data obtained from the interviews as well as those obtained from other sources. Information provided by the farmers in the forest concession was based purely on recall and experience. Microsoft Excel is used for the calculations of the investment analysis.

4.4.2 Yield, Prices and Returns

Yield and revenue figures used need some explanation. There are three types of cocoa varieties that farmers are planting. These are the traditional Amelonado variety, the Amazonian variety and the Amazonian hybrid[1]. More than 80% of the farmers interviewed are planting Amazonian cocoa because it is more readily available, it has higher yielding capacity and it yields early. Though farmers prefer Amazonian hybrid because they are superior to the Amazonian seedlings, the seedlings are not available to some farmers, as they have to travel to Tafo in the eastern Region to purchase the seedlings. Yield estimates are therefore for Amazonia cocoa.

Yields for shaded and unshaded cocoa are difficult to predict, as evidence is particularly sketchy for the later years of the life of the trees. This is because not much work has been done to determine the yield profile of cocoa with shade and without shade in Ghana. Ahenkorah and Afrofi (1970) observed that the mean yield per annum of unshaded cocoa over a twelve-year period was two times higher than the shaded farms, with the latter showing a rising trend and the former a falling trend. Though their study suggests that shaded cocoa yield less than unshaded cocoa in the early part of their productive life, it also suggests that yield position may change in favour of the

University of Ghana http://ugspace.ug.edu.gh

former during the latter part of their productive life cycle. In Gwira Banso, while farmers who are not planting timber trees but keep some amount of unevenly distributed trees to provide shade are getting 6 x 62.4 kg per hectare, those planting trees are also getting similar yield. The role of shade in the management of cocoa-agroforests is rather complex as it affects or is related to several other growth factors (Wessel 1987). In the absence of a clear-cut evidence of the potential yield, yield of cocoa for both cocoa monocropping and cocoa agroforests used in the study is 12 x 62.4 kg for two hectares, even though the national average is of 624 kg per hectare. Yield profile for cocoa is based on current on-going studies at Cocoa Research Institute of Ghana (CRIG), which is similar to those used by Okali (1974) and Rourke (1974). This assumption undoubtedly may affect the cash flows situation of the two systems

At the time of the survey, farmers were yet to harvest their black pepper, even though a few of the farms were in their first fruiting stage. Hence, expected yield and yield profile was based on information gathered from the Plant Genetic and Resources Centre (PGRC) at Bunsu and farmers in Sefwi Wiaso and Bunso area who are planting the crop. To account for differences in soil, climatic and agronomic condition and practices associated with research stations and off-station situations, expected yield is reduced by 30% .

Yields of kola were also based on yield from the source of supply. According to Karim (2000) Kola hybrid supplied to farmers in Gwira Banso are capable of producing 2000 nuts per tree and this is being achieved in CRIG. The study assumed 50% of this yield and approximately 70% of the trees yielding per annum, as farmers are not properly maintaining their farms[2] and on-station conditions are quite better than off-station.

---

[1] Cross bred between the traditional amelonado variety and varieties from the upper and lower Amazon

[2] Personal Communication: Dr. Karim

University of Ghana http://ugspace.ug.edu.gh

Farmers indicated that, on the average, three out of every ten trees planted died due to transporting of the seedlings and improper planting. Though farmers replace dead trees, it is expected that not all the timber trees will mature hence the study assumed a survival rate of 70%.

Average yield of honey in the concession as recorded by the JFM project was less that one gallon per hive per annum even though a colonised beehive is capable of producing four gallons of honey twice a year (pers com. Aidoo 2000). The study therefore assumed that a hive produced one gallon per annum. This low yield of honey could be attributed to a number of reasons, including poor maintenance of hives, disturbance by predators and the long periods of raining season.

While some farmers occasionally catch fish from their ponds for consumption, others rarely harvest their ponds. A farmer who harvested his pond last year had four medium size baskets which was sold for ¢50,000 per basket. This information was used to represent the yield from the fishing activity, even though it might not be a true reflection of the average yield for the farmers. Similarly, even though farmers used snail for home consumption, some farmers sold 1150 units on the average.

Expected yield profile and price per unit of output from the various farm enterprises are indicated in Table 4.4

University of Ghana http://ugspace.ug.edu.gh

Table 4.4 **Expected Annual Yields and Prices from the Various Activities**

Year	Cocoa Bags	Kola Nut	BP Kg	Timber Log	Snail Unit	Fish Basket	Honey Gallon
0	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-
2	-	-	-	-	1120	4	3
3	-	-		-	1120	4	3
4	1.8	-	33	-	1120	4	3
5	3.0	17325	66	-	1120	4	3
6	4.8	21000	115.5	-	1120	4	3
7-10	6.0	26250	165	-	1120	4	3
11	6.0	42000	165	-	1120	-	3
12	6.0	42000	165	-	1120	-	3
13	6.0	42000	165	-	1120	4	3
14	6.0	42000	165	-	1120	4	3
15	6.0	42000	165	-	1120	4	-
16	6.0	42000	165	-	-	4	-
17	6.0	42000	165	-	-	4	3
18-21	6.0	42000	165	-	1120	4	3
22	6.0	42000	165	-	1120	-	3
23	6.0	42000	165	-	1120	-	3
24-29	6.0	42000	165	-	1120	4	3
30	6.0	42000	82.5	-	1120	4	-
31	6.0	42000	82.5	-	1120	4	-
32	6.0	42000	82.5	-	-	4	3
33	6.0	42000	82.5	-	-	-	3
34	6.0	42000	82.5	-	1120	-	3
35-39	6.0	42000	82.5	-	1120	4	3
40	6.0	42000	82.5	56	1120	4	3
Price (¢)	140,000	50	6,000	698623	500	50,000	35,000

4.5 litres=1 gallon

4.4.3 Estimation of Input Costs

No value is placed upon land in the calculation because of the difficulty in determining the appropriate value to use. Methods of acquiring land in Gwira Banso forest concession vary greatly depending on whether the farmer is a native or migrant, location of the land, type of the soil and the topography. Most of the land is held by migrant farmers on lease as grant or gift from the stools on payment of token payments (less than ¢5000) and/or annual drink payments. The annual drink payments of ¢5000 is used as rent in the study. This is because irrespective of the size of land, each

University of Ghana http://ugspace.ug.edu.gh

household in the forest concession pays this amount annually as 'ntow'[3] to the chief for development purpose.

Cost of transporting farm products from farm to house and to the point of sale were not included in the calculations because of the difficulty in determining transport cost from farm to the point of sale. This is because farmers carry their produce to the market. Instead, this cost is assumed to be captured by the selling cost which, in the case of this study, is meant to be the selling time and carrying of farm produce. Admittedly, this assumption is weak and requires further studies.

At the time of the survey, some farmers, particularly in Tabakrom, were nursing kola seedlings for sale at ¢1000 per seedling. This amount is used in the cost calculation for without incentives scenario. Initially the seedlings were provided free of charge by JFM to the farmers. However, to commit farmers to maintain their farms, JFM decided to charge ¢19500 per pole[4]. This amount is used in the scenario where incentives from JFM's are considered.

Farmers construct their own fish pond and padlock for snail. The study adopted for calculation a padlock constructed by one farmer with the help of her husband using odum wood. The rationale for this is that most farmers are likely to follow suit, as was revealed during the interviews. This is because it is spacious, easy to walk through and attend to the snails, and mash used in construction also prevent the snails from moving out of the padlock.

Based on responses from the interviews, the study assumed that sharpening stone would be replaced after every four years. Drying mats and harvesting hooks are to be replaced every three years, though some farmers recognised that it could be used for much longer when properly maintained and handled. Hives would need to be replaced after every 15 years, smoker and hive

[3] Ntow is the annual drink payments
[4] One pole is equivalent to half of a hectare

University of Ghana http://ugspace.ug.edu.gh

tools every 10 years, and gloves three years. Though farmers are not likely to use the bee-suit continuously because of low yield, the suits as expected wear out in five years and as such need to be replaced. It is also expected that farmers will make general rehabilitation and repairs of the fish pond after every ten years at half the cost of construction. The following are the average costs and prices used in the study.

Inputs	**Costs/Prices (¢)**
Hired and family labour / manday @ 5hrs	3,000
Project lalour / manday @ 5hrs	4,000
Rent	5,000
Cutlass	7,000
Basket (medium size)	2,000
Drying mat	25,000
Cocoa seedling (100 pods)	25,000
Insecticides / litre	20,000
Kola seedling/unit	1,000
Black pepper seedling/ unit	500
Cost of beehive (3units)	240,000
Cost of padlock for snail	150,000
Bee-suit including veil	75,000
Smoker	40,000
Bee gloves	5,000
Hive tool	5,000
Wellington boot	25,000

University of Ghana http://ugspace.ug.edu.gh

Land clearing/ha	30,000
Tree felling (manpower)	100,000
Cost of fingerlings	50,000
Cost of snails (20)	10,000

Table 4.5 shows the value of incentives to farmers for the establishment phase. This value excludes the cost of transportation, consultancy and extension services. For cost incurred by farmers in a situation where incentives from the JFM are considered, annual cash outflows differ by about ¢828,900 in the year of establishment and ¢125,000 in year one, for planting material, labour cost for planting and other input costs for beekeeping, snail and fish farming. Without the incentives from JFM, input costs for beekeeping for establishment period and year one combined is much higher than the rest. This is followed by cocoa, fish farming, kola, snail farming and black pepper, with timber having the least cost.

University of Ghana http://ugspace.ug.edu.gh

Table 4.5 **Estimated value of Input Support to Farmers by JFM for Two Hectare Land**

Activity	Planting cost ¢	Cost of inputs ¢	Total ¢
Cocoa	-	-	-
Kola	58,000	55,500	113.500
Black pepper	76,800	125,000	201,800
Fish farming	-	100,000	100,000
Snail farming	-	10,000	10,000
Beekeeping	-	375,000	375,000
Timber trees	153,600	-	153,600
Total	288,400	665,600	953,900

Source : Author's Own Calculation With Data From JFM

4.5 Cash Flows

The pattern of cash flows varies from activity to activity and depending upon the time crops start bearing fruits. Budget for cocoa monocropping, cocoa agroforest and the diversified system are presented in Tables 4.6 to 4.8. Costs incurred for both cocoa monocropping and cocoa agroforest, if the costs of planting timber trees are not included, tend to be the same. For the diversified system cost is about twice the others. A considerable part of farmers' costs basically relate to labour cost, which in most cases are family labour. This implies that though family labour is valued the same wage as hired workers, not all the cost farmers incurred involve an outlay of cash. Many farmers make use of communal labour or planting materials from either their farms or farms of friends and relatives. Nevertheless, much labour and perhaps cash are required in the case of the diversified system in the establishment period, especially where project support is not given. Annual cost for

University of Ghana http://ugspace.ug.edu.gh

cocoa, black pepper and kola increases when they start bearing fruits because of maintenance, harvesting and selling expenses.

Annual net cash flows differ between cocoa monocropping and cocoa agroforests only in the first year (when cost of planting timber is borne by JFM) and fortieth year by the amount derived from the sale of timber trees. This is so because of the assumption that the yield of cocoa for these two systems is the same. Revenue from timber is expected to be earned in the fortieth year, but this is expected to be greater in the case of cocoa agroforests than the diversified system because part of the land in the diversified system is used for fishpond and snail farming. With a mean volume of about $17m^3$ per tree for an estimated yield of 56 logs to the cocoa agroforests and 49 logs to the diversified system (from two hectares of land), revenue from timber for the two systems are ¢39,122,888 and ¢34,232,527 respectively, using the average price per log of ¢698623. However, between cocoa agroforest and diversified system, cash flow stream from the diversified system is about seven times that from the cocoa agroforest, except in the fortieth year. This implies that, the diversified system has the potential for higher and continuous net cash flow than the other systems. Whiles positive returns are earned from year two in the case of the diversified system, for cocoa monocropping and cocoa agroforests, positive net cash flows start from year five, though revenue starts flowing in from year four.

In the case of the diversified system, snail, fish and honey production have positive returns beginning from year two, while cocoa, kola and black pepper have positive returns from the fifth year. In certain years, net cash flow streams from fish, snail and honey production are negative because of major re-investment in the form of reconstruction of fishponds and padlocks and replacement of beehives. The effect of these on the aggregate net cash flow for the diversified system is positive but smaller returns.

University of Ghana http://ugspace.ug.edu.gh

Table 4.6 **Budget for Cocoa Monocropping**

Year	0	1	2	3	4	5		7	8	9	10	11	12	13	14	15-40
REVENUE																
Cocoa					554400	840000	134400	1512000	1680000	1680000	1680000	1680000	1680000	1680000	1680000	1680000
COSTS																
Land clearing	60000															
ree felling	200000															
Burning (1.2 M.D.)	7200															
Sharpening stone	4000				4000				4000				4000			
Cutlass (2)	14000	14000	14000	14000	14000	14000	1400	14000	14000	14000	14000	14000	14000	14000	14000	14000
Baskets (2 units)	6000	6000	6000	6000	6000	6000	600	6000	6000	6000	6000	6000	6000	6000	6000	6000
Protective clothing	15000	15000	15000	15000	15000	15000	1500	15000	15000	15000	15000	15000	15000	15000	15000	15000
Wellington boot	25000	25000	25000	25000	25000	25000	2500	25000	25000	25000	25000	25000	25000	25000	25000	25000
Rent (ntow)		5000	5000	5000	5000	5000	500	5000	5000	5000	5000	5000	5000	5000	5000	5000
Planting cost (21.5 M.D.)	129000															
Cost of seedlings (200 pods/ha	100000															
Weeding (23.3/35 M.D.)		139800	210000	210000	139800	139800	13980	139800	139800	139800	139800	139800	139800	139800	139800	139800
Plucking (9.6 M.D.)					57600	57600	5760	57600	57600	57600	57600	57600	57600	57600	57600	57600
Gathering &heaping (4.8 M.D.)					28800	28800	2880	28800	28800	28800	28800	28800	28800	28800	28800	28800
Pods breaking & fermentation					38000	38000	3800	38000	38000	38000	38000	38000	38000	38000	38000	38000
Drying of beans (6.8 M.D)					40800	40800	4080	40800	40800	40800	40800	40800	40800	40800	40800	40800
Selling cost (5 M.D.)					30000	30000	3000	30000	30000	30000	30000	30000	30000	30000	30000	30000
Drying mats (2)					50000			50000			50000			50000		
Harvesting hooks (3)					15000			15000			15000			15000		
Spraying (1.4 lit/ha @ 2 sprays)					175200	175200	17520	175200	175200	175200	175200	175200	175200	175200	175200	175200
TOTAL COSTS	560200	204800	275000	275000	644200	575200	57520	640200	579200	575200	640200	575200	579200	640200	575200	575200
NET REVENUE	-560200	-204800	-275000	-275000	-89800	264800	76880	871800	1100800	1104800	1039800	1104800	1100800	1039800	1104800	1104800

M.D- Mandays of labour

Table 4.7 **Budget for Cocoa Agroforest Without Incentive to Farmers**

Year		1	2	3	4	5	6	7		9	10	11	1	13	14	15-39	40
REVENUE																	
Timber																	39122860
Cocoa					554400	840000	1344000	1512000	168000	1680000	1680000	1680000	168000	1680000	1680000	1680000	1680000
TOTAL REVENUE					554400	840000	1344000	1512000	168000	1680000	1680000	1680000	168000	1680000	1680000	1680000	40802860
COSTS																	
Land clearing	6000																
Tree felling	20000																
Burning (1.2 M.D.)	720																
Sharpening stone	400				4000				400				400				4000
cutlass (2)	1400	14000	14000	14000	14000	14000	14000	14000	1400	14000	14000	14000	1400	14000	14000	14000	14000
Baskets (2 units)	600	6000	6000	6000	6000	6000	6000	6000	600	6000	6000	6000	600	6000	6000	6000	6000
Protective clothing	1500	15000	15000	15000	15000	15000	15000	15000	1500	15000	15000	15000	1500	15000	15000	15000	15000
Wellington boot	2500	25000	25000	25000	25000	25000	25000	25000	2500	25000	25000	25000	2500	25000	25000	25000	25000
Rent (ntow)		5000	5000	5000	5000	5000	5000	5000	500	5000	5000	5000	500	5000	5000	5000	5000
Planting cost (21.5 M.D.)	12900																
Cost of seedlings (200 pods/ha	10000																
Weeding (23.3/35 M.D.)		139800	210000	210000	139800	139800	139800	139800	13980	139800	139800	139800	13980	139800	139800	139800	139800
Plucking (9.6 M.D.)					57600	57600	57600	57600	5760	57600	57600	57600	5760	57600	57600	57600	57600
Gathering &heaping (4.8 M.D.)					28800	28800	28800	28800	2880	28800	28800	28800	2880	28800	28800	28800	28800
Pods breaking & fermentation					38000	38000	38000	38000	3800	38000	38000	38000	3800	38000	38000	38000	38000
Drying of beans (6.8 M.D)					40800	40800	40800	40800	4080	40800	40800	40800	4080	40800	40800	40800	40800
selling cost (5 M.D.)					30000	30000	30000	30000	3000	30000	30000	30000	3000	30000	30000	30000	30000
Drying mats (2)					50000			50000			50000			50000			50000
Harvesting hooks (3)					15000			15000			15000			15000			15000
Spraying (1.4 lit/ha @ 2 sprays)					175200	175200	175200	175200	17520	175200	175200	175200	17520	175200	175200	175200	175200
Planting of timber trees	15360																
TOTAL COSTS	71380	204800	275000	275000	644200	575200	575200	640200	57920	575200	640200	575200	57920	640200	575200	575200	644200
NET REVENUE	-71380	-204800	-275000	-275000	-89800	264800	768800	871800	110080	1104800	1039800	1104800	110080	1039800	1104800	1104800	40158660

M.D- Mandays of labour

Table 4.8 Budget for Diversified System Without Incentive to Farmers

Year	0		2	3	4	5	6	7	8	9	1	11	12	13-39	40
REVENUE:															
Cocoa					277200	420000	672000	756000	840000	840000	84000	840000	840000	840000	840000
Kola						866250	1050000	1312500	2100000	2100000	210000	2100000	2100000	2100000	2625000
Black pepper					198000	396000	693000	990000	990000	990000	99000	990000	990000	990000	495000
Honey			105000	105000	105000	105000	105000	105000	105000	105000	10500	105000	105000	105000	105000
Snail			560000	560000	560000	560000	560000	560000	560000	560000	56000	560000	560000	560000	560000
Fish			200000	200000	200000	200000	200000	200000	200000	200000	20000			200000	200000
Timber															34232505
TOTAL			**865000**	**865000**	**1340200**	**2547250**	**3280000**	**3923500**	**4795000**	**4795000**	**479500**	**4595000**	**4595000**	**4795000**	**39057505**
COSTS															
General Expenses:															
Land clearing	60000														
Tree felling	200000														
Burning (2.4 M.D.)	7200														
Sharpening stone	4000				4000				4000				4000		4000
cutlass (2)	14000	1400	14000	14000	14000	14000	14000	14000	14000	14000	1400	14000	14000	14000	14000
Baskets (3 units)	6000	600	6000	6000	6000	6000	6000	6000	6000	6000	600	6000	6000	6000	6000
Protective clothing	15000	1500	15000	15000	15000	15000	15000	15000	15000	15000	1500	15000	15000	15000	15000
Wellington boot	25000	2500	25000	25000	25000	25000	25000	25000	25000	25000	2500	25000	25000	25000	25000
Rent (ntow)		500	5000	5000	5000	5000	5000	5000	5000	5000	500	5000	5000	5000	5000
Cocoa:															
Planting cost (21.5 M.D.)	64500														
Cost of seedlings (200 pods/ha)	50000														
Weeding (23.3/35 M.D.)		6990	105000	105000	69900	69900	69900	69900	69900	69900	6990	69900	69900	69900	69900
Plucking (9.6 M.D.)					28800	28800	28800	28800	28800	28800	2880	28800	28800	28800	28800
Gathering &heaping (4.8 M.D.)					14400	14400	14400	14400	14400	14400	1440	14400	14400	14400	14400
Pods breaking & fermentation					19000	19000	19000	19000	19000	19000	1900	19000	19000	19000	19000
Drying of beans (6.8 M.D)					20400	20400	20400	20400	20400	20400	2040	20400	20400	20400	20400
selling cost (5 M.D.)					15000	15000	15000	15000	15000	15000	1500	15000	15000	15000	15000
Drying mats (2)					50000			50000			5000			50000	50000

University of Ghana http://ugspace.ug.edu.gh

Table 4.8 Continued

Harvesting hooks (2)					10000			10000			10000			10000	10000
Spraying (1.4 lit/ha @ 2 sprays)					87600	87600	87600	87600	87600	87600	87600	87600	87600	87600	87600
Kola:															
Planting cost (14.5 M.D.)	58000														
Cost of seedlings	19500														
Weeding (26.2 M.D.)		78600	78600	78600	78600	78600	78600	78600	78600	78600	78600	78600	78600	78600	78600
Collection of pods (12.8M.D)					38400	38400	38400	38400	38400	38400	38400	38400	38400	38400	38400
Pods breaking															
Pods peeling															
Storage															
selling cost (3 M.D.)					9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
Black pepper:															
Planting cost (19.2M.D.)	76800														
Cost of seedlings(500/seed for 250	125000														
Pruning &thinning (12.8 M.D.)		38400	38400	38400	38400	38400	38400	38400	38400	38400	38400	38400	38400	38400	38400
Harvesting (25.6 M.D.)					76800	76800	76800	76800	76800	76800	76800	76800	76800	76800	76800
Drying(11.2)					33600	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600
Knife															
Weeding cost (20.8 M.D.)		62400	62400	62400	62400	62400	62400	62400	62400	62400	62400	62400	62400	62400	62400
Selling cost(3 M.D.)					9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
Beekeeping:															
Cost of hive (3)	240000														
Cost of smoker		40000									40000				40000
Beesuit including veil		75000					75000					75000			
Hive tool		5000									5000				
Gloves		5000			5000			5000			5000			5000	5000
Hive stand	10000														
Inspection & maintence (5.2 M.D.)		15600	15600	15600	15600	15600	15600	15600	15600	15600	15600	15600	15600	15600	15600
Harvesting & processing of honey (2 M.D.)		6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Fish:															
Construction of ponds	150000														
Cost of fingerlings (200 pcs)	100000														
Cost of net															

Table 4.8 Continued

Feeding & maintenance (36.4 M.D.)		109200	109200	109200	109200	109200	109200	109200	109200	109200	109200		109200	109200	109200
Harvesting & selling (4 M.D.)			12000	12000	12000	12000	12000	12000	12000	12000	12000			12000	12000
Reconstruction of pond												75000			
Feeding cost		34667	34667	34667	34667	34667	34667	34667	34667	34667	34667		34667	34667	34667
Snail:															
Padlock construction	150000														
Cost of snails	10000														
Feeding & maintence (36.4 M.D.)		109200	109200	109200	109200	109200	109200	109200	109200	109200	109200	109200	109200	109200	109200
collecting and selling(3 M.D.)			9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
Reconstruction of padlock															
Timber:															
Planting cost(38.4 M.D.)	153600														
Seedling															
TOTAL COSTS	**1538600**	**713967**	**645067**	**645067**	**1030967**	**961967**	**1036967**	**1026967**	**965967**	**961967**	**1071967**	**956100**	**953967**	**1026967**	**1070967**
NET REVENUE	**-1538600**	**-713967**	**219933**	**219933**	**309233**	**1585283**	**2243033**	**2896533**	**3829033**	**3833033**	**3723033**	**3638900**	**3641033**	**3768033**	**37986538**

M.D. -Mandays of labour

University of Ghana http://ugspace.ug.edu.gh

4 .6 Profitability and Viability of the Farming Systems

This study seeks to explore the profitability/viability from the point of view of a farmer who wishes to decide between growing a cocoa monocrop, cocoa intercropped with timber trees and a diversified system of cocoa agroforest on a two hectare plot of land. A discount rate of 10% is applied. The analysis is done under the two scenarios of the farmer receiving some support or incentives from the JFM project and the farmer not receiving such incentives. These alternatives are described as 'with' and 'without' support to farmers. Tools of investment analysis such as NPV and IRR are used to assess the financial viability of investment alternatives.

The results presented in Table 4.10 show that at a discount rate of 10%, the NPV for cocoa monocrop is ¢5,102,332, indicating that it is profitable. Also the resulting interest rate (IRR) at which the NPV is zero amounts to 30%. The IRR also confirms the profitability of the system, since an IRR of 30% exceed the discount rate of 10%. The results also show that agroforest gives a NPV of ¢5,784,529 and an IRR of approximately 28% if a farmer operates without incentives. With incentives, the NPV and IRR are ¢5,888,165 and 30% respectively. Similarly, diversified system of cocoa agroforests gives a NPV of ¢ 19,159,115 and an IRR of 40% if a farmer operates without incentives, and NPV and IRR of ¢ 20,015,966 and 53% respectively, if the farmer operates with incentives.

University of Ghana http://ugspace.ug.edu.gh

Table 4.9 **Results of Investment Analysis for the Various Farming Systems for both With and Without Incentives to Farmers**

Criteria	Cocoa monocropping	Cocoa agroforests	Diversified system
NPV(¢):without incentive	5,102,332	5,784,529	19,159,115
With incentive	5,102,332	5,888,165	20,015,966
IRR (%):Without incentive	30	28	40
With incentive	30	30	53

Source : Author's Own Calculation With Data From JFM

Although all the farming systems considered indicate positive NPVs, with IRRs which are higher than the discount rate and therefore are all profitable, the NPV for the diversified system is about three times as high as that of cocoa agroforest and four times that of cocoa monocropping. By comparison, Cocoa agroforest is more profitable than cocoa monocropping, but the diversified system is superior to the other two in terms of profitability. Equally important is the positive effect of incentives on the profitability of both systems of cocoa agroforestry. The NPVs evaluated by taking into account incentives to farmers tend to be higher than when farmers do not receive support. By implication, with all the IRRs (both for 'with' and 'without' incentives) higher than the 1999 nominal market interest rate of 27%, all the three farming systems considered would be profitable, even if the market interest rate is used.

Tables 4.10 shows the investment results for the various enterprises in the diversified system for both 'with' and 'without' incentives. The results indicate that with the exception of fish farming, which exhibits a negative NPV and is therefore unprofitable, all the other farm enterprises realized positive NPV, IRRs higher than the 10% discount rate and are thus profitable. Though fish farming proves to be unprofitable, its effect on the diversified system is negligible. This means that a hectare

University of Ghana http://ugspace.ug.edu.gh

of cocoa farm intercropped with timber trees is capable of returning about ¢2,263,595 to a farmer for a forty year period.

Table 4.10 **Results of Investment Analysis of Various Farm Enterprises in the Diversified System**

Farm enterprises	**Without incentives**		**With incentives**	
	NPV@10% (¢)	**IRR (%)**	**NPV@10% (¢)**	**IRR (%)**
Cocoa	**2,263,595**	28	**2,263,595**	28
Kola	**10,140,237**	55	**10,143,419**	64
Black pepper	**3,221,969**	36	**3,405,423**	48
Timber	**525,803**	14	**665,439**	21
Snail	**3,041,716**	98	**3,050,807**	102
Fish	**-1,148,626**	4	**-57,717**	6
Honey	**45,057**	12	**375,636**	175

Source: Authors Own calculation

This result compares favourably with the results of Rourke (1973) and COCOBOD (1997) that returns investments in the establishment of cocoa are high, particularly when returns from intercrops included. Comparatively, the result further shows that NPVs from about half a hectare of kola and a fifth of a hectare of black pepper are higher than that from one hectare of cocoa. This confirms the importance of diversifying cocoa production with other cash crops such as those considered in this study. This result confirms the assertion by Imex International Incorporation that black pepper will yield four times more than cocoa and earn about five times more foreign exchange, given the same

University of Ghana http://ugspace.ug.edu.gh

piece of land[5]. Interestingly, all three cash crops thrive well under similar agro-climatic conditions, therefore they can complement each other in generating returns to the farmer. Similarly, NPV for snail production far exceeds that of cocoa, even though the size of land farmers use is less than a tenth of the land for cocoa.

Using the 1999 market interest rate of 27% for the various enterprises in the diversified system, fish farming and tree planting would not be profitable, even with incentives. Beekeeping is profitable only when incentives are considered at this market rate, as indicated in Table 4.10.

Whereas profitability deals with difference between income and expenses and can be measured by net farm income, viability assesses the attractiveness of the proposed investment alternatives to farmers and to other participants including the society as a whole. Viability is therefore concerned with the widespread adoption of the practice, its ability to uplift the economic standards of the rural population (which includes how rural development can be enhanced and rural poverty reduced), its relevance to large-scale applications, and its longer-term macroeconomic role in the development processes.

With a mean of about 17 cubic metres per tree, a hectare of cocoa agroforest with about 28 timber trees is capable of producing approximately 476m^3. Besides, farmers and their trees grow old together. Thus, for a farmer who started clearing forest and planting cocoa in 1959, when he was 25, an earning of ¢17,116,252 from a hectare of land in 1999, could be a perfect retirement capital, if he had planted timber trees, as indicated in Table 4.3. Most farmers interviewed consider the planting of trees as property they are likely to bequeath to their children.

The trees can also provide the initial condition for cocoa cultivation or replanting, thus ensuring the sustainability of the cocoa industry. Such an agroforestry strategy copies and improves

[5] Personal Communication: Dr E. Blay. Crop Science Department, University of Ghana, Legon. Accra.

University of Ghana http://ugspace.ug.edu.gh

the shifting cultivation concept, which allows farm land to be re-used and for agriculture to return to the same place after a period of use (Zade and Ruf 1998). The ability of cocoa to produce reasonably well under shade could be used to increase the supply of timber in the country. With about 600,000 to 800,000 cocoa farmers in the country, intercropping timber trees in cocoa farms could be a sure way of curbing deforestation as farmers will appreciate the value of trees when clearing land for cultivation. This is possible because cocoa producing areas have the same environmental and climatic conditions for timber tree growing. Cost of production as evidenced in the study is also low and returns are high. Besides, maintaining cocoa farms means indirectly maintaining the trees, which may even reduce the gestation period of the trees.

Even though fish farming proves to be unprofitable, its role as a source of protein, in an area as remote as Gwira Banso where access to transport and market is a problem, cannot be over emphasized. The same applies to snail farming and beekeeping.

4.6.1 Sensitivity Analysis

Detailed results of the sensitivity analysis for the three farming systems 'with' and 'without' incentives are summarised in Tables 4.11 to 4.16. The results as indicated in Table 4.11 reveal that all the three farming systems will continue to be profitable when revenue declines by up to 50%, whether incentives are provided or not. But as revenue falls relative profitability is reduced. This makes the investments less attractive and more sensitive to falling revenue. By comparison, cocoa monocrop is most sensitive followed by cocoa agroforest and then the diversified system. However, as revenue declines beyond 10%, cocoa monocrop and cocoa agroforest system 'with and without' incentives tend to be unprofitable, when the IRR's results are compared with the 1999 interest rate of 27%. At this market interest rate, the diversified system becomes unprofitable as

University of Ghana http://ugspace.ug.edu.gh

revenue declines beyond 30% and 40% for the systems 'with out' and 'with' incentives respectively. As expected farming systems without incentives are more sensitive to declining revenue than those with incentives.

Table 4.11 **Decline in Revenue**

Decline in revenue	**Cocoa monocrop** NPV @	IRR (%)	**Cocoa-agroforests** NPV (¢)	IRR (%)	**Diversified system** NPV (¢)	IRR (%)
Without incentives						
10%	4,131,000	27	4,698,614	25	16,282,197	36
20%	3,159,669	24	3,648,699	22	13,405,280	33
30%	2,188,337	20	2,598,784	19	10,528,362	29
40%	1,217,006	16	1,548,870	16	7,651,445	24
50%	245,675	11	498,955	12	4,774,527	20
With incentives						
10%	-	-	4,838,250	27	17,139,049	48
2 0%	-	-	3,788,336	24	14,262,131	43
30%	-	-	2,738,421	21	11,385,214	38
40%	-	-	1,688,506	17	8,502,960	32
50%	-	-	638,591	13	5,631,379	25

As in Table 4.11, the results obtained when the IRR's for the three farming systems are compared with the 1999 interest rate are the same, if revenues are disaggregated into prices and outputs, as indicated in Table 4.12. However, Unlike the case where all the farming systems are profitable when revenues decline by 50%, using the NPVs, Table 4.12 indicates that cocoa monocropping is unprofitable when output or prices fall by 50%. The results emphasize the superiority of the cocoa-agroforest and diversified system over the cocoa monocrop in terms of profitability.

University of Ghana http://ugspace.ug.edu.gh

Table 4.12 **Decline in Prices or Outputs**

Decline in price/output	Cocoa monocrop		Cocoa-agroforests		Diversified system	
	NPV @	IRR (%)	NPV (¢)	IRR (%)	NPV (¢)	IRR (%)
Without incentives						
10%	3,689,846	26	4,169,054	24	15,832,407	36
2 0%	2,725,601	22	3,128,961	21	13,005,465	33
30%	1,761,356	18	2,088,870	17	10,178,525	29
40%	797,111	14	1,048,778	14	7,351,585	24
50%	-167,134	9	8,687	10	4,524,644	19
With incentives						
10%			4,308,690	26	16,689,258	48
2 0%			3,268,598	22	13,862,317	43
30%			2,228,506	19	11,035,376	38
40%			1,188,415	15	8,208,436	32
50%			148,323	11	5,381,495	25

With regard to increases in production cost using the NPVs, the results revealed that when costs go up by 10% and revenue declines by up to 50% simultaneously, all the three farming systems will continue to be profitable, whether incentives are provided or not. When costs go up by 20%, cocoa monocrop and cocoa agroforests become unprofitable if revenue falls by 50%. Cocoa monocrop becomes unprofitable when costs increase by 30% and revenue declines by 40%, but when costs go up to 40%, both cocoa monocrop and cocoa agroforest become unprofitable. At 50% increase in costs, cocoa agroforest becomes unprofitable if revenue declines by 40% whiles cocoa monocrop becomes unprofitable at 30%. The diversified system become unprofitable only when incentives are not provided, at both 50% increases in costs and reduction in revenue simultaneously

University of Ghana http://ugspace.ug.edu.gh

(Tables 4.13-4.17). This indicate that diversified system is less sensitive and more robust to declining revenue and increasing costs rate than the other two systems.

On the contrary, as cost increases and revenue declines simultaneously beyond 10%, cocoa monocropping and cocoa agroforest systems become unprofitable when the market interest rate of 27% is compared with the IRR results obtained. At this market rate, the diversified system becomes unprofitable, when costs increase beyond 10% and revenue also declines beyond 20% when incentives are not considered and 30% when incentives are considered.

Table 4.13 Costs increase by 10% while revenue declines by 10%,20%, 30%, 40%, 50%

Without incentives						
Decline in revenue	Cocoa monocrop		Cocoa-agroforests		Diversified system	
	NPV (¢)	IRR (%)	NPV (¢)	IRR (%)	NPV (¢)	IRR (%)
10%	3669902	25	4223552	23	15321191	33
20%	2698571	22	3173637	20	12444274	30
30%	1727239	18	2123723	17	9567356	26
40%	755908	14	1073808	14	6690439	22
50%	-215424	9	23893	10	3813521	17
With incentives						
10%	-	-	4377152	25	16263728	44
20%	-	-	3327237	22	13386810	39
30%	-	-	2277323	18	10509893	34
40%	-	-	1227408	15	7632975	28
50%	-	-	177493	11	4756058	22

Table 4.14 **Costs increase by 20% while revenue declines by 10%,20%, 30%, 40%, 50%**

Decline in revenue	Cocoa monocrop		Cocoa-agroforests		Diversified system	
	Without incentives					
	NPV (¢)	IRR (%)	NPV (¢)	IRR (%)	NPV (¢)	IRR (%)
10%	3208804	22	3748490	21	13715680	31
20%	2237472	19	2698575	18	10913242	27
30%	1266141	16	1648661	15	8110804	24
40%	294809	11	598746	12	5308367	20
50%	-76522	6	-451169	9	2505929	15
	With incentives					
10%	-	-	3916054	22	16263728	44
20%	-	-	2866139	19	13386810	39
30%	-	-	1816224	16	10509893	34
40%	-	-	766309	13	7632975	28
50%		-	-283605	9	4756058	22

Table 4.15 **Costs increase by 30% while revenue declines by 10%,20%, 30%, 40%, 50%**

Decline in revenue	Cocoa monocrop		Cocoa-agroforests		Diversified system	
	Without incentives					
	NPV (¢)	IRR (%)	NPV (¢)	IRR (%)	NPV (¢)	IRR (%)
10%	2747706	20	3273428	19	13399179	28
20%	1776374	17	2223514	16	10522262	25
30%	805043	13	1173599	13	7645344	22
40%	-166289	9	123684	10	4768427	18
50%	-1137620	4	-926231	7	1891509	13
	With incentives					
10%	-	-	3454956	20	14513086	37
20%	-	-	2405041	17	11636168	33
30%	-	-	1355126	14	8759251	28
40%	-	-	305211	11	5882333	23
50%	-	-	-744704	8	3005416	17

University of Ghana http://ugspace.ug.edu.gh

Table 4.16 **Costs increase by 40% while revenue declines by 10%,20%, 30%, 40%, 50%**

Decline in revenue	Cocoa monocrop NPV (¢)	Cocoa monocrop IRR (%)	Cocoa-agroforests NPV (¢)	Cocoa-agroforests IRR (%)	Diversified system NPV (¢)	Diversified system IRR (%)
Without incentives						
10%	2286607	18	2798366	17	12438173	26
20%	1315276	15	1748452	15	9561256	23
30%	343944	11	698537	12	6684338	20
40%	-627387	7	-351378	9	3807421	16
50%	-1598719	4	-1401293	6	930503	11
With incentives						
10%	-	-	2993857	18	13637765	34
20%	-	-	11943943	16	10760848	30
30%	-	-	894028	13	7883930	25
40%	-	-	-155887	10	5007012	20
50%	-	-	-1205802	7	2130095	15

Table 4.17 **Costs increase by 50% while revenue declines by 10%,20%, 30%, 40%, 50%**

Decline in revenue	Cocoa monocrop NPV (¢)	Cocoa monocrop IRR (%)	Cocoa-agroforests NPV (¢)	Cocoa-agroforests IRR (%)	Diversified system NPV (¢)	Diversified system IRR (%)
Without incentives						
10%	1825509	16	2323304	16	1147167	24
20%	854177	13	1273390	13	8600250	21
30%	-117154	10	223475	11	5723332	18
40%	-1088486	5	-826440	8	2846415	14
50%	-2059817	1	-1876355	5	-30503	10
With incentives						
10%	-	-	2532759	17	12762444	32
20%	-	-	1482844	14	9885527	27
30%	-	-	432929	11	7008609	23
40%	--	-	-616985	8	4131692	18
50%	-	-	-	6	1254774	13

University of Ghana http://ugspace.ug.edu.gh

4.7.0 Linear Programming Model

Results of the investment analysis for the diversified system indicate that all the individual enterprises, except fish farming, are profitable. However, this analysis so far fails to account for the constraints farmers face and how these will determine the optimum mix of enterprises in terms of the highest possible returns to farmers. The Linear Programming Model is used to address these shortcomings of the investment analysis. Table 4.18 shows the estimated levels of constraints and resource requirement used in the linear programming. The LP matrix is presented in Appendix B.

Table 4.18 **Estimated Levels of Resource Constraints and Requirement**

Crops/Others	Cocoa	Timber	Snail	Fish	Kola	Black Pepper	Bee Keeping	Total amount Required
Land Used/ha	1	1	1	1	1	1	1	7.6
Labour used/ MD	2181	51	1485	1479	1652	2842	448	13320
Capital used (¢)	5,923,200	74,120	534,120	2,056,800	816,000	569,600	1,717,480	44,086,500
Net Returns (¢)	2,263,595	525,803	3,041,716	-148,626	10,140,237	3,221,969	450,574	RT

MD= Mandays of Labour

University of Ghana http://ugspace.ug.edu.gh

4.7.1 Linear programming formulation

1) MAXIMISE NPV=

$2263595\ C + 10140237\ K_o + 3221969\ B + 525803\ T + 3041716\ S - 148626\ F + 450574BK$

SUBJECT TO

2) $5923200\ C + 816000\ K_o + 569600\ B + 74120\ T + 534120\ S + 2056800\ F + 1717480\ BK <= 44086500$

3) $2181\ C + 1652\ K_o + 2842\ B + 51\ T + 1485\ S + 1479\ F + 448\ BK <= 13320$

4) $C + K_o + B + T + S + F + BK <= 7.6$

5) $C >= 1$
6) $K_o >= 1$
7) $T >= 1$
8) $B <= 0.4$
9) $F <= 0.4$
10) $S <= 0.4$
11) $BK <= 0.2$
12) $B >= 0$
13) $S >= 0$
14) $F >= 0$
15) $BK >= 0$

Where C = Cocoa, K_o = Kola, T = Timber, B =Black pepper, S =Snail, BK = Beekeeping, F = Fish

Equation 1 is the objective function and equations 2, 3 and 4 are constraints for capital, labour and land respectively. Equations 5 to 11 are restrictions imposed on the respective activities of the model, whiles 12 to 15 are non-negativity constraints.

The study assumed that at least one hectare of land must be planted to cocoa and kola, at most 0.4 hectare to planting black pepper and fishpond each, and 0.2 hectare for beekeeping.

The linear programming model was estimated using Lindo INteractive Optimzer (LINDO) Computer Software. The LP solution (present in pages 82 and 83) indicates which mix of enterprises is optimal in terms of profitability. The optimal mix of enterprises from a land of 7.6 hectares is 5.01 hectares kola, one hectare each of cocoa and black pepper, 0.4 hectares of timber, and no snail production, fish rearing and beekeeping. The optimal solution to the LP model, which is the maximum NPV attainable from combining kola, cocoa, black pepper and timber, taking into consideration constraints farmers faced is ¢56,498,960. However, for a farmer to consider the production of fish, snail and beekeeping which have been excluded from the mix of the diversified system, the results indicate that the NPVs should be increased up to ¢9,226,962 for fish, ¢6,073,448 for snail, and ¢2,299,320 for beekeeping. This implies that a farmer will lose ¢9,226,962 from fish production, ¢6,073,448 from snail production, and ¢2,299,320 from beekeeping, if he is to consider them in the mix of farming enterprises. The results further indicate that the NPVs of cocoa, kola, black pepper and timber could be allowed to increase, each by less than ¢11,123,728, ¢6,891,656, ¢14,222,676 and infinity respectively without changing the result. However, an increase equal to these amount and beyond might change the solution. Similarly, the NPVs of cocoa and black pepper could be allowed to decrease up to infinity without causing any change in the result. However, the decline in the NPVs of kola and timber should not exceed ¢6,756,456 and ¢212,756 respectively, if the result is to remain the same.

The model also gives an indication of the unused resources. Thus, ¢33,475,852 of capital is idle and could be used elsewhere by the farmer. That is, capital could be allowed to increase by any amount or could be decreased by up to ¢33,475,852. Labour, on the other hand, is fully used, but the results show that it could be allowed to increase by about 314 and decrease by 6625 without changing the results of the model. However, the extra cost of increasing labour by one unit is ¢6138. This means that it will cost more to bring additional labour to the diversified system once the optimal is reached and labour is used up. On the hand, this implies that an additional unit of labour

University of Ghana http://ugspace.ug.edu.gh

will reduce the maximum NPV by ¢6138. From the results, unused land is about 0.2 hectares even though the size of it could be increased to any amount and the optimal NPV will not change. But decreasing the size of land by about 0.2 will change the result. This implies that the results of the model are very sensitive to changes in land area. The results further indicate that the size of land allotted to cocoa, kola, timber and black pepper could each be allowed to increase by about 3, 4, 2.3 and 0.2 hectares respectively without changing the results of model.

The results of the LP are presented below.

The LP Solution

OBJECTIVE FUNCTION VALUE

1) 56,498,960

VARIABLE	VALUE	REDUCED COST
C	1.000000	0.000000
K_o	5.0100048	0.000000
B	1.000000	0.000000
T	0.4000000	0.000000
S	0.000000	6073448.5
F	0.000000	9226962
BK	0.000000	2299320.75

ROW	SLACK OR SURPLUS	DUAL PRICES
2)	33475852	0.000000
3)	0.000000	6138.158203
4)	0.189952	0.000000
5)	0.000000	-11123728
6)	4.010048	0.000000
7)	0.000000	-14222676
8)	0.400000	212756.937500
9)	0.400000	0.000000
10)	0.400000	0.000000
11)	0.200000	0.000000
12)	0.000000	0.000000
13)	0.000000	0.000000
14)	0.000000	0.000000
15)	0.000000	0.000000

RANGES IN WHICH THE BASIS IS UNCHANGED:

	OBJ COEFFICIENT RANGES		
VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
C	2263595	11123728	INFINITY
K_o	10140237	6891656	6756456
B	3221969	14222676	INFINITY
T	525803	INFINITY	212756.937500
S	3041716	6073449	INFINITY
F	-148626	9226962	INFINITY
BK	450574	2299321	INFINITY

University of Ghana http://ugspace.ug.edu.gh

RIGHTHAND SIDE RANGES

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
2	44086500	INFINITY	33475852
3	13320	3130799988	6624.599609
4	7.600000	INFINITY	0.189925
5	1.000000	3.037414	0.593195
6	1.000000	4.010048	INFINITY
7	1.000000	2.330964	0.263697
8	0.400000	0.196002	0.400000
9	0.400000	INFINITY	0.400000
10	0.400000	INFINITY	0.400000
11	0.200000	INFINITY	0.200000
12	0.000000	0.000000	INFINITY
13	0.000000	0.000000	INFINITY
14	0.000000	0.000000	INFINITY
15	0.000000	0.000000	INFINITY

University of Ghana http://ugspace.ug.edu.gh

CHAPTER FIVE

Conclusions and Recommendations

5.1 Conclusions

Literature has revealed that cocoa monocropping is not sustainable and has had a major impact on deforestation in Ghana. To arrest the increasing trend of deforestation and ensure sustainable agriculture, cocoa agroforests, a practice in which cocoa is intercropped with forest trees species as opposed to shifting has been proposed. This study analyzed the investment benefits of cocoa monocropping, cocoa-agroforest and a diversified form of cocoa agroforest. It also modelled the diversification of the current agricultural practices in Gwira Banso JFM project. The results presented in the study are meant to be a guide, not a prediction of the exact benefits and costs a farmer will experience. Site conditions, local prices and yields, and local customs vary widely even in Gwira Banso and Western Region in general. All of these factors can have a dramatic effect on the profitability and viability of cocoa production.

Because of the attractive appearance and the nature of the grain of the trees farmers are planting, the trees are valued for both domestic and industrial uses are there highly priced. With about 452 timber industries in the country, a ready market also exists for the trees farmers are growing. Besides, the ability of cocoa to produce reasonably well under shade could be used to increase the supply of timber trees in the country. From the results, a hectare of cocoa-agroforest is capable of producing approximately 476 m^3. Therefore, if cocoa farmers in Ghana numbering between 600,000–800,000 would intercrop their farms with forest tree species, then cocoa agroforest could be used to restore the depleted forest. The trees could also provide the initial condition for cocoa cultivation and replanting, thereby ensuring the sustainability of the cocoa

University of Ghana http://ugspace.ug.edu.gh

industry. Thus, unlike food crop production that involves shifting of crop fields and therefore clearing of forests, cocoa agroforests are semi-permanent or permanent. This also means better protection of and improvement in soil organisms or below ground bio-diversity over time. Farmers will come to appreciate the value of timber trees especially when clearing new lands for cultivation, if they plant trees themselves. More so, the trees could be a perfect retirement capital for the farmers who plant them or wealth of property to bequeath to their dependents.

The results of the study indicate that annual net cash flows differ between cocoa monocropping and cocoa agroforest only in the establishment year (when planting cost of timber is borne by JFM) and the fortieth year by the amount of revenue derived from the sale of timber trees. However, the annual net cash flows for the diversified system is about seven times that of cocoa monocrop and cocoa agroforest. Thus, while major differences exist in the cash flows of diversified system and the other farming systems, the differences in cash flow of cocoa monocropping and cocoa agroforest is negligible except in the establishment year and at the end of the life of investments. Diversifying cocoa agroforest to include other cash crops such as black pepper and kola and other income generating activities also has the potential to earn positive returns from year two and generate higher and continuous net cash flows.

Though all the farming systems are profitable according to the NPV and IRR criteria, cocoa-agroforest is more profitable and viable than cocoa monocropping, but the diversified system is superior to cocoa monocropping and cocoa-agroforest in terms of profitability and viability. It was observed that cocoa monocropping is most sensitive to declining prices or output than revenue, followed by cocoa-agroforest and then the diversified system. In addition to being less sensitive to declining revenue, the diversified system is more robust to the combined effect of increasing costs and declining revenue than cocoa-agroforest and cocoa monocropping. Thus, diversifying cocoa

University of Ghana http://ugspace.ug.edu.gh

production to include growing timber trees, other shade-loving cash crops like kola and black pepper in addition to short-term income generating activities such as beekeeping, snail and fish farming have the potential to improve the livelihood of small scale farmers.

The optimal solution to the LP model, which is the maximum NPV attainable from combining kola, cocoa, black pepper and timber, taking into consideration constraints farmers faced is ¢56,498,960 from 5.01 hectares of kola, one hectare each of cocoa and black pepper, and 0.4 hectares of timber. However, a farmer will lose ¢9,226,962 from fish production, ¢6,073,448 from snail production, and ¢2,299,320 from beekeeping, if he is to consider them in the mix of farming enterprises.

5.2 Recommendations

The recommendations that follow are made in the light of the findings, conclusions and the situations in Gwira Banso forest concession. The study recommends a more aggressive use of agroforestry as a tool for rural development and poverty alleviation as well as environmental conservation. However, much labour and cash are required especially during the establishment phase. Therefore, incentives in the form of providing minimal material inputs, combined with technical assistance for seedling production and planting could help reduce 'out of pocket' expenditure for farm families for whom cash is a scarce resource and reduce the perceived risk of new practices. The support should be made for a limited period, reduced gradually and eventually eliminated once farmers become aware of the immense benefits to the system. Besides, extension and technical support need to be highly responsive to farmers' concerns and should provide a range of options and outline their advantages and disadvantages.

Alternatively, because benefits start accruing from the second year for the diversified

University of Ghana http://ugspace.ug.edu.gh

system, a viable credit scheme or arrangement to allow farmers to make payments for labour, after product sales is essential to ensure expansion of agricultural production.

Farmers in Gwira Banso forest concession fear possible expropriation of their land or future inability to harvest and sell trees without permit, because of some harvesting laws and regulations created to protect the forest in the country. Farmers with insecure land and tree rights will face particular constraints for agroforestry investment. Mechanisms should be promoted which exempt on-farm timber tree plantings from costly approval procedures. Simple systems to register trees planted by farmers could serve this purpose and would maintain protection for natural forest areas while removing constraints to tree planting.

Even though CARE is providing extension services, there is the need to train and use farmers or community members to liaise between extension agents and communities to provide direct link with farm and community when the extension agents cannot be present. Training of farmers through participation in community and family nurseries could reduce the need for continued technical assistance, making local communities more self-sufficient and lower the need for project or government assistance. Furthermore, successful past results achieved by farmers could be an effective way to convince other farmers to engage in agroforestry, especially when they can discuss the results with the farmers who implemented them.

Above all, assistance in the identification and development of markets should be provided as an effective incentive to encourage farmers to undertake these agroforestry practices. Higher producer price is essential to accelerate these innovations.

5.3 Suggestions for Future Research

In Ghana, environmental contributions associated with agroforestry and farm forestry are

University of Ghana http://ugspace.ug.edu.gh

usually assumed rather than scientifically confirmed, because of the near to total lack of research. Therefore, more socio-economic studies are needed to develop cocoa agroforestry systems, which could provide greatest social benefits.

Regarding cocoa research, reorientation of the breeding program to develop disease resistant and shade-tolerant varieties is necessary to reduce management and maintenance cost, and make it more economically attractive to farmers. Besides, while researchers have much to learn about these complex systems from farmers, an area of potential effort that could improve the productivity of the cocoa agroforest lie in the rationalization and optimal arrangement and spacing of trees. Also complete assessment of the range of livelihood opportunities affecting the rural poor is necessary if the incentives to reduce poverty are considered.

University of Ghana http://ugspace.ug.edu.gh

REFERENCES

Abeney E.A., Owusu I.G. K., (1999) Workshop for media personnel on forestry and wildlife proceeding. IRNR, UST, Kumasi.

Agyeman V.K., Brookman-Amissah J. (1987) Agroforestry as a sustainable Agricultural Practice in Ghana. Forest Products Research Institute, Kumasi.

Ahenkorah Y., Akrofi G. S. (1968) Amazon cacao (Theobroma cocoa L.) shade and manurial experiment (2-01) at the Cocoa Research Institute of Ghana; First five years. Agronomy Journal 60:591-594.

Ahenkorah Y., Akrofi G. S. and Adri A K (1974) The end of the first cocoa shade and manurial experiment at the Cocoa Research Institute of Ghana, Journal of Horticulture Science 49:43-51

Ahenkorah Y., Akrofi G. S. (1977) Amazon cacao (Theobroma cocoa L.) shade and manurial experiment (K2-01) at the Cocoa Research Institute of Ghana. 111 Cumulative yield analysis. Cocoa Research Conference. Ibadan Nigeria 1975.

Aidoo (2000) Personal communication. Bee Expert for JFM.

Alpizer L., Fassbender H.W, Heuveldop J., Foelster H. and Enriquez G. (1966) Modelling Agroforestry Systems of cocoa (Theobroma cacao) with Laulel (Cordiaoalliodra) or Poro(Erythrina poeppigiana) in Costa Rica. Part 1 Inventory of organic matter and nutrients Agroforestry systems 4: 175-190.

Amanor K S (1997), Socio-economic survey for the Gwira Banso project, Institute of African Studies, Legon.

Amanor K S (1994). The New Frontier (eds.), Farmer Response to Land Degradation. A West Africa Study. UNRISD, Geneva.

Amoah F.M. Muertey B.N., Baidoo-Addo, Oppong F. K., Osei Bonsu K., Asamoah T.E.O. (1995) Underplanting oilpalm with cocoa in Ghana. Agroforestry systems 30:2899-299.

Amoah J.E.K. (1995) Development of coca consumption, commercial production and marketing .No 1. Cocoa Outline Series.

Amoah J.E.K. (1997) Marketing of Ghana cocoa: Local Purchasing and External Marketing.

Anderson D. (1987) The economics of afforestation: A case study in Africa. Occasional

University of Ghana http://ugspace.ug.edu.gh

Paper No.1 John Hopkins Press, Baltimore USA.

Anim-Kwapong G J and Tekehaimanot Z (1995), Reclamation of Degraded Cocoa Land using Albizia zygia. Land Degradation and Rehabilitation, vol. 6, 2:109-123.

Anonymous, (undated), Joint Forest Management Project, Management Plan. Unpublished.

Antwi L.B. (1999)What We Have : Our forest Heritage. In Abeney E.A., Owusu J.G.K. (1999) Workshop for Media Personnel on Forestry and Wildlife Proceedings. IRNA,UST, Kumasi.

Appiah M and Pedersen T R (1998), Participatory Forest Management in Gwira Banso, Ghana. Master thesis for the Department of Economic and Natural Resources, Royal Veterinary and Agricultural University, Copenhagen. Unpublished.

Araya B., Asafu-Adjaye (1999) Returns of Farm-Level Soil Conservation on Tropical steep Slopes: The case of the Eritrean Highlands: Journal of Agricultural Economics.

Arnold J.E.M. (1984) Economic consideration in Agroforestry Systems. Agroforestry Systems 1(4)299-317.

Arnold J.E.M. (1994) Non-farm employment in small-scale forest-based enterprise: policy and Environmental issues. Oxford forestry Institute. Department of Plant Science. Univ. of Oxford, UK.

Ashraf M.(1990) Economic evaluation of alley cropping for sustainable agriculture in humid West Africa. Univ. of Florida USA.

Barnana C.S., Nix J.S. (1979) Farm Planning and Control (2nd eds). Cambridge Univ. Press. Melbourne, Sydney.

Beer J, Bonneman A, Chavez W, Fassbender H W, Imbech A C , Martels I (1990) .Moddelling agroforestry systems of cacao with coria and Erythrna poeppigiana in Costa Rica. V. Productivity indices, organic matters models and sustainability over ten years. Agroforestry systems 12:229-249

Beer J (1987), Advantages, disadvantages and desirable characteristics of shade for coffee, cocoa, and tea. Agroforestry systems 5: 3-13.

Beer J (1988) Litter production and nutrients cycling in coffee (coffea arabia) or cacao (theobroma cacao) plantations with shade . Agroforestry systems 7:1030114.

Betters D R (1988), planning optimal economic strategies for Agroforestry systems. Agroforestry systems 7:17-31.

University of Ghana http://ugspace.ug.edu.gh

Brown M.L. (1979) Farm budget from farm income analysis to agricultural project analysis. John Hopkins Univ. Press .Baltimora, London.

Bonaparte E. E. N. A. (1973) Recent Research finding and their implications for cocoa production ".In Kotey R A, Okali C and Rourke B E (1973) (eds.), The economics of Cocoa Production and Marketing. Proceedings of Cocoa Economics Research Conference Legon, ISSER.

CARE International (1999), The Gwira Banso Community Forest Management Project 1999-2004. Unpublished.

Chaing A C (1984) (eds) Fundamental Methods of Mathematical Economics. McGraw Hill. Singapore.

Cobbinah J.R. (1992) Snail Farming in West Africa. A practical Guide. Technical Centre for Agricultural and Rural Cooperation (CTA) Hong Kong

COCOBOD (1997) Repot of the advisory committee on credit scheme for cocoa farmers , GHANA COCOA BOARD.

Cunningham RK (1963), What shade and fertilizers are needed for good cocoa production. Cocoa Growers Bull 1:11-16.

Cunningham RK and Lamb J (1959), A cocoa shade and manurial experiment at West African Cocoa Research Institute, Ghana I. First year J Hortic sci 34:14-22.

Current D., Lutz E., Scherr S.J. (1995) The costs and benefits of agroforestry to farmers . The World Bank Researcher Observer Vol. 10 No 2:151-180

Current D and Scherr (1995), Farmer Costs and Benefits from agroforestry and farm forestry projects in Central America and Caribbean: implications for policy. Agroforestry Systems 30:87-103.

Danida (1995), Proposal. Joint Forest Management Project, Ghana: Ministry of Foreign Affairs. Unpublished.

DLH (1995) Proposal to Danida's Private Sector Program, Ghana: Technical co-operation on Joint Forest Management Between Ghana Primewood Products Limited, Ghana and Dalhoff Larsen & Horneman A/S, Denmark. Unpublished.

Duguma B, Gockowskib J, Bakala J. (n d) Smallholder Cocoa (Theobroma cscao Linn.) Cultivation in Agroforestry Systems of West and Central Africa: Challenges and Opportunities. Yaounde, Cameroon.

University of Ghana http://ugspace.ug.edu.gh

Dumanski J., Terry E., Byerlee D. and Pieri C.(1998a) Performance indicator for Sustainable Agriculture, (Discussion Paper) Rural Development Sector .World Bank .Washing ton. D.C.

Dumanski J, Terry E and Pieri (1998b), Sustainable land and crop Management Performance Indicators for sustainable Agriculture, Rural Development, World Bank. Unpublished.

Dunn W W, Lynch A M and Morgan P (1990), Benefit- Cost Analysis of Fuelwood Management using native alder in Ecuador. Agroforestry Systems 11:125-139.

Egbe N.E., Adenikuga S.A. (1990) Effects of intercropping on the potential yield of cocoa in south western Nigeria. Cafe 'cacao The'34(4):281-284.

Ehui S. K., Kang B.T., Spencer D.S.C.(1990) Economic Analysis of soil Erosion Effects in alley cropping, No-till and bush Fallow Systems an South western Nigeria. Agricultural systems (in press).

Ekanade O. (1987) Spatio-temporal Variations of Soil Properties Under Cocoa Interplanted with Kola in a part of the Nigeria Cocoa Belt. Agroforestry Systems 5:418-428.

Elliot (1973) A benefit/cost analysis of development programs in Ivory Coast .In Kotey R A, Okali C and Rourke B E (1973) (eds.). The economics of Cocoa Production and Marketing. Proceeds of Cocoa Economics Research Conference Legon, ISSER.

FAO (1988) An interim Report on the State of Forest Resources on Developing Countries. FAO Rome.

Fassbender H.W., Alpizar L. Heuveldop J., Folster H., Enriquez G. (1988) Modelling Agroforestry Systems of cocoa (Theobroma cacao) with Laulel (Cordiaoalliodra) or Poro(Erythrina poeppigiana) in Costa Rica. 111 Cycles of organic matter and nutrients. Agroforestry Systems 6:49-62.

Fassbender H.W., Beer J., Heuveldop J., Imbeach A.,Enriquez G.and Bonnemann A Beer .(1991) Ten-year Balance of organic matters and nutrients in Agroforestry systems of CATIE, Costa Rica

Fujisaka S., Wollenberg E.(1991) From Forest to agroforest and logger to Agroforest: A case study. Agroforestry Systems 14:113-129

GAP (1994), Ghana Primewood Products: Proposal for pilot project, project identification study. Unpublished.

GEAP (1991) Ghana Environmental Action Plan (EAP) Ghana

Ghana Timber Marketing Board. (1969) Ghana Hard Woods

University of Ghana http://ugspace.ug.edu.gh

Gittinger J P (1982), (eds.) Economic Analysis of Agricultural Projects. John Hopkins University Press, Baltimore.

Goodin R. (1982) Discounting, Journal of Public Policy 2:53-72 (quoted in Araya B.,Asafu-Adjaye 1999)

Greenwood and Djokoto (1952) Quoted in Ekanade O. (1987) Spatio-temporal Variations of Soil Properties Under Cocoa Interplanted with Kola in a part of the Nigeria Cocoa Belt. Agroforestry Systems 5:418-428.

Hans-Joachm G. (1995) Economic Analysis of Agroforestry Systems, Plant Research and Development Vol.41/42. Institute for Scientific Cooperation, Tubingen, Germany.

Hartley C.W.S.(1966)The oilpalm .(2nd ed) Longman 806pp.

Herzog F.(1994) Multipurpose shade Trees in Coffee and Cocoa plantations in Coted' lvoire. Agroforestry Systems 27:259-267

Heuveldop J., Fassbender H.W., Alpizar L., Enriquez G. Folster H.(1988) Modelling Agroforestry Systems of cocoa (Theobroma cacao) with Laulel (Cordiaoalliodra) or Poro(Erythrina poeppigiana) in Costa Rica. 11. Cacao and wood production, litter production and decomposition. Agroforestry systems 6 37-48

Hoekstra D A,(1987), Economics of Agroforestry. Agroforestry Systems 5:293-300.

Hoekstra D A, (1990), Economics of Agroforestry. In MacDicken K G and Vergara N T (eds.) Agroforestry: Classification and Management. Wile, New York, USA.

Imbach A.C., Fassbender H.W., Borel R., Beer J and Bonnemann A. (1989) Modelling Agroforestry Systems of cocoa (Theobroma cacao) with Laulel (Cordiaoalliodra) or Poro(Erythrina poeppigiana) in Costa Rica. V. Productivity indices, organic material models and sustainability over ten years. Agroforestry Systems 12:229-249

IRAD (1997) Progress Report on Slash and burn agricultural research in Cameroon; IRAD, Yaounde, Cameroon.

Jezard A., Akikumah N. (1989) Bees for beginners GRATIS project Tema

JFM (1997) Gwira Banso Project. Unpublished.

Jickling J (1989) Short-term Economic Benefits of Agroforestry :A Survey Report to USDA Forestry Support Program, USDA Washington DC USA

Johnson D.V, Nair P.K.R. (1984) Perennial Crop Based Agroforestry in North east Brazil.

University of Ghana http://ugspace.ug.edu.gh

Agroforestry Systems 2:281-222.

Johnson D.V., Nair P.K.R. (1983) Perennial Crop Based Agroforestry Systems in North-East Brazil . Agroforestry Systems 3:269-273

Karim (2000) Personal Communication. Cocoa Research Institute of Ghana. Tafo, Ghana..

Kotey R A, Okali C and Rourke B E (1973) (eds.). The economics of Cocoa Production and Marketing. Proceedings of Cocoa Economics Research Conference Legon, ISSER.

Kotto-Sam J.P.L., Woomer M., Appolinaire, Zapfact L. (1997) Carbon dynamics in slash-and-burn agriculture and land use alternatives in the humid forest zone of Cameroon Agriculture Ecosystems and Environment,1205.

Koutsoyiannis A (1979) (eds) Modern microeconomics. ELBS Macmillan, Hong Kong.

Leach J.R., Sheperd R., Turner P.D .(1974) Under planting coconut with cocoa in West Indies .Cocoa Growers Bulletin 16:21-26.

Lilieholm R. J.,Reeves L. H.(1991) Incorporating Economic Risk Aversion in Agroforestry Planning. Agroforestry Systems 13:63-71

Lowe P.D., Twunasi-Ankrah R. (1992) Economics of agroforesry cropping systems. FAO Accra

MacDicken K G, and Vergara N T (1990), (eds.) Agroforestry: Classification and Management. Wiley, New York, USA.

Manu M and Tetteh (1987), A Guide to Cocoa Cultivation. CRIG.

Mary F., Michon G. (1987)When agroforests Drive Back Natural Forest: A Socio-economic analysis of a Rice-agroforest system in Sumatra. Agroforestry systems 5:27-55.

Ministry of Lands and forestry (1994) Forestry and Wildlife Policies.

Ministry of Lands and Forestry-MLF (1998)Quality Management of Ghana's Forest, Principles Document. Unpublished.

Mussak M F and Laarman J G (1989), Farmers Production of Timber Trees in the cocoa-coffee region of Coastal Ecuador. Agroforestry Systems 9:155-170.

Nair PKR (1993) An Introduction to Agroforestry. Kluwer Academic Publishers. London.

Nair P K R (1990), The Prospects for Agroforestry in the Tropics. World Bank Technical Reports paper number 131.

University of Ghana http://ugspace.ug.edu.gh

Nash C.A., Pearce (1981) The Social Appraisal of Projects. A Text in Cost Benefit analysis. ELBS, Macmillan.

Ofori F., Stennett H. R., Dampson J. A.(1990) Agroforestry an option for revising environmental degradation and improving agricultural productivity. Proceedings of the National Workshop on agroforestry. Agroforestry Unit, Crop Services Dept. MOFA

Ohene-Cofie F. (1997) Trees as Accumulated capital for Rural communities .Ghana Journal of Forestry Vol.5:17-22, FORIG Kumasi.

Olayemi (1973) Costs and returns to cocoa and alternative crops in Western Nigeria. In Kotey R A, Okali C and Rourke B E (1973) (eds.), The economics of Cocoa Production and Marketing. Proceedings of Cocoa Economics Research Conference Legon, ISSER.

Omotoso (1971) quoted in. Ekanade O. (1987) Spatio-temporal Variations of Soil Properties Under Cocoa Interplanted with Kola in a part of the Nigeria Cocoa Belt. Agroforestry Systems 5:418-428.

Oni and Adubi (1973) The economics of fertilzer use in cocoa production. In Kotey R A, Okali C and Rourke B E (1973) (eds.), The economics of Cocoa Production and Marketing. Proceedings of Cocoa Economics Research Conference Legon, ISSER.

Ossei J.E.K.(n.d.) Cola- Some Aspect of its cultivation and economics in Ghana. The Ghana Farmer Vol 7 No3:96-97

PGRC (n.d.) Factsheet on Black Pepper (piper nigrium)

PGRC (n.d.) Producing Black Pepper. FactSheet. Plant Genetic and Resources Centre.

Pleydell G. (1994) The Tropical Timbers of Ghana, TEDB

Prah E (1997,1998,1999), Reports of the Joint Forest Management-Gwira Banso Project. Unpublished.

Price C. (1989) The theory and Application of Forest Economics. Blackwell Oxford.

Price C (1995), Economic evaluation of financial and non-financial costs and benefits in Agroforestry and the value of sustainability. Agroforestry systems 30:75-86.

Price C. (1995) Moderate Discount rate and the competitive Case for Agroforestry. Agroforestry Systems 32:53-61.

Purseglove (1976) Tropical Crops: Dicotyledons. Harlow, Longman.

University of Ghana http://ugspace.ug.edu.gh

Raintree J. B., Turray F.(1980) Linear Programming Model of an Experimental Leucaena-rice alley cropping systems. IITA Research Briefs 1:5-7

Ramadasan K., Abdullah I., Teoh K. C., Vanialigan T. and Chan E.(1978). Intercropping of coconuts with cocoa in Malaysia. Magazine of the Incorporated Society of Planters 54(622):329-342.

Rourke B E (1973) Profitability of cocoa and alternative crops in Eastern Region, Ghana. In Kotey R A, Okali C and Rourke B E (1973) (eds.), The economics of Cocoa Production and Marketing. Proceedings of Cocoa Economics Research Conference Legon, ISSER.

Ruf and Zade (1998) Cocoa from deforestation to Reforestation. CIRAD.

Sayer J A, Harcourt C S and Collins N M (1992), The Conservation Atlas of Tropical Forests. Africa.

Schroeder P. (1994) Carbon Storage Benefits of Agroforestry Systems. Agroforestry Systems 27:89-97.

Seluavinayagam K. (1991) Financial analysis in Agricultural project preparation. FAO Investment Centre. Technical Paper 8. Rome.

Sheperd R., GubertJ.R., Turner P.D., Cowlling R.G. (1977) Aspect of cocoa cultivation under coconut on two estates in Peninsular Malaysia Planter Kuala Lumpur 53:99-117.

Smyth A.J. (1980) Soil Classification and the cocoa Grower. Cocoa Grower Bulletin. No 30

Sumberg J.E., Malntire J., Okali C., Atta-Krah A.N. (1987) Economic analysis of alley farming with small ruminants. ILCA Bulletin 28:2-6.

Stennett H R , Dampson J A (1990) Development of Agroforestry Programme and Extension in the ministry on agriculture. In Ofori F., Stennett H. R., Dampson J. A.(1990) Agroforestry an option for revising environmental degradation and improving agricultural productivity. Proceedings of the National Workshop on agroforestry. Agroforestry Unit, Crop Services Dept. MOFA

TRM(1997) Acts 527. Timber Resources Management, Forestry Commission. Accra

Tutu K.A., Baah-Nuakoh A (1994) Western Region Environment- economic Linkage.

Tutu K (n.d.) Environmental impact of Ghana's Structural Adjustment. University of Ghana, Accra.

Verinumbre I., Knipscheer H.C., Enubor G.E.(1984) The economic potential of leguminous

University of Ghana http://ugspace.ug.edu.gh

tree crops in zero -tillage cropping in Nigeria: A linear programming model. Agroforestry systems 2:129-139.

Wessel M (1985) Shade and nutrient. In: Wood GAR and Lass R A(eds) Cocoa. Tropical Agricultural Series, Longman Scientific &Technical ,Harlow.

Wojtkowski P A, Jordon C F and Cubbage F W (1991), Bio-economic modelling in Agroforestry: a rubber-cacao example. Agroforestry Systems 14:163-177.

Wojtkowski P A (1991) A bordered matrix approach to the bioeconomic modeling of agroforestry systems. Agroforestry Systems 14:81-97.

Wojtkowski P.A., Brister H., Cubbage W.(1988) Using Multiple Objective Linear Programming to evaluate Multi-participant agroforestry Systems. Agroforestry Systems 7:184-197

Wood G.A.R. (1973) Cacao longman Group Ltd London.

Wood GAR and Lass RA (1985) (eds) Cocoa. Tropical Agricultural Series, Longman Scientific & Technical, Harlow.

World Bank (1988) Staff Appraisal Report: Ghana Forest Resources Management Project (No. 7295-GH). World Bank, Washington DC USA, 119pp.

University of Ghana http://ugspace.ug.edu.gh

APPENDICES

APPENDIX A: Sample Questionnaire

ECONOMICS OF COCOA AGROFOREST IN THE GWIRA BANSO JOINT FOREST MANAGEMENT PROJECT IN WESTRN REGION OF GHANA

SECTION A

A. GENERAL No ....

Date of Interview: ....

Location :Settlement/village: ....

District: ....

SOCIO-ECONOMIC CHARACTERISTICS.

1. Name of the farmer
2. Age:...
3. Gender: 1 = Female 2 = Male
4. Marital status: 1 = Single 2 = Married 3 = Widow/Divorce
   4 = Separate 5 = Others (specify)..
5. Ethnicity : 1 = Ewe 2 = Krobo 3 = Gwira 4 = Akwapim
   5 = Fanti 6 = Ashanti 7 = Frafra 8 = Others (specify)..........
6. How long have you been farming in this area? ....yrs

6.b Could you please tell why you choose to farm in this area?

....

7. Distance between house and farm..
8. Other off-farm income generating activities.....................

9.a. Total household members:

Age group	male	female
65 and above	....	....
15 - 64	....	....
below 15	....	....

University of Ghana http://ugspace.ug.edu.gh

9b. Household members available for farm work:

Age group	male	female
65 and above	……..	……..
15- 64	…….	……..
below 15	……..	…….

SECTION B

A. FARMING PRACTICE (S) AND LAND USE

10. How many farms do you have? …………………..

11.a Could you please tell the total size of your land/farm holdings in this area ?………….. (poles/acres)?

b. What size of farmland is currently under cultivation?
……. (poles/acres)

12.a What size of the land cultivation is used for cocoa cultivation?
……...(poles/acres)

b. Of this land used for cocoa cultivation, could you please tell the size that host
Abandoned cocoa farms ………..(poles/acres),
Young cocoa farms (1-3yrs)………(poles/acres),
Less mature cocoa farms (4-10yrs)……..(poles/acres),
Mature cocoa farms (above 10yrs)……...(poles/acres),
Cleared land for cocoa cultivation…….. (poles/acres)?

13.a Which other crops do you cultivate on your cocoa farms?
1= kola 2= black pepper 3= timber trees
What size of your land is used for the following in poles/acres
1= cocoa/kola………….. 2=Cocoa/black pepper………..
3=kola/black pepper……… 4=kola/timber tree ……….
5=cocoa/black pepper /timber …….. 6=cocoa/kola/black pepper……
7=black pepper/ kola/ timber ………

14.a Which cocoa variety(s) do you cultivate on your farms?
1=Amazon 2=Amelonado/Tetteh Quarshie 3=Hybrid

University of Ghana http://ugspace.ug.edu.gh

b Could you please give reason(s) for you choice?

....

B. LAND PREPARATION

15. How do you prepare your land for cultivation?

....

16. How do you fell the trees for land preparation ....

....

17.a Do you use any other method to kill the trees apart from felling? Yes/No

If yes, could you please describe the method?..............................

18.a Do you clear all the trees from your land when preparing it for cultivation?

Yes/ No,

If no, how many trees do you normally leave on a piece of land? ....

19. Are the trees cleared not important to you ?..........

20.a Which type(s) of trees are left on the farm when clearing land for cultivation?

1=timber trees 2=trees to provide shade 3= others...........

21. Could you please mention some of the trees you leave on your farm? (see appendix)

22.a Are the trees you leave on the farms the only ones you normally would have wished to leave? Yes/No

b. If no, which other trees would you have liked to leave? (see appendix)

c. What prevented you from maintaining them on your farms?.............

C TREE PLANTING

23.a Have you planted timber trees in your farms? Yes/No

IF YES, PLEASE ANSWER THE FOLLOWING QUESTIONS

b. How many trees have you planted so far?.................trees

24. Could you please tell the number of trees you planted during the following years?

1996................ 1997...........

1998................ 1999............

25.a Were all the trees planted in your cocoa farms? Yes/No

b. If no, how many trees did you plant in your cocoa farms during the following years?

1996...... 1997.......

University of Ghana http://ugspace.ug.edu.gh

1998.......... 1999..........

c. Of the trees planted in your cocoa farms, could you tell the number that was planted in the following farmlands?

Farmland	1996	1997	1998	1999	Total
Abandoned cocoa					
Young cocoa farm(1-3yrs)					
Less mature farms(4-10yrs)					
Mature cocoa farms(above 11yrs)					
Cleared land for cocoa cultivation					

27. Could you please name the different types of trees you have planted? (See appendix)
28. How do you care for the trees you grow?...................................
29. What benefit do you expect to gain from the trees in your farms and the ones you are growing? Please rank them

    1=medicine 2=income from sale 3=Shade for cocoa farms

    4=improve soil fertility 5=reduce deforestation

    6=Reduce soil erosion Others..................................
30. What motivated you to start growing trees?

    1=because everybody is planting trees

    2=I expect to get some support from JFM/CARE INT.

    3=Just as explained in Q. 29

    4=others..

31a. Where do you get your seedlings for planting the trees?

1=nurse them myself 2=purchase 3=JFM

4=others..

31b If you purchase, how much is the cost per seedling? ø.......................

32. If the answer to Q 31 is JFM, then what will happen when they stop providing you with the seedlings?

    1=stop planting explain..

University of Ghana http://ugspace.ug.edu.gh

2=purchase/nurse the seedling myself and reduce planting

3=purchase/nurse and continue planting till achieve target

4=others...

33. Do all the trees you plant grow? Yes/No

If no, how many die out of every ten trees planted?.........................

If no, could you please explain the cause of their death?

1=natural 2=accident 3=poor maintenance

4=no maintenance 5=others...

34. Do you have problem(s) with the tree planting? Yes/No

If yes, explain

1=trees compete for space and nutrients

2=can't look after them

3=trees take long time to grow and bring money

4=others...

35. Could you suggest solutions to the problem(s) you encounter with the tree planting?...

36. How do you intend to use the trees when they mature?

1=sell to JFM 2=open saw-mill

3=sell to the highest biding timber contractor

4=others...

37. How would you manage to harvest the trees so as to minimise damage to the farms?...

38. What will happen after you have sold all economic trees from your farms?

1=stop planting trees 2=continue planting trees

explain your answer...

D. LAND ACQUISITION

A. LANDLORD

39. How did you acquire the land? Please indicate the value per unit(pole acre)

1=purchase......... 2=rent ....year

University of Ghana http://ugspace.ug.edu.gh

3=gift................ 4=inherited.........

5=loan............... 6=others..............

40. Do you practice share cropping? Yes/No

b. If yes, which type of share cropping? 1=Abunu 2=Abusa

How much do they pay for the land?

Type	number of sharecropping	Unit	Value
Abunu	....	....	....
Abusa	....	....	....

B. TENANT/SUBTENANT

41. How did you acquire the land?

1=chief 2=family land 3=individual land owner

4=others........................

42. What type of tenant agreement do you have? Please give the value or percentage

1. fixed rent(amt. per acre per year) ....
2. abunu ....
3. abusa ....
4. provision of labour ....
5. others(specify) ....

43. Do you share cost? Yes/No

If yes, how?........................

44. If you happen to own the land, what will be your attitude towards tree planting in your farms?..

University of Ghana http://ugspace.ug.edu.gh

E. PHYSICAL GOODS

45. Could you please state the inputs/tool/machines you use on your cocoa farms (from land preparation to the time cocoa trees start to bear fruits), the quantity used per year, unit price, useful life and their sources per pole/acre?

Items	Quantity	Sources FP, H, S, P,	Useful life YRS.	Unit price
Cutlass				
Hoe				
Axe				
Prunner				
Hook				
Spade				
Basket				
Sack				
Spraying machine				
Fertilizers				
Drying mats				
Pesticides				
Mist blower				
Wellington boot				
Protective clothing				
Sharpening stone				
Pick axe				
Others				

FP=Farm produced H= Hired S=Shared P=Purchase

46.a When the cocoa start bearing fruit, do you still use the same quantity(s) Yes/No

b. If no, what quantity do you use from then onwards in a year?

47. Which type of fertilizer/ fungicides/ pesticides do you use to apply/ spray on your cocoa farms? Please indicate the quantity use per units of land and cost/unit

Type	Q'ty/unit of land	Cost /unit
Fertilizer	....	....
Fungicide	....	....
Insecticide	....	......

48. How many days in a year do you hire the tools/machines indicated in Q 45? Please indicate the charge per day

Tools/machines	No. of day hired	Cost per day
....	....	....

49. How do you acquire the seedlings/suckers for planting in your cocoa farms? Please indicate their sources, quantity per pole/acre and price per unit

Crop	Source	Quantity/acre/pole	Price/unit
Cocoa			
Kola			
Black pepper			
Timber trees			
Others			

Source code : P-purchase G-gift N-nurse them J-JFM O-others

F. **LABOUR**

50.a Which months of the year are your major farming season? ....

b. Which months of the year are your major farming season? ....

51.a Do you use hired labourer for work? Yes/ No

b. Do the hired labourer work on per day basis or per contract? ....

Please indicate the numbers days and how much it cost per pole/acre per contract or day labourer for the following activity

Activity	Contract		By day	
	Days	Cost	Days	Cost
Land clearing				

University of Ghana http://ugspace.ug.edu.gh

Tree felling				
weeding				

51. How many hours do hired labourers spend on the farm per day during?

1=Major season...........hrs 2=Minor season .... .hrs

52. How many hours does your household spend on the farm per day during?

1=Major season...........hrs 2=Minor season ....hrs

53. How many days in a week does your household spend on the farm per day during

1=Major season..........days 2=Minor season ....days?

54.a How much do you pay to hire labourers per day during?

1=major season ¢................ 2=minor season ¢...................

b. In addition to cash, what else do you give them?

1=Cooked food ¢........... 2=Farm products ¢........... 3=Nothing ¢.......

Do you always give them something anytime you employ them? Yes/No

55. Could you please indicate the number of days spend (D), the type of labour (T) and number of labour (N) you use in doing the following activities per units of land per year from land preparation onwards

	Cleared forest			Young cocoa farm			Kola			Black pepper			Timber trees		
	D	T	N	D	T		D	T	N	D	T	N	D	T	N
Land Clearing															
Tree felling															
Burning															
Apam															
Planting :cocoa															
Planting trees															
Planting kola															
" :black pepper															
Making traps															
Weeding															

University of Ghana http://ugspace.ug.edu.gh

Remove chupoun															
Pruning/thinning															
Mistletoe control															
Spraying															
Fertilizer application															
Others															

Type code 1=male 2=female 3=hired 5=others

56. How many times in a year do you do the following activity(s)?

Activity	Young cocoa	Mature cocoa	Timber trees	Black pepper	Kola
Weeding					
Fertilizer application					
Prunning					
Spraying					
Mistletoe control					
Others					

G. HARVESTING AND SALE OF COCOA

57. How many days, number of people and type of labourer do you use to harvest and sell cocoa?

Activity	No. of Days	No. of people	Type of labour
Plucking of cocoa			
Gathering & heaping			
Pod breaking			
Fermentation			
Carrying to drying point			
Carrying to selling point			

University of Ghana http://ugspace.ug.edu.gh

58. How many days, number of people and type of labour do you use to harvest and sell the other crops you grow in your cocoa farms?

Crop	No. of Days	No. of People	Type of labour
Kola			
Black pepper			
Timber trees			
Others			

H. OUTPUT (S)

59. Could you please indicate the volume of output **PER YEAR** of your produce, how much of it goes into consumption and sale, period of sale, unit price and location of sale?

Crop variety	Output/kg bags/basket	Home consumption	Q'ty sold	Period of sale	Unit price	Location of sale
Cocoa						
Kola						
Black pepper						
Others						

60. Which other product(s) do you get from your farms that are **not** grown by you? Please list them ……………………………………………………

61a. Do you have problems concerning the sale your produce? Yes/No

b If yes could you please tell the kind for problem(s) you encounter?……………………………………………………………………………………

c. How would you want the problem(s) to be solved?………………………

……………………………………………………………………………………………

University of Ghana http://ugspace.ug.edu.gh

SECTION C

OTHER INCOME GENERATING ACTIVITY

62. Apart from cocoa and tree planting, do you also undertake any of the following?

Beekeeping	Yes/No
Snail rearing	Yes/No
Mushroom growing	Yes/No
Fish farming	Yes/No

A. FISH FARMING

a. When did you build the pond?.............................

b How many ponds do you have?.............................

c How are they doing ?...

d How many times in a year do you fish from the pond?.............................

e How many basket(s) of fish do you get in each catch?.................................

f How many basket(s) is used for home consumption?...................................

g How much do you sell for a basket? ¢...

h How much does it cost to build a pond?

	No./size	price/unit	value
Land	....	....	....
Labour	....	....	....
Water	....	....	....
Fish(fingerlings)	....	....	....
feed	....	....	....

B. SNAIL REARING, BEE-KEEPING FARMING ACTIVITIES

	Snail	beekeeping	mushroom
a. How many farms do you have for each activity?	....	....	....
b. How many units are in each farm?	....	....	....
c. When did you start each activity?	......	....	....

University of Ghana http://ugspace.ug.edu.gh

d. How many units did you start with in each? ....

e Output per year? ....

f. How many times in a year do they produce ....

g. How many days in a week do you attend to them? ....

h. How many hours in a day do you spend on them? ....

i. How much do you sell per unit? ....

j. Cost of maintenance per day? ....

k. Inputs used for each activity? (Assign q'ty) ....

l. Percentage of output used for home consumption ....

m. Units cost of each inputs?

<u>Bee</u>	<u>cost</u>	<u>snail</u>	<u>cost</u>
Hive	....	padlock	......
Veil	....		
Brush	....		
smoker	....		

University of Ghana http://ugspace.ug

Appendix B LINEAR PROGRAMMING MATRIX

			Cocoa	Kola	B P
Max. NPV (¢' million)			2.264	10.14	3.222
Subject to resource:					
Capital (¢' million)	44.09		5.923	0.816	0.570
Labour (MD)	13320		2181	1652	2842
Land (ha.)	7.6		1	1	1
	0	<	1	0	0
	0	<	0	1	0
	0	<	0	0	1
	0.4	>	0	0	0
	0.4	>	0	0	0
	0.4	>	0	0	0
	0.2	>	0	0	0
	0	<	0	0	0
	0	<	0	0	0
	0	<	0	0	0
	0	<	0	0	0

BP- Black Pepper

University of Ghana http://ugspa

Timber	Snail	Fish	Honey
0.526	3.042	-0.144	0.045
0.074	0.534	2.057	1.717
51	1485	1479	448
1	1	1	1
0	0	0	0
0	0	0	0
0	0	0	0
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1